ECONOMIC AND LOGISTICAL BACKGROUND OF SOLID BIOMASS PRODUCTION FROM AGRICULTURE IN HUNGARY AND SERBIA

László MAGÓ[1], Goran TOPISIROVIĆ[2],
Snežana OLJAČA[3], Mićo V. OLJAČA[2]
[1]Szent István University,
Faculty of Mechanical Engineering
Páter K. u. 1., Gödöllő, H-2103, Hungary
Tel.:+36 28 522-000/1453,
E-mail: Mago.Laszlo@gek.szie.hu
[2]Faculty of Agriculture,
Institute of Agricultural Engineering
Nemanjina 6, Belgrade, 11080, Serbia
[3]Faculty of Agriculture, Institute of Crop Science,
Nemanjina 6, Belgrade, 11080, Serbia

Abstract

The research aimed to measure the quantity of agricultural biomass suitable for energy purposes at regional level (mostly in Serbia and Hungary). Furthermore, our common research also aimed to determine the potential of biomass for energy purposes with regards to the grown plants. We also aimed to name the possibilities and ways of utilisation of the solid biomasses of various origins.

Experiments of this kind have already commenced in Hungary and Serbia, in the Gödöllő-based Hungarian Institute of Agricultural Engineering, also in the Faculty of Mechanical Engineering of Szent István University, Gödöllő and in the Beograd - Zemun-based Institute of Agricultural Engineering of Faculty of Agriculture University of Belgrade.

The potentials of different types of solid biomass from agriculture are presented in the paper. The survey has included the comparative presentation of solid biomass potentials in Hungary and Serbia.

Keywords

solid biomass, agricultural biomass potential, renewable energy, energy utilisation, economy and logistic

Introduction

Renewable energy sources are strongly emphasized among the other items for renewable energy production and environmental protection. Besides, very important are improvements in rural development, employment, energy supply diversification, lower fossil fuels consumption, reliability of energy supply, engagement of domestic industry, etc.

According to the EU Directive 2003/30/EC, the biomass is defined as following: 'biomass' means the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste.

In the Action plan for biomass 2010 - 2012, that was designed by the Ministry of Environment and Spatial Planning and the Ministry of Energy and Mining of the Serbian Government, this definition is more precise: biomass is the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and wood industry, as well as the biodegradable fractions of industrial and municipal waste, which use in energy production is allowed, according to the relevant regulation from the field of environmental protection.

Basically, biomass is plant or animal matter (hence organic resources) that can be used to produce energy through different processes. The energy of plant matter is recaptured by the plants in the photosynthesis, transforming the sunlight into chemical energy and providing the base for the environmental chain. During the photosynthesis, plants combine carbon dioxide from the air and water from the ground to generate carbohydrates, which form the building blocks of biomass. In this way, the solar energy is stored in the chemical bonds of the structural components of biomass. This energy can be extracted using different methods. On the other hand, the main source of energy from animal sources mainly comes from cattle manure.

The general importance of the renewable energy sources in the EU economy can be illustrated by the following table, that presents the planned increase of renewable energy sources in the EU from 1995 to 2010.

Table 1. Renewable energy sources in the EU in 1995 and the predicted capacities in 2010

Type of energy	Renewable energy source potentials in 1995	Predicted potentials in 2010	Increment index
1. Wind	2,5 GW	40 GW	16
2. Water	92 GW	105 GW	1,1
Large power plants	82,5 GW	91 GW	0,01
Small power plants	9,5 GW	14 GW	1,5
3. Photovoltaic cells	0,03 GW	3 GW	100
4. Biomass	44,8 M toe	135 M toe	3
5. Geothermal			
Electricity	0,5 GW	1 GW	2
Heat	1,3 GWt	5 GWt	3,8
6. Solar collectors	$6,5 * 10^6$ m^2	$100 * 10^6$ m^2	15,3
7. Passive solar energy		35 Mtoe	-
8. Other		1 GW	-

Hungarian preview

According to surveys there is a significant biomass potential in Hungary. The total bulk of biomass in the country is up to 350-360 million tons out of which 105-110 million tons (about 30 %) reproduce themselves annually. The energy content of the biomass developing annually is up to 1185 PJ which is 5 % more than the total annual energy consumption of the country (1120 PJ). The fact that quantity of coal generated annually by plants is four times as much as the quantity of fossil coal exploited for energetic purposes in a year – as much as 30.4 million tons.

Table 2. Potential and utilization possibilities of energetic biomass from the agriculture

No.	Biomass	Quantity 1000 t/year		Energy content PJ/year	
		Min.	Max.	Min.	Max.
I. Biomass for combustion					
1.	Straw	1.000	1.200	11,7	14,0
2.	Stalk	2.000	2.500	24,0	30,0
3.	Energy grass	500	600	6,0	7,0
4.	Vine- and orchard shoot	300	350	4,3	5,0
5.	Energy plants on arable land	1.800	2.500	27,3	38,0
II. Production of biofuels					
1.	Corn maize	1.200	2.000	14,4	24,0
2.	Wheat/rye	600	1.800	7,2	21,6
3.	Rape	220	460	3,3	7,0
4.	Sunflower	50	200	0,8	3,2
III. Biogas production					
1.	Liquid manure, organic waste	6.000	10.000	5,4	9,0
2.	Silomaize, sorghum	1.600	3.200	5,4	10,8
Total:				109,8	169,6
In % of the total Hungarian energy consumption of 1120 PJ				9,7 %	15,0 %

In the primary biomass produced by the agriculture first of all the by-products arising in better amount can be reckoned with for energetic purposes. Under common or regular conditions 2,6-2,9 million tons of **cereal straw** is processed annually of which 1,6-1,7 million tons are utilized for animal breeding and for industrial purposes. The major part of the remaining 1,0-1,2 million tons of cereal straw could be used for energy production and annually 11,7-14 PJ energy could be produced of it. At present straw is practically not utilized for energetic purposes in Hungary due to the lack of appropriate stokes.

Maize stalk production in Hungary is 8-10 million tons of which 2-2,5 million tons could be utilized for energetic purposes which could yield 20-24 PJ energy p.a. Among the by-products of crop growing sunflower stalk and rape straw also arise in big quantities which could be utilized for burning and could supply 5-6 PJ thermal energy annually should the appropriate technologies for harvesting and burning be available.

The quantity of **vineyard and orchard pruning residues** (branch tendrils and fruit tree loppings) arising annually is 300-350 thousand tons which could supply 4,3-5 PJ energy. There have only been attempts for their burning till now. The harvesting in bales and burning in small stokes of branch tendrils is a viable solution on the vine growing farms. For the chopping, collecting and burning of pruning residues no technology has been developed so far.

Among the plants which can be produced on big areas for energetic purposes first of all the energy-grass and the energetic tree plantations can come into consideration in Hungary.

The energy-grass as a short rotation herbaceous grasses is able to provide a dry bulk of 10t/ha which can be baled for several years the energy content of which is 110-120 GJ/ha. The energy-grass can easily be pelletized. 6-7 tons of pellets can be produced of the grass yield of one hectare the burning features of which are more auspicious in lower capacity stokes than that of the chopped material in thermal power stations.

Should the final form of firing technology of energy-grass be developed cropping could be started in a short time maybe on 50-60 thousand hectares which would supply a 500-600 thousand ton bulk of biomass annually, of which 6-7 PJ energy can be produced. Another prospective source of bio-energy is the energetic tree plantation classified in the agricultural plantation management cultivation sector by which dendromass can be produced relatively fast and in big quantity for energetic purposes.

According to experiences hitherto it is expedient to plant the **short rotation wooden crops** varieties (poplar, willow) with a number of plants 12000-15000/ha which will be ready for felling in 3-5 years. The re-shooting tree stock can be harvested in another 3-5 years by felling totally 5-7 times assuming a plantation lifespan of 15-25 years. On the basis of long term-experiments made with different tree varieties yields of 11-20 t/ha/year can be achieved, of which 185-330 GJ/ha energy can be produced.

A rapid territorial expansion of the energetic plantations is expected in the near future which can achieve, or even exceed 100 thousand hectares of which 25-30 PJ energy can be gained.

For energy production under arable land conditions *triticale in the form of whole plant* cut into windrow and baled can also be taken into account the yield of which may reach 8-10 t/ha with 40 % grain bulk in it. Its energy content is 15-16 GJ/t so 120-160 GJ/ha energy can be produced. It has a favorable feature from the point of view of firing technology, that in baled form it burns more slowly and with a more even heat regress than wheat straw.

These biomasses originating from plants which can be produced on the field and utilized by direct burning are gaining a growing emphasis in our national energy policy in the coming years.

Table 3. The real and feasible capacity for energetic utilization of solid biomass in Hungary

Biomass	Utilization	Actual capacity			Expected growth till 2020		
		Unit (pieces)	Capacity (MW)	Biomass demand (2000 t)	Unit (pieces)	Capacity (MW)	Biomass demand (1000 t)
1. Wood chips (forest or planted wood)	Electricity	5	140	1000	8	420	2800
	Central heating	5	24	25	25	120	150
	Central heating + electric energy production	2	12	32	20	120	180
2. Straw, Energy grass	Straw power plant, electric energy production and heat utilization	-	-	-	2-3	40-60	450
Sum total		12	176	1057	55-56	700-720	~ 3600

Serbian preview

The agricultural biomass wastes are coming from cereals, mostly wheat, barley and corn, and from industrial crops mostly sunflower, soya, and rapeseed. In addition, there are many livestock farms in agricultural regions, where liquid and solid manure are considered as biomass waste. Fruit growing is also present in the agricultural areas, but the main area of fruit growing is the hilly region on the south, where main types of fruit are plums, apples, cherries, peaches, and grapes.

Actual annual biomass production in Serbia is app. 12.5 million t (2.7 million of TOE). From this sum, 1.7 million TOE is agricultural biomass, and 1.02 million TOE comes from the forestry.

Table 4. Possibilities for energy production from biomass in Serbia

Biomass source	**Potential (toe)**
Wood biomass	1.527.678*
Wood for combustion	1.150.000
Wood residues	163.760
Wood processing residues	179.563
Outside forests wood	34.355
Agricultural biomass	1.670.240
Crop production residues	1.023.000
Fruit and grape production and processing residues	605.000
Liquid manure (for biogas production)	42.240

* Recent research on wood biomass, according to the FAO methodology

For easier classification, biomass that originate from agriculture can be divided in three main categories: from crop production, fruit production and livestock breeding.

Biomass from crop production

In Serbia, there are many small individual landowners who deal with production of cereals or industrial plants, like sunflower or soya. A great deal of crop farming production, almost 75% is achieved in small or medium size private ownership, while only about 25% of crop farming production belongs to agricultural companies of relatively larger size.

The modern way of livestock breeding does not consider extensive use of bio mass residues for animal bedding. At large agricultural farms it is more favorable and cost effective to collect biomass residues in bales, and use them without any further preparation in small or medium sized boilers.

About half of bio mass residues at large agricultural farms can be used for energy purposes, while only about 20% bio mass residues generated on relatively small private farms can be used for energy purposes.

Table 5. Yield of main species in crop farming and energy potential of their residues

Plant	**Yield (10^3t)**	**Total residues (10^3t)**	**Residues for energy use (10^3t)**	**Energy potential (toe)***
Wheat	2.905,0	2.905,0	1.365,0	Average heating value 14MJ/kg
Barley	365,0	295,0	180,0	
Rye	14,1	15,5	4,4	
Corn	4.827,0	5.310,0	1.140,0	
Sunflower	280,0	705,0	240,0	
Soya	160,0	320,0	130,0	
Rape seed	2,6	7,8	1,6	
Total		9.560,0	3.060,0	1023000

*1 toe – ton of oil equivalent = 41,860 MJ

Greater amount of bio mass residues generated on small agricultural farms can be used for energy if these owners would have appropriate ovens and boilers for burning biomass residues, or if they find an interest to collect residues and sell them.

Biomass from fruit production and viticulture

One of main activities in fruit growing and viniculture is pruning of small branches, and these cut small branches can be available for energy purposes. Total number of registered fruit trees is about 94*106. Half of this number are plum trees, about 20% are apple trees and almost 15% are cherry trees, both sour and sweet cherry.

The total bio mass residues from fruit growing amounts about 475.000 t, with average heating value of 14 MJ/kg the energy potential of biomass residues from fruit trees pruning is about 159.000 toe. The energy potential of vine pruning residues is about 155.000 toe.

Table 6. Energy potential of biomass residues deriving from fruit cultivation and processing

Species	**Number of trees [10^3ha]**	**Type of biomass residues**	**Biomas residues [t]**	**Annual energy equivalent [toe]**
Plum	50.630	pruning, stones	393.500	132.600
Apple	17.570	pruning, peel	36.200	10.900
Cherries	12.280	pruning, stones	55.000	16.500
Pear	7.080	pruning, peel	14.000	4.300
Peach	4.450	pruning, stones	35.100	11.700
Apricot	1.900	pruning, stones	15.500	4.100
Walnuts	2.100	pruning, shell	55.000	14.100
Grape	77.390	pruning, peel, seeds	515.000	166.300
				Total: 360.500

Stones of plums, cherries, peaches, and apricots together with peels and seeds of apples, pears, and grapes are wastes derived from processing of fruit. The quantity of these wastes amounts to about 200,000 t. With a relatively modest heating value of 9 GJ/t, the energy potential of fruit processing wastes is about 46,000 toe. This value is relatively small comparing to the energy potential of other fruit residues derived from growing. But an important advantage of these wastes is that they are already collected in every company dealing with fruit processing.

The overall energy potential of bio mass residues from fruit growing, viniculture and fruit processing is about 605,000 toe.

Biomass from livestock breeding

Liquid manure deriving from cattle and pig breeding together with poultry litter are potential energy sources as well. Because of high water content (up to 90%) these slurries are usually treated by anaerobic digestion. These wastes are recommended for anaerobic digestion, not only for an energy reason, but also for get ting more suitable and environmentally friendly fertilizers.

Livestock breeding in Serbia comprises mainly cattle, pigs, poultry and sheep.

Table 7. Livestock in medium and great farms and energy potential of their manure (Dänzer, 2006; FNR, 2006)

Livestock	Location of farms	Number of heads	Manure [m^3/day]	Biogas [m^3/day]	Annual energy equivalent [toe]
Cattle	Flat regions	149.300			
	Hilly regions	111.000			
	Total	260.300	5.270	105.000	20.140
Pigs	Flat regions	1.369.500			
	Hilly regions	285.600			
	Total	1.655.100	4.560	91.200	17.500
Poultry		2.350.000	480	24.000	4.600
				Total	42.240

The major part of livestock is located in small farms, with only a few heads in each. An organized manure collection from these small farms is not likely to be easily technically feasible, and the financial feasibility is uncertain as well. Therefore, in the analysis of energy potential, only manure in medium and great farms is considered as a prospective source of fuel, since manure from these farms does not need to be transported, and can be efficiently treated in an aerobic digestion.

Competition between food and energy production

FAO and OECD estimate that food consumption will increase 10% annually, while energy consumption will increase 3% by 2030. Increased need of food will be covered with bio-technical progress before all on suitable location for agricultural production. Some analysts note that oil prices will not stay on present price of US$87.63 a barrel - the highest level since late 2008. Considering that oil price has exceptional influence on bioenergy production, production of bioethanol in Brasil is rentable without subsides if the oil price is between US$30 and US$40 per barrel. In such areas more agricultural land will be used for energy production and higher food prices will be reasonable consequence.

EU commission evaluates profitability of biofuel production in Europe when oil prices are between US$60 and US$90 a barrel which means double than breakeven point in Brasil. According research (Quirin and Reinhart, 2005) food production in Europe will be still in the foreground ahead energy production. According to the authors' (Henniges and Zeddies, 2005), own calculations for EU countries, domestically produced biofuels would not be viable without a subsidy of some kind unless oil prices were consistently higher than US$80 a barrel. Given that such prices are not imminent, the biofuel industry in Europe, as in the United States, is heavily dependent on continuing political support. The European Union has supported biofuel production primarily to promote sustainable farming, protect the countryside, create additional value added and employment in rural areas, reduce the cost of farm support policies, and diversify its energy supplies. Reducing emissions of greenhouse gases is only a secondary goal because the net energy efficiency of the biofuel crops grown in Europe is low. Thus the biofuel industry has much higher carbon abatement costs than do some other fields of energy use.

Partly as a result of negative publicity regarding biofuels, the European Union watered down its 2020 biofuels conversion goals while Germany began to remove tax credits that aided its domestic biodiesel industry. The biofuel tax increases, aimed at ultimately creating tax parity between biofuels and conventional fuels, rendered the domestic German biodiesel industry unable to compete with subsidized biodiesel from South American and the US. 27% of German capacity shut down altogether, while 36% ran at less than 50% of capacity. Meanwhile, the European Union flirted with doing away with a 10 percent biofuels target and 2008-2020 conversion schedule. The EU ultimately agreed to confirm the targets as a renewable energy conversion, but 30% of the target would be met by electric cars or trains, with the remainder to come from biofuels. The EU also said it would develop regulations by 2010 to limit the impact of indirect land-use change, while biofuels developed from non-food sources will receive preferred treatment under the agreement. The agreement will need to be ratified by the European Parliament and all 27 EU members.

Real meaning of bioenergy and reality of other sources

Actual results of bioenergy use are not much encouraging except direct burning of biomass. Bioenergy contribution is marginal in total energy balance. If we use half of all arable land for bioenergy production, it will cover only 5% of energy needs. Although some researches are in progress, there is no new kind of bioenergy on market such as BtL (Biomass-to-liquid) (FNR, 2006). There are prospect that mankind will have secure and cheap sources of energy such as nuclear fission and fusion (atomic power plant for the future) (Oljača S., 2006), (Potočnik, 2006).

Conclusions

The energy crisis on the world draws the attention to the energy sources which can be produced by the agriculture. The lasting energy deficiency can be replaced with the big mass of biomass gained mostly from the agriculture and forestry. The agriculture would be capable to cover 10 % of the country's energy needs from renewable energy sources on a middle term.

A new power generating section of the agriculture takes shape across Europe in the immediate future expectedly, that may contribute in a considerable measure to the reduction of the energy deficiency collaborating tightly with the energy producer's and the service provider's sections of the countries, while he secures new revenue source.

- Bioenergy contribution is marginal in total energy balance except direct burning of biomass.
- Economy of bioenergy production depends of subsidies in EU and without them only biomass combustion is cost effectively.
- Producer's dilemma what is better to produce: food or energy depends of income and household capacities.
- Ecological acceptability of bioenergy is not always positive.
- Ethnical questions (burning of grains) sometimes are significant but economy is in first plan.
- Plant use for energy in EU will not significantly decrease food production but it will increase food prices.

Comments

This paper is the parts of results of the project „Determination of Solid Biomass Potential from Agriculture in Hungary and Serbia" of the Hungarian Institute of Agricultural Engineering, Gödöllő, Faculty of Mechanical Engineering of Szent István University, Gödöllő and the Institute of Agricultural Engineering, Belgrade.

References

1. Anonymous. 1997: Energy for the future: Renewable sources of energy. White Paper for a Community Strategy and Action Plan. COM (97)599 final (26/11/1997).

2. Anonymous. 2010: Akcioni plan za biomasu 2010 – 2012. Ministarstvo rudarstva i energetike Republike Srbije, Vlada Republike Srbije. Beograd.

3. Bickert, C. 2006: Wie knapp wird Getreide? DLG Mitteilungen 4/2006: 74-77.

4. Bošković, D. 2006: Tekma za koruzo. Delo, sobotna priloga 19.10.06: 11.

5. Breitschuh, G., Reinhold, G., Vetter, A. 2005: Wirtschaftlichen Bedeutung der energetischen Nutzung nachwachsender Rohrstoffe für Landwirtschaft: Der Landwirt als Energiewirt – Potenziale für die Erzeugung. KTBL-Schrift 420: 19-36.

Dänzer, D. 2006: Vom Landwirt zum Energiewirt. Energietechnik, oktober 2006: 3.

6. FNR - Fachagentur Nachwachsende Rohrstoffe. 2006: BtL: Biokraftstoff der Zukunft. Landtechnik 4/2006: 206-207.

7. Guidi, D., Best, G. 2003: The clean development mechanism. Implications for energy and sustainable agriculture and rural development projects. FAO, Rome: 44pp.

8. Krajnc, N. 2003: Lesna biomasa in politika Evropske unije na področju izrabe obnovljivih virov energije. Gospodarjenje z odpadki, No. 46, p.p. 19-22. [COBISS.SI-ID 1105318]

9. Kopetz, H. 2005: Die energetische Nutzung der Biomasse als Beitrag zum Klimaschutz und zur Energieversorgung. KTBL-Schrift 420: 7-18.

10. Ilic, M., Grubor, B., Tesic, M. 2004. The State of Biomass Energy in Serbia. Thermal Science: Vol. 8, No. 2, pp. 5-19. Belgrade.

11. Hajdú J., Magó L. 2006: The Possibilities of Use of the Biomass in Hungary, Proceedings of the 34th International Symposium "Actual Tasks on Agricultural Engineering", Opatija, Croatia, 21-24. February 2006. Proc. 111-120.

12. Hajdú J., Magó L. 2008: Agricultural Biomass Potential in Hungary, Proceedings of 10th International Congress on Mechanization and Energy in Agriculture, Antalya, Turkey, 14-17 October 2008., p. 512-517.

13. Henniges O. Zeddies J. 2005: Economics of Bioethanol in the Asia-Pacific: Australia – Thailand – China, in F. O. Licht's World Ethanol and Biofuels Report, Vol. 3, No. 11. 45

14. Magó L., Topisirovic G., Oljaca S., Oljaca M. V. 2010: Solid Biomass Potential From Agriculture in Hungary and Serbia, Agricultural Engineering Scientific Journal, Belgrade-Zemun, Serbia, December 2009. Vol XXXV. No 4., p. 35-45.

15. Oljača, S. 2006, Čiste tehnologije i očuvanje životne sredine u poljoprivredi, Poljoprivredni kalendar 2007:323.

16. Quirin, M., Reinhart, G.A. 2005: Ökobilanzen von Bioenergieträgern – ein Überblick. KTBL Schrift 420: 37-45.

Potočnik, J. 2006: Zlitje prihodnosti. National Geographic, september 2006: 31-38.

17. Schenkel, R. 2006: Z dejstvi nad predsodke in strahove. Delo 20.7.06; 17.

18. Topisirović G., Oljača S., Oljača M. V., Magó L. 2011: Economical Background and Potential of Solid Biomass Production from Agriculture in Hungary and Serbia, Abstracts of the II. International Conference "Synergy in the Technical Development of Agriculture and Food Industry", Gödöllő, Hungary, 9-15. October 2011. p. 82.; Full Paper in CD Issue

19. Twidell, J., Weir, T. 2006: Renewable Energy Resources. Second edition. Taylor & Francis Group, London and New York.

20. Uffelmann, W., Graser, S. 2006: Was ist nachhaltiger? DLG Mitteilungen 10/2006: 10.

21. Zimmer, Y. 2006: Aufs richtige Pferd setzen. DLZ Agrarmagazin 8/2006: 142-144.

http://www.cid.csic.es/enof/whitebook.pdf