OPPORTUNITIES FOR THE ENERGY USAGE OF NON--ARBOREAL AGRICULTURAL BY-PRODUCTS IN HUNGARY

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The member states of the European Union favour the renewable energy sources. Biomass is one of them. For those countries which have large agricultural area or forests, biomass means an important renewable energy potential. Biomass can be main product or secondary product, too. If the country uses its agricultural products for the food or feed industry, only the by-products can be raw materials for the energy industry. The paper analyses the economic aspects of the energy usage of non-arboreal agricultural by-products in Hungary. The authors study the burning of by-product in different types of power and heating plants. The authors approach the problem in two different ways: from the aspect of the farmer and from the aspect of the energy plant to decide the viability of different types of green plants, which use only tillage (non-arboreal) by-products. This research contains useful information about the energetic usage of tillage by-products for those countries which have large agricultural areas like Hungary.

Keywords: power plants, heating plants, non-arboreal agricultural by-products, decentralised energy supply

Introduction

Energy becomes indispensable nowadays. The economic standard of the countries is strongly affected by their energy supply. The fossil energy sources are rare, so more and more renewable energy is needed to satisfy the human needs. The most used renewable energy source in the world is biomass. It gives the 30 – 35 % of the energy supply in the developing countries and 3 – 4 % in the developed countries (Demirbas, 2004; Zeng et al., 2007).

Due to the regulation of the European Union, all member states focus on green energy and also on biomass. Hungary favours the production of green power similarly to other countries in the European Union, based on the directive 2001/77/EK. The country guarantees a raised takeover price to the promotion of the proportion of produced electric energy from renewable resources, which is reached by the operating of the obligatory takeover system (KÁT). In the future from 2013, a new system (METÁR) will stand up in place of the KÁT which will focus not only on the green electric energy but the green heat energy as well.

Arboreal and non-arboreal biomass is suggested to differentiate if the biomass is burnt in an energy plant. Arboreal biomass is formed mostly by the wood chips and non-arboreal biomass can be made from energy grass for example. The differentiation of non-arboreal and arboreal biomass is expedient in point of firing techniques. This two different combustible types demand different boiler type and logistics, but the firing both of them is insurable at the present technological standard.

Besides the biomass, by-products are also produced. If the usage of the by-product is not possible in other industry field, the energy usage of this can be a real opportunity.

Biomass can be a determinative renewable energy source in those countries where the ratio of agricultural territories is high, for example in Hungary, Poland or Ukraine.

Hungary has excellent natural facilities in plant growing. A large amount of biomass is produced in Hungary every year. The biomass means the biggest energy potential for Hungary (Giber, 2006) and that is why the country should focus to this.

By-products are also produced with the biomass, so the analysis of their usage is needed. There are different studies about the possible amount of the agricultural by-products used for energetic usage in Hungary: Bai (2011) has calculated 7 – 8 million t yearly and Gyulai (2007) has written about maximum 10 million t of which 40 – 45% can be used.

The official statistics of the Hungarian Electric Company (MVM, 2009), has defined that 52% of Hungary's electric production come from fossil energy and 40% come from nuclear energy. The remaining 8% come from renewable energy sources of which 80% is biomass (MVM, 2009). We can state the conclusion that the usage of biomass is an important question in Hungary.

The opening of the carbon dioxide market brought an economically bad situation for the former coal heated power plants but the biomass burning could give a new chance for them in Hungary.

We analyse the energy usage of the non-arboreal agricultural by-products and define those energy plants which can burn the agricultural by-products from the economic aspect. We study the tillage by-products like the straw of the wheat, rape plant, corn and sunflower in the group of non-arboreal by-products. We analyse the opportunities of burning in global and local heat/electric power plants of these agricultural by-products.

Matherial and Methods

Four European power plant types are analysed in detail in the paper:

"A" A big green power plant which produces only electric energy to the global network. It can not sell the produced heat. It has 20 MW net power (which means 62.5 MW gross power if the efficiency is 32%).

"B" A big green power plant which sells electric energy for the global network. This power plant can sell the heat energy also so it is a combined power plant. It has 20 MW net power (which means 28.6 MW gross power if the efficiency is 70%).

"C" A typical municipal heating plant which can supply heat for a small settlement or some of its institutions. We represent it with a 2 MW net power (which means 2.5 MW gross power if the efficiency is 80%). It is important to highlight that the total efficiency of the district heating is around 50%. We count only with the furnace efficiency in our paper.

"D" A local power plant which can supply the local heat and electric energy demands. It is a combined power plant with 2 MW net power (it has 2.86 MW gross power if the efficiency is 70%.

"C" and "D" types of power plants produce energy locally for the so called smart grid while the power plants "A" and "B" produce energy for the global network. Two generally different power plant models are analysed in the paper. We suppose 8000 h working time yearly. The power plants work in summer also so they must find customer for the produced energy.

We presupposed that the power station is capable for buying up all of the agricultural by-products nearby, in the course of the minimum road transportation distances necessary to the power station's supply.

We do sensitivity analysis for the heating value, special output and harvesting area of the by-products. The heating value is highly dependent on the moisture content. We analyse the extremes of the air-dry stage (12 – 20% moisture content) in our paper. We get the specific outputs from the connected literature. We define the analysed values of the harvesting area with the AKI, 2011 statistics which are about the Hungarian statistic regions:

- Regional maximum: the detail of the statistics region of Hungary where the harvesting area of the given plant has the biggest rate.
- Average of the country: the average harvesting area of Hungary.
- Regional minimum: the detail of the statistics region of Hungary where the harvesting area of the given plant has the smallest rate.

The authors studied four non-arboreal agricultural by-products: wheat-, rape-, corn-, and sunflower straw. With the present technological standard the wheat straw and the rape straw can be reviewed from the non-arboreal agricultural by-products which can be harvested, while the harvesting of the corn stalk and the sunflower stalk suitable for power station firing is not solved currently in Hungary.

Economic calculations

We get the needed details for our economic calculations from Gockler (2011). The transportation, bale and bale loading costs are analysed at the non-arboreal by-products. The income is defined by the price which is paid for the by-product by the power plant.

We do sensitivity analysis at the costs and at the incomes. We analyse how the change of the total costs and the change of the price which is given by the power plant to the farmer can influence the needed transportation distance of the power plant which defines the interest of the farmer.

Results

The issue was studied from two different sides: the aspect of the energy plant and the aspect of farmer were compared in our paper. The minimum needed transportation distance for the heating / power plant was defined and compared with the calculated maximum economic distance of the farmer. We know that a green power plant can be supplied only by agricultural by-products if the condition of the Table 1 exists.

Table 1 The condition of the running of power plant on agricultural by-products only

Aspect of the power plant	Vondition	Aspect of the farmer
Minimum supply distance necessary for the safe working of the power plant in km	≥	maximum economic transportation distance of the farmer in km

Source: Pintér, 2012

Based on the Table 1, an energy plant can be safely supplied with by-porducts when the maximum economic transportation of the farmer is at least as big as the minimum supply distance necessary for the safe running of the power plant.

Consequently:

$$F \leq F'$$

where:

$$F = \sqrt[e]{(A / f / t / 1000 / v) \times 10\pi}$$

$$F' = \frac{H - fk}{sz}$$

after simplification:

$$\sqrt[e]{\frac{A}{f \times t \times z \times \pi}} \leq \frac{H - fk}{sz}$$

The markings are in the Table 2.

We summarise the logic of our research in the Table 2 where the 1 – 8 steps illustrate the side of the power plant and the 9 – 11 lines illustrate the side of the farmer.

We do sensitivity analysis to the values of "z" (which is dependent on the geographical place of the power plant), to the heating value and the specific output of the by-product and to the incomes and costs of the farmer so as to better suit to reality. The 4 – 6 steps and the 9 – 10 steps demonstrate this in the Table 2.

The power station operating with the agricultural by-product can be supplied by agricultural by-products economically, if the transportation distance necessary to the safe supply of the power station is equal in maximum possible way to the transportation distance which is just economical for the farmer.

The variables of the context: the calorific value, the average yield, harvest area on the power station side, and the expenses and incomes on the smallholder's side. We analysed the change of all of them with sensitivity examination.

We took the revenues, i.e. the price of the paid agricultural by-products by the power station into consideration as income in the course of the burning of the non-arboreal agricultural by-products. The transportation, the bale and bale loading expenses are incorporated in the expenses. It is obvious that the transportation expense is directly proportional to the distance, while the expense of the baling and the loading is independent to the transportation distance so it is constant pro ton.

We defined the maximum economic transportation distance ≈ 15 km on the producers' side based on our calculations. We compared this distance with the minimum transportation distances necessary to the supply of the different power station types, and we emphasized those situations with red colour when the stock demand of the power station can not be ensured from an economic viewpoint (Table 3).

We see from the details of the Table 3 that types "A" and "B" power plants (burning by only wheat and rape straw) cannot be economically supplied in Hungary. The minimum needed road transportation distance of 29 km would be worth for "B" type of power generation in the regional maximum (Western Transdanubia Statistic Regio) if either the given price from the by-products of the power plants increase with 10% "ceteris paribus" or the cost decrease 10% "ceteris paribus".

"D" and "C" local energy plants can be supplied only by wheat straw everywhere in the country if the specific output and the heating value are

Table 2 The logic of the research

Step	Mark	Defined value	Unit	Condition
Side of the energy plant				
1.	P_{gross}	gross energy product of the power plant	MW	$P_{gross} = P_{net} / \eta$
2.	P_{annual}	annual energy production	MWh	run 8 000 h/year
3.	E	needed input energy	GJ	1 MWh = 3.6 GJ
4.	A	needed total amount of the by-products	t	the heat value is known (*f*) in GJ/t
5.	C	needed tillage where only the given plant is grown	ha km^2	the specific output of the by-product is known (*t*) in t/ha
6.	T	needed supply area, which has "*z*" % tillage for the given plant	ha km^2	the "*z*" in % is known
7.	r	the radius of the supply area (air distance)	km	$T = r^2 \times \pi \rightarrow r = \sqrt{(T/\pi)}$
8.	F	the needed minimum road transport to supply the power plant	km	the (road distance)/(air distance) is known (*e*)
Side of the farmer				
9.	K	costs	Ft/t Ft/tkm	different cost types are known: dependent on the transportation distance (*sz*) in Ft/tkm and independent on it (*fk*) in Ft/t
10.	B	incomes	Ft/t	given price by the power plant is known in Ft/t
11.	*F'*	Maximum economictransportation distance for a power plant	km	costs and Incomes are known in Ft
The comparison and analyseS of the 8th and the 11th lines				

Source: the authors own processing

Table 3 The economic supply of the analysed power plant types with different kind of non-arboreal by-products

Name	Types of power plants minimum needed road transportation distance in km (plantation of the area in %)	Type „D" combined energy production in MW	Type „C" heat energy production in MW	Type „B" combined energy production in MW	Type „A" only electric energy production in MW
WHEAT straw	regional maximum (16% wheat)	7.1 – 15.7	6.6 – 14.7	22.4 – 49.7	33.1 – 73.5
	average in Hungary (11.78% wheat)	8.3 – 18.3	7.7 – 17.1	26.1 – 57.9	38.6 – 85.6
	regional minimum (7% wheat)	10.7 – 23.8	10.0 – 22.2	33.9 – 75.1	50.1 – 111.1
RAPE straw	regional maximum (5% rape)	13.5 – 20.7	12.7 – 19.4	42.8 – 65.4	63.3 – 96.7
	average in Hungary = (2.7% rape)	18.4 – 28.2	17.2 – 26.3	58.3 – 89.0	86.2 – 131.6
	regional minimum (1% rape)	30.3 – 46.3	28.3 – 43.3	95.8 – 146.3	141.6 – 216.3
WHEAT+ RAPE	regional maximum (16% wheat and 5% rape)	6.3 – 12.4	5.9 – 11.6	19.8 – 39.3	29.4 – 58.2
	average in Hungary = (11.43% wheat and 2.7% rape)	7.6 – 15.4	7.1 – 14.4	24.1 – 48.8	35.7 – 72.2
	regional minimum (7% wheat and 1% rape)	10.1 – 21.1	9.4 – 19.7	31.9 – 66.6	47.2 – 98.5

■ the transportation is not worth

Source: the authors own processing

over the average. "D" and "C" local energy plants using only rape straw can be viable only in the regional maximum, in the Western Transdanubia Statistic Region. If the local energy plants burn wheat and rape straw together, they can be viable in the Western Transdanubia Statistic Region at the interval of the examined heating value and specific output, while in other regions they can be viable only with bigger heating value and specific output than the average.

If the nutrient supply is analysed, the farmers will not transport their by-product from the tillage to the power / heating plants because the price of the needed nutrient is much higher than the incomes from the by-product burning.

Discussion

According to international and domestic publications it can be defined that the renewable energy sources and within them the biomass will receive even more roles in the future. The energy usage of agricultural renewable energy sources has numerous questions which need to be answered. Due to our research results we give the following statements:

Our studies have demonstrated that neither the "A" ($P_{net} = 20$ MW, this power plant can sell only electricity) nor the "B" ($P_{net} = 20$ MW, it can sell both electricity and heat) power plant types can be supplied only by non-arboreal agricultural by-products. The minimum needed supply area for both power generation types is higher than the maximum of the economic transportation distance of the farmer.

The results of the paper have partly confirmed that burning agricultural by-products can be a viable solution only in local heating plants and power plants in Hungary.

Local heating plants and power plants (type "C" and "D") can be supplied safely and economically by wheat straw everywhere in Hungary but by rape straw only in the regional maximum (in the statistic region of Western-Transdanubia).

Local heating plants and power plants (type "C" and "D") heated by only non-arboreal agricultural by-products can be safely and economically supplied by wheat and rape straw together everywhere in Hungary.

The agricultural by-products are not worth selling if the farmer counts with the nutrient management. In this case the farmer will sell neither the wheat straw nor the rape straw.

Conclusions

Biomass will play more and more important role in the member states of the European Union. Those countries whose agriculture is dominant should focus on the biomass. Not only should the main product be used but also the by-product. The tillage by-products are produced locally in the countryside, so local heating plants or power plants are necessary to burn the studied non-arboreal by-products. The paper shows the different interest of the farmer and the power plant, and focus on the importance of the power plant type. The local power plants can burn only non-arboreal agricultural by-products viably. The power of the plant is really important. There is a limit of the economy of scale, so the non-arboreal by-products are suggested to be used in local power plants.

Our study confirms the necessity of the local energy networks. If the energy is produced locally, less transportation will be necessary, so less CO_2 will be emitted. We have demonstrated that only a local plant can be viable in case of burning of non-agricultural by-products. These plants can give new working places in local regions. Because of the nutrient management, the farmers will sell only a part of their by-products and the rest will stay in the tillage.

Those countries, where agriculture has a big and important role should focus more on the usage of the agricultural by-products, because they are not waste, as they are suitable to be used.

References

AGRÁRGAZDASÁGI KUTATÓ INTÉZET – Research Institute of Agricultural Economics. 2011. Tájékoztató jelentés a nyári mezőgazdasági munkákról, AKI Statisztikai Osztály, Budapest, 2011. december, p. 5 – 17.

BAI, A. – TARSOLY, P. 2011. A hazai melléktermék-hasznosítás, Agrárium, A Magyar Agrárkamarák Lapja, 21. évf, 2011, no. 5, p. 46 – 47.

DEMIRBAS, A. 2004. Combustion characteristics of different biomass fuels, Progress in Energy and Combustion Science, vol. 30, 2004, no. 2, p. 218 – 228

DIRECTIVE 2001/77/EC of the European Parlament and of the council of 27 September 2001, on the promotion of electricity produced from renewable energy sources in the internal electricity market.

GIBER, J. (szerk.) 2006. Magyarország energiapolitikai tézisei 2006 – 2030, Magyar Villamos Művek Közleményei, 2006, no. 43, (különszám), p. 63

GOCKLER, L. 2010. Mezőgazdasági gépi munkák költsége 2011-ben, VM Mezőgazdasági Gépesítési Intézet, Gödöllő, 2010, p. 4, 10, 32.

GYULAI, I. 2007. A biomassza-dilemma, Magyar Természetvédők Szövetsége, Budapest, 2007, p. 35.

MAGYAR Villamosenergia-Rendszer. 2008. Évi statisztikai adatai (2009), MVM, Budapest, p.14.

PINTÉR, G. 2012. Opportunities of the energy usage of some agricultural by-products in Hungary, PhD dissertation, University of Pannonia, Keszthely, 2012, p. 54.

ZENG, X. – YITAI, M. – LIRONG, M. 2007. Utilization of straw in biomass, energy in China, Renewable and Sustainable Energy Reviews, vol. 11, 2007, no. 5, p. 976 – 987.

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