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POSSIBILITIES OF ACQUIRING AND ENERGETIC USE OF BIOMASS IN COMMUNES IN MAŁOPOLSKA VOIVODESHIP

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Abstract. This analysis touches upon an evaluation and estimation of the potential of communes in Małopolska voivodeship in terms of energetic use of plant biomass. The research results showed that if biomass, in the form of straw and hay not used in agriculture and willow (salix) cultivated on lands out of agricultural production, was marked for energetic aims, the generation of about 8.3 PJ of energy would be possible. It was also pinpointed that within the group of communes with the highest potential of hay and willow for energetic use (25% of communes), environmental (the quality of production space) and economic factors (the area structure, and configuration, etc.) will hinder the development of the biomass market. The same conditions which contributed to the regress of agriculture are seen as an obstacle to effective and profitable biomass production. The only real opportunity for development of the biomass market is seen in straw, which can be acquired in communes with the best natural and economic conditions.

Key words: energetic potential, biomass, Małopolska voivodeship

INTRODUCTION

One of the fundamental objectives of the European Union is sustainable development, which should be compatible with building one of the most competitive economies in the world, giving priority to environmental protection and the future of EU residents (Jachymek, 2008; Jasiulewicz, 2014). This concept also encompasses efforts aimed at identification and creation of new types of economic activity involving production of energy from renewable sources (Bania and Mierzejewski, 2014).

Considering the need to minimise the adverse impact of various RES installations, energy generation based on solid biomass may play an important role in Poland (Gostomczyk, 2015; Jarosz et al., 2014). It appears that this development path could be taken in regions characterised by large areas of land taken out of agricultural production (Jasiulewicz, 2014). This is echoed by the provisions of Polish Energy Policy (PEP 2030), indicating that one of the goals is "(...) sustainable use of agricultural areas for RES purposes, including biofuels, so as to prevent competition between the renewable energy sector and agriculture and to preserve biodiversity" (Polityka energetyczna..., 2009). Concentration of biomass production in regions that encompass areas not used by agriculture could contribute to a range of beneficial processes. It is an opportunity for the development of rural areas, particularly peripheral ones, characterised by

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a limited range of non-agricultural activity and employment (Piwowar and Dzikuć, 2013; Gostomczyk, 2015). In view of the declining competitiveness of agricultural production in areas of the weakest agricultural potential, development of biomass production for energy purposes could be an innovative method of application of land as a production factor (Karwat-Woźniak, 2013). Furthermore, harvesting the material from lands which now lie fallow may contribute to an improvement of soil and water conditions and to preservation of biodiversity.

The use of the energy potential of biomass on a global as well as local scale depends on many factors. The most important of them is the economic factor that determines the establishment, long-term operation and development of economic undertakings (entities) aimed at the application of biomass in energy generation. The extent of biomass use on a local scale, e.g. within a commune, depends largely on accurate estimation of local potential for biomass production. The natural and economic factors of agricultural development play a crucial role here, because they determine whether or not the production will be profitable.

MATERIALS AND METHODS

The main aim of this study is to estimate the energy reserves existing in the production space not being used for agricultural purposes, where biomass is spontaneously produced. Another is to evaluate the natural and economic factors and chances of successful development of biomass production in the communes of Małopolska voivodeship.

All the analyses were conducted for rural and urban-rural communes of Małopolska voivodeship (a total of 168 administrative units). The main source of data were the results of the General Agricultural Census 2010. The investigation focused on the technical potential of biomass, i.e. the area that can be allotted to biomass production, taking into account the current use of the agricultural production space. It was assumed that biomass would be obtained from plant production, including straw, hay and land not kept in a good agricultural condition as well as meadows and pastures out of production. In the determination of the energy potential it was assumed that lands out of agricultural production will be used to grow willow (Salix). Willow has been adopted as a kind of indicator plant that can be grown on fallow land. The authors chose not to discuss in detail the matters of selection of energy crops according to the existing environmental conditions (e.g. water conditions, soil quality, particular natural values etc.).

Since a number of simplifications have been applied, the value of potential estimation at the technical level can only serve as a basis for further research focusing on the specific territorial units. It is the starting point for technical and economic optimisation of potential projects involving biomass production and conversion into various forms of energy. The assumptions (Table 1) make it possible to estimate the maximum amount of energy obtainable from biomass not used in agriculture.

Because there is no data on cereal yields for the individual communes, they were estimated on the basis of the Agricultural Production Space Valuation Ratio (APSVR). The multiple regression model was used for this purpose in the following form: Y (yield) = 0.032 + 0.448 x (number of APSVR points). This model enables determination of the mean crop yield at an 85% confidence level (Gruda, 2006). For other plants the yield values were sourced from specialist literature. The annual average yield was assumed to be 6 tonnes of dry matter for willow and 3.5 tonnes for hay.

In the estimation of the area for straw the assumption was made that it must first meet the demand of livestock production (bedding and feed) and fertilisation needs (for incorporation into soil by ploughing), to maintain the correct balance of organic matter in the soil. According to this assumption, the demand for straw for cattle feed and bedding is 0.6 $t \cdot year^{-1}$, for pigs – 0.28 $t \cdot year^{-1}$, and for sheep – 0.2 $t \cdot year^{-1}$, whereas 20% of the acreage of cereal will be earmarked for straw incorporation into the soil. Having considered the headage of cattle, pigs and sheep, the amount of biomass available for use was calculated from the equation (Ludwicka and Grzybek, 2010):

$$S = P - (Db + Df + Di)$$

where:

S – surplus straw for alternative use (energy production)
P – production of straw from cereals and canola
Db – demand for bedding straw
Df – demand for feed straw
Di – demand for straw for incorporation into soil.

When estimating the technical potential of biomass from permanent grasslands (PG) it was assumed that

Table 1. Assumptions concerning availability and yielding of energy crops
Tabela 1. Założenia odnośnie do dostępności i plonowania roślin energetycznych

Type of biomass Rodzaj biomasy	Availability Dostępność	Yielding (annual average) Plonowanie (średnioroczne)	Calorific value Wartość opałowa	Conversion efficiency of heat Sprawność konwersji na ciepło (%)
Willow Salix (lands out of production) Wierzba Salix (grunty wyłączone z produkcji)	100% of agricultural lands not kept in a good agricultural condition, meadows and pastures (permanently out of production) 100% powierzchni użytków rolnych nieutrzymywanych w dobrej kulturze rolnej oraz łąk i pastwisk (trwale) wyłączonych z produkcji	6.0 t DM·ha^{-1} 6,0 t s.m.·ha^{-1}	13.5 GJ·t^{-1} DM 13,5 GJ·t^{-1} s.m.	85
Straw of crops Słoma zbóż	Surface was evaluated as a difference between the total acreage of grain crops and the acreage used by agriculture for productive aims. Yield of straw is equal to 67% of yield of grain Powierzchnia została obliczona jako różnica między całkowitym areałem roślin zbożowych a areałem wykorzystywanym przez rolnictwo na cele produkcyjne. Plon słomy jest równy 67% plonu ziarna	It is estimated on the basis of information about the quality of agricultural production area. The humidity of straw is on the level of 14% Oszacowano na podstawie informacji o jakości rolniczej przestrzeni produkcyjnej. Wilgotność słomy przyjęto na poziomie 14%	17.8 GJ·t^{-1} DM 17,8 GJ·t^{-1} s.m.	80
Hay Siano	The surface was evaluated as a difference between the total acreage and the acreage used by agriculture for productive aims Powierzchnia została obliczona jako różnica między areałem TUZ a areałem wykorzystywanym przez rolnictwo na cele produkcyjne	3.5 t DM·ha^{-1} 3,5 t s.m.·ha^{-1}	16.4 GJ·t^{-1} DM 16,4 GJ·t^{-1} s.m.	80

Source: own elaboration on the basis of: Tańczuk and Ulbrich (2009), Siejka et al. (2008).
Źródło: opracowanie na podstawie: Tańczuk i Ulbrich (2009), Siejka i in. (2008).

0.75 ha permanent grasslands (PG) is required to feed 1 LSU of ruminant animals, and the remaining area can be used for energy production (Fereniec, 1999). For communes with a negative potential of energy production from hay and straw (where the production is less than the demand in agriculture) it was assumed to be zero. That is because it is not a common practice to purchase hay or straw for agricultural production purposes. In many farms supporting large herds hay is replaced with silage or grass-silage obtained from arable land (e.g. maize for silage), and no bedding is used in livestock breeding. Hence, a negative hay and straw balance, especially at commune level, is highly unlikely.

When estimating the technical potential, i.e. the energy reserves offered by agricultural land out of production, it was assumed that the entire acreage of lands not kept in a good agricultural condition as well as meadows and pastures out of production would be earmarked for energy crops.

Since, from the economic viewpoint, biomass production will only be reasonable in the case of a relatively high material concentration, after calculating the technical potential of biomass it was converted to 100 ha AL (i.e. 1 km^2). The units were then arranged in ascending order and a ranking of communes with respect to biomass production potential was compiled. The communes included in the ranking were additionally divided

into four groups according to the first, second and third quartile values. The decision to use quartile values as a criterion of commune division was due to the fact that the distribution of the values of the variable investigated was not close to normal distribution, which excluded the use of classic measures of variability (e.g. arithmetic mean). In practice, the use of quartiles means that the population studied is divided into 4 equinumerous groups. Identification of regions abundant in various forms of biomass will make it possible to evaluate the natural and economic factors and chances of successful development of power industry based on agricultural biomass.

BIOMASS RESERVES FOR ENERGY PRODUCTION AND THE ENVIRONMENTAL AND ECONOMIC POSSIBILITIES OF THEIR USE

The results of investigation indicate that, assuming the use for energy generation of all the surplus biomass in the form of straw, hay and willow not used in agriculture (harvested from lands out of agricultural production), it will be possible to generate about 8352.3 TJ of energy (Fig. 1). For comparison, in 2011 the energy consumption in Małopolska voivodeship for heating purposes (heating and hot water) was 91 069 TJ (Kulczycka et al., 2013). Therefore, it must be stressed that even on very optimistic assumptions concerning the availability of biomass it would be possible to cover only 10% of heating demand of Małopolska voivodeship.

In Małopolska voivodeship biomass from meadows and pastures has by far the highest energy potential. Biomass obtained from perennial plants grown on lands permanently out of production also has a considerable energy potential. Straw has a slightly lower technical potential. In practice, however, as a low-cost by-product it has the highest economic potential and is therefore sold for energy generation purposes.

The substantial surplus of hay in Małopolska voivodeship is largely due to a relatively high share of permanent grasslands in AL area and a serious deficit of ruminant livestock (Musiał et al., 2013). It is also worth mentioning that the concentration of material is comparatively low in the case of hay because 25% of communes with the largest hay resources can generate only 1 564.4 TJ, i.e. 50% of the entire potential of the voivodeship (Table 2). The considerable dispersion of surplus hay will negatively affect the chances of organising local outlets or creating distributed power industry installations.

Communes with a large energy potential of hay (above 914 GJ/100 ha AL) the AL area is more than 135 500 ha, of which only about 18 700 ha is owned by farms larger than 15 ha. The average AL area is relatively small (4.4 ha), and the agrarian structure is usually unfavourable, which is also indicated by a large share of farms containing more than 10 land lots (Table 3).

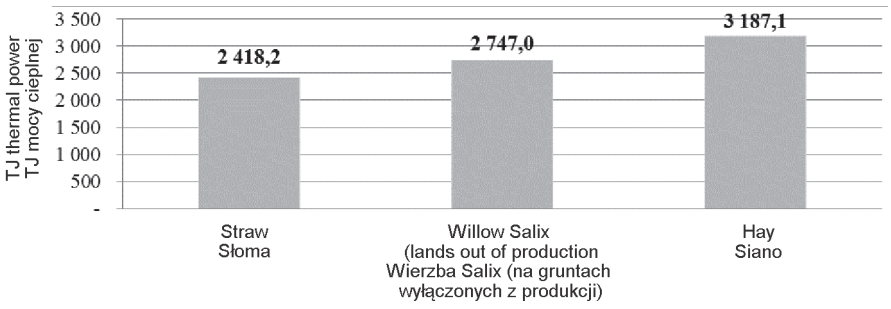

Fig. 1. The maximum technical potential of biomass for chosen plants in Małopolska voivodeship
Source: own elaboration on the basis of Agricultural Census, 2010.
Rys. 1. Maksymalny potencjał techniczny biomasy wybranych roślin w województwie małopolskim
Źródło: opracowanie własne na podstawie danych PSR, 2010.

Table 2. Energetic potential of hay and the surface of agricultural lands and permanent grasslands in communes in Małopolska voivodeship
Tabela 2. Potencjał energetyczny siana oraz powierzchnia użytków rolnych i TUZ w gminach województwa małopolskiego

Potential of communes Gminy o potencjale	Number of communes Liczba gmin	Energetic potential of hay (TJ) Potencjał energetyczny siana (TJ)	Surface of AL (thousands ha) Powierzchnia UR (tys. ha)	Surface of AL in farms above 15 ha (thousands ha) Powierzchnia UR w gospodarstwach powyżej 15 ha (tys. ha)	Surface of permanent grasslands (ha) Powierzchnia TUZ (ha)	Percentage of permanent grasslands (% of AL) Odsetek TUZ (% UR)
Above 914 GJ/100 ha AL Powyżej 914 GJ/100 ha UR	42	1 564.4	135.5	18.7	83.6	61.7
From 560 to 914 GJ/100 ha AL Od 560 do 914 GJ/100 ha UR	42	1 017.1	142.4	15.8	70.3	49.4
From 244 to 560 GJ/100 ha AL Od 244 do 560 GJ/100 ha UR	42	528.7	126.8	17.4	41.3	32.6
Below 244 GJ/100 ha AL Poniżej 244 GJ/100 ha UR	42	76.9	206.8	45.4	23.1	11.2
In total – Ogółem	168	3 187.1	611.5	97.3	218.3	35.7

Source: own elaboration on the basis of Agricultural Census, 2010.
Źródło: opracowanie własne na podstawie PSR, 2010.

Table 3. Chosen characteristics of agriculture of communes in Małopolska voivodeship depending on the energetic potential of hay
Tabela 3. Wybrane charakterystyki rolnictwa gmin województwa małopolskiego w zależności od potencjału energetycznego tkwiącego w sianie

Potential of communes Gminy o potencjale	Number of communes Liczba gmin	The quality of natural conditions (Agricultural Production Space Valuation Ratio) Jakość warunków przyrodniczych (WWRPP)	Average surface of agricultural lands (ha)* Średnia powierzchnia UR (ha)*	Number of farms above 15 ha Liczba gospodarstw powyżej 15 ha	Share of farms above 10 land lots Udział gospodarstw posiadających powyżej 10 działek ewid.
Above 914 GJ/100 ha AL Powyżej 914 GJ/100 ha UR	42	56.1	4.4	371	16.1
From 560 to 914 GJ/100 ha AL Od 560 do 914 GJ/100 ha UR	42	60.5	4.0	355	14.9
From 244 to 560 GJ/100 AL Od 244 do 560 GJ/100 ha UR	42	69.7	4.1	370	6.0
Below 244 GJ/100 ha AL Poniżej 244 GJ/100 ha UR	42	83.6	5.3	1 241	6.3
In total – Ogółem	168	67.8	4.4	2 337	11.1

*Farms above 1 ha AL.
Source: own elaboration on the basis of Agricultural Census, 2010.
*Gospodarstwa o wielkości powyżej 1 ha.
Źródło: opracowanie własne na podstawie danych PSR, 2010.

Therefore, it must be emphasised that despite the relatively high potential of energy production from hay, the adverse agrarian structure may severely limit the possibility of supplying large quantities of material for energy generation. Areas characterised by a high potential of biomass based on hay also offer very difficult conditions for crop production (low soil quality, unfavourable topography, harsh climate) and there is practically no alternative to grasslands. With the decreasing headage of ruminant livestock, there will be an increasing surplus of biomass, which presumably will not be harvested or used in production. A good solution might be to utilise it for energy generation, although it is economically unsound in many cases.

It should be stressed that the unfavourable topography is a large obstacle to material harvesting that increases the costs of production. Because of the reduced production profitability there is relatively little interest from biomass producers. Furthermore, unlike straw, hay constitutes the main product of the process. Its production involves a number of steps, including mowing, drying and baling, which is labour- and cost-intensive – particularly in mountainous regions, characterised by a considerable atomisation and spatial dispersion of lots which can be utilised for hay production. In addition, traditional grasslands occupy the least favourable locations (e.g. in shaded places, on slopes or on irregularly-shaped fields) so the possibilities of harvesting material at acceptable prices (for customers) are rather limited.

In communes characterised by a lower potential for energy generation from hay (560–914 GJ/100 ha AL) and at the same time better natural conditions, the main obstacle will be the economic conditions, including advanced deagrarianisation. These units are chiefly situated in the western part of the voivodeship and in the vicinity of cities. A large part of the population formerly employed in farming have now ceased to farm the land and do not have the appropriate machines or farm buildings. The remaining groups of communes (above 560

Table 4. Energetic potential of willow and the surface of agricultural lands and lands out of agricultural production in communes in Małopolska voivodeship
Tabela 4. Potencjał energetyczny wierzby oraz powierzchnia użytków rolnych i gruntów wyłączonych z produkcji rolniczej w gminach województwa małopolskiego

Potential of communes Gminy o potencjale	Number of communes Liczba gmin	Energetic potential of Willow Salix Potencjał wierzby (TJ)	Surface of AL (thous. ha) Powierzchnia UR (tys. ha)	Surface of AL in farms above 15 ha (thous. ha) Powierzchnia UR w gospodarstwach powyżej 15 ha (tys. ha)	Surface of lands out of agricultural production* Powierzchnia gruntów wyłączonych z produkcji rolnej* (ha)	Percentage of lands out of agricultural production Odsetek gruntów wyłączonych z produkcji rolnej (%)
Above 787 GJ/100 ha AL Powyżej 787 GJ/100 ha UR	42	1 135.7	96.7	10.3	36.4	37.6
From 383 to 787 GJ/100 ha AL Od 383 do 787 GJ/100 ha UR	42	905.8	153.2	23.0	29.0	18.9
From 178 to 383 GJ/100 ha AL Od 178 do 383 GJ/100 ha UR	42	488.5	165.4	22.7	15.6	9.5
Below 178 GJ/100 ha AL Poniżej 178 GJ/100 ha UR	42	216.9	196.3	41.3	6.9	3.5
In total – Ogółem	168	2 747.0	611.5	97.3	87.9	14.4

*The sum of agricultural lands not kept in a good agricultural condition along with meadows and pastures out of production.
Source: own elaboration on the basis of Agricultural Census, 2010.
*Suma użytków rolnych nie utrzymywanych w dobrej kulturze rolnej oraz wyłączonych z produkcji łąk i pastwisk.
Źródło: opracowanie własne na podstawie danych PSR, 2010.

GJ/100 ha AL) offer far better natural and economic conditions, but the technical potential of hay is very low because of the predomination of production on arable land.

A considerable area of land in Małopolska voivodeship has been excluded from agricultural production and now constitutes fallow land. These areas are subject to spontaneous ecological succession, i.e. they are overgrown first by dicotyledons, then monocotyledons and finally undergo uncontrolled afforestation. It seems that they could be utilised for plantations of perennials, such as willow, miscanthus, multiflora rose, Virginia mallow, poplar or other plants. The selection of plants should be preceded by detailed analyses and take into account the local natural conditions and environmental regimes. It was assumed in this study that the farming land will be utilised by willow plantations; the authors wish to point out that willow is supposed to serve as a kind of indicator plant. The overall heat that could be generated in the communes characterised by large areas of land out of agricultural production which could be utilised for growing energy crops (potential above 787 GJ/100 ha AL) is about 1 135 TJ (Table 4). However, these are chiefly small communes with a total AL area of 96 700 ha, i.e. about 15% of AL of Małopolska voivodeship.

Communes with relatively large biomass reserves (above 787 GJ/100 ha AL) have a very large share of land out of agricultural production (37.6% AL), but due to the great spatial dispersion of these lands the chances of utilising them for energy production are very limited (Table 5). The mean farm area is a mere 3.6 ha in these units, and only 10% of AL is used by farms larger than 15 ha. Another problem is the high fragmentation of lots, which hinders concentration of production and preparation of larger product batches. On the one hand the small production volume cannot guarantee a buyer, and on the other, it is not very profitable.

When evaluating the natural conditions of communes characterised by a high potential of energy production from willow, it should be observed that they are slightly worse than the voivodeship average, but there are some exceptions – several communes near Cracow offer very good conditions for agricultural production.

Table 5. Chosen characteristic of agriculture of communes in Małopolska voivodeship depending on energetic potential of willow
Tabela 5. Wybrane charakterystyki rolnictwa gmin województwa małopolskiego w zależności od potencjału energetycznego wierzby

Potential of communes Gminy o potencjale	Number of communes Liczba gmin	The quality of natural conditions Jakość warunków przyrodniczych (WWRPP)	Average surface of AL* Średnia powierzchnia UR (ha)*	Number of farms above 15 ha Liczba gospodarstw powyżej 15 ha	Share of farms above 10 land lots Udział gospodarstw posiadających powyżej 10 działek ewid. (%)
Above 787 GJ/100 ha AL Powyżej 787 GJ/100 ha UR	42	58.2	3.6	182	18.6
From 383 to 787 GJ/100 ha AL Od 383 do 787 GJ/100 ha UR	42	61.6	4.0	486	9.9
From 178 to 383 GJ/100 ha AL Od 178 do 383 GJ/100 ha UR	42	70.4	4.6	559	8.3
Below 178 GJ/100 ha AL Poniżej 178 GJ/100 ha UR	42	80.5	5.4	1110	7.3
In total – Ogółem	168	67.8	4.4	2 337	11.1

*Farms above 1 ha AL.
Source: own elaboration on the basis of Agricultural Census, 2010.
* Gospodarstwa powyżej 1 ha UR.
Źródło: opracowanie własne na podstawie danych PSR, 2010.

Nevertheless, the inhabitants of this region (as well as of the communes in the western part of the voivodeship) have been employed outside agriculture for at least two generations. They have discontinued agricultural production and converted (or pulled down) farm buildings, thus seriously limiting the possibilities of biomass harvesting.

By far the smallest areas of land that could be used for growing energy crops are situated mainly in the communes characterised by a high intensity of agricultural production, i.e. in the northern part of the voivodeship and in the vicinity of Nowy Sącz. The administrative units with an energy potential below 178 TJ/100 ha AL have a very low percentage of land out of agricultural production and therefore the chances of the development of biomass market based on energy crops are minimal. Utilising land of very good quality for energy production would also be unreasonable.

By contrast, the technical and economic potential of straw is very high in Małopolska voivodeship, and its northern communes are particularly abundant in this form of biomass. It is a region of intensive agricultural production with a definite predominance of plant, mainly cereal production. The large potential of straw production arises, amongst others, from the best soil conditions in the voivodeship (the agricultural production space valuation ratio is ca. 30% than the voivodeship average) and a relatively good agrarian structure (mean AL area of 5.2 ha), as well as regulated ownership relations and strongly developed agricultural function. In the communes characterised by the highest potential of energy generation from straw, i.e. above 622 GJ/100 ha AL, there are ca. 176 000 ha AL in use, more than 25% of which (45 000 ha) is contained within farms with an area of more than 15 ha (Table 6).

In communes with the highest potential of energy generation from straw the total cereal and canola cultivation area is 101 900 ha, which constitutes nearly 70% of the sown area. It should also be emphasised that farmers are generally keen to sell straw, although now it is purchased (for energy production purposes) almost exclusively from farms with the largest areas. Communes with a biomass potential above 622 GJ/100 ha AL offer very good conditions for growing cereals and the possibility of harvesting large quantities of straw, which is often left over in the farm. A great

Table 6. Energetic potential of straw and the surface of agricultural lands and grain sowing in communes in Małopolska voivodeship
Tabela 6. Potencjał energetyczny słomy oraz powierzchnia użytków rolnych i zasiewów zbóż w gminach województwa małopolskiego

Potential of communes Gminy o potencjale	Number of communes Liczba gmin	Energetic potential of straw Potencjał słomy (TJ)	Surface of AL (thous. ha) Powierzchnia UR (tys. ha)	Surface of AL in farms above 15 ha (thous. ha) Powierzchnia UR w gospodarstwach powyżej 15 ha (tys. ha)	Surface of crop plants and rape (thous. ha) Powierzchnia roślin zbożowych oraz rzepaku (tys. ha)	Percentage of sowing in the AL Odsetek zasiewów w powierzchni UR (%)
Above 622 GJ/100 ha AL Powyżej 622 GJ/100 ha UR	42	1 645.2	173.6	45.0	101.9	79.3
From 237 to 622 GJ/100 ha AL Od 237 do 622 GJ/100 ha UR	42	654.8	158.5	21.7	59.9	50.5
From 0,1 to 237 GJ/100 ha AL Od 0,1 do 237 GJ/100 ha UR	42	118.2	130.4	13.3	32.2	31.1
Below 0,1 GJ/100 ha AL Poniżej 0,1 GJ/100 ha UR	42	0.0	149.1	17.3	14.0	14.8
In total – Ogółem	186	2 418.2	611.5	97.3	208.1	45.4

Source: own elaboration on the basis of Agricultural Census, 2010.
Źródło: opracowanie własne na podstawie danych PSR, 2010.

Table 7. Chosen characteristics of agriculture of communes in Małopolska voivodeship depending on the energetic potential of hay
Tabela 7. Wybrane charakterystyki rolnictwa gmin województwa małopolskiego w zależności od potencjału energetycznego słomy

Potential of communes Gminy o potencjale	Number of communes Liczba gmin	The quality of natural conditions Jakość warunków przyrodniczych (WWRPP)	Average surface of AL (ha)* Średnia powierzchnia UR (ha)*	Number of farms above 15 ha Liczba gospodarstw powyżej 15 ha	Share of farms above 10 land lots Udział gospodarstw posiadających powyżej 10 działek ewid. (%)
Above 622 GJ/100 ha AL Powyżej 622 GJ/100 ha UR	42	87.6	5.2	1 065	5.8
From 237 to 622 GJ/100 ha AL Od 237 do 622 GJ/100 ha UR	42	75.6	4.0	578	4.5
From 0,1 to 237 GJ/100 ha AL Od 0,1 do 237 GJ/100 ha UR	42	62.5	4.1	343	12.2
Below 0,1 GJ/100 ha AL Poniżej 0,1 GJ/100 ha UR	42	45.4	4.5	351	22.3
In total – Ogółem	168	67.8	4.4	2 337	11.1

*Farms above 1 ha AL.
Source: own elaboration on the basis of Agricultural Census, 2010.
* Gospodarstwa powyżej 1 ha UR.
Źródło: opracowanie własne na podstawie danych PSR, 2010.

advantage of these units is the relatively good agrarian structure, and therefore greater chances of purchasing large quantities of straw from a single supplier (Table 7).

In communes situated in the central and eastern part of the voivodeship (energy generation potential between 237 and 622 GJ/100 ha AL) the natural and structural conditions are worse, so it is only possible to obtain 655 TJ. Because of the smaller area of cereal cultivation and lower yields there is little surplus straw in these units. Furthermore the subregion in question is characterised by a relatively small mean farm area (4.0 ha) and a low share of largest farms. The remaining part of the voivodeship, i.e. communes with the lowest cereal and straw production potential are largely mountainous areas suitable for livestock production on the basis of fresh biomass, hay silage and hay. Because of very small compact areas of cereal cultivation, low yields, high livestock headage per unit area and spatial dispersion of farms the straw harvesting potential is very low. From the economic viewpoint the chances of obtaining larger quantities of straw are marginal.

SUMMARY

The energy potential of a particular region depends on the natural conditions, the area that can be earmarked for biomass production as well as the broadly defined economic conditions justifying the acquisition of material.

Analyses show that hay harvested from permanent grasslands has by far the largest biomass potential in Małopolska voivodeship. This potential is somewhat lower in areas taken out of agricultural production, which could be used for perennial plant cultivation, and the lowest in the case of straw. With regard to the chances of using hay for energy generation, it should be emphasised that at present a large part of land is not mowed, so there are no surplus amounts of hay to speak of. The technical potential is very high, but the economic potential will be far lower. In this case the economic factors play a decisive role. Similarly, in the case of biomass harvested from fallow land the technical potential is very high, but in communes with a large share of fallow land the possibilities of resuming agricultural production, this time for energy generation purposes,

are very limited. Most farms have discontinued production for good, disposing of agricultural machines and equipment, and farm buildings have been converted to serve other purposes. A real and high energy potential in Małopolska voivodeship is offered by straw, which can be harvested in the communes situated in the northern part of the voivodeship. These areas with highly developed agriculture are characterised by a relatively good agrarian structure of farms and very good natural conditions.

To sum up, it must be emphasised that Małopolska voivodeship has considerable reserves of biomass for energy generation purposes. However, when considering agricultural production as an alternative and renewable energy source one must take into account the obstacle in the form of broadly defined economic factors. It is almost impossible to implement in Małopolska voivodeship the provisions of PEP 2030 stating that harvesting solid biomass should not have a negative effect on agriculture and energy crops should be cultivated in areas out of agricultural use. The research results have led to the conclusion that the areas in question have a number of features rendering production of solid biomass unprofitable. Communes offering large areas of land out of production are characterised by adverse natural conditions accompanied by highly disadvantageous economic conditions. In the past, these circumstances have contributed to the marginalisation of the agricultural functions, so production for energy generation purposes has rather limited chances of successful development. Given the present prices of fuels and the challenges due to the natural and economic factors the surplus biomass produced by agriculture will be used by the renewable energy sector to a very limited extent.

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MOŻLIWOŚCI POZYSKANIA I ENERGETYCZNEGO WYKORZYSTANIA BIOMASY W GMINACH WOJEWÓDZTWA MAŁOPOLSKIEGO

Streszczenie. W pracy oszacowano i oceniono potencjał gmin województwa małopolskiego w zakresie energetycznego wykorzystania biomasy pochodzenia roślinnego. W badaniach wykazano, iż przy założeniu, że biomasa w postaci słomy i siana, które nie są wykorzystywane w rolnictwie, a także wierzby uprawianej na gruntach wyłączonych z produkcji rolniczej zostanie przeznaczona na cele energetyczne, możliwe będzie wytworzenie około 8,3 PJ energii. Stwierdzono również, że w grupie gmin o największym potencjale siana oraz wierzby na cele energetyczne (25% gmin) zarówno uwarunkowania przyrodnicze (jakość przestrzeni produkcyjnej), jak i ekonomiczne (struktura obszarowa, rozłóg pól itp.) będą znacznie utrudniać rozwój rynku biomasy. Te same uwarunkowania, które przyczyniły się do regresu rolnictwa, nie pozwolą na efektywną i opłacalną produkcję biomasy. Realne szanse rozwoju rynku biomasy dotyczą jedynie słomy, która może być pozyskiwana w gminach o najlepszych warunkach przyrodniczo-ekonomicznych.

Słowa kluczowe: potencjał energetyczny, biomasa, województwo małopolskie

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