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BIOMASS POTENTIAL IN HUNGARY

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ABSTRACT

Nowadays the energetic utilization of biomass is important not only from environmental point of view but also due to its social, political and economic impact. Biomass is considered as a promising renewable energy resource in Hungary and Europe as well. The European Union is planning to increase the current 6 % of the renewable energy use up to 20% (in case of Hungary up to 13%) by 2020. Biomass has a leading role in the utilization of renewable energy (e. g. solar, wind, hydro and geothermal) resources. Its proportion is increasing (3.9% in 2007 and 6.7% in 2010) in the annual renewable energy consumption balance in Hungary. Biomass is mainly used in power stations for energy production in Hungary. In order to realize the national renewable energy objectives by 2020 the sustainable utilization of the biomass and its application should be increased and widened. In this study the Hungarian potential of solid, liquid and thermal bioenergy production is discussed.

KEYWORDS:
solid biofuel, liquid biofuel, thermal bioenergy sources

1. INTRODUCTION

The share of the renewable energy resources has considerably grown in recent years in the Hungarian total energy consumption, which was 1125, 1056 and 1085 PJ in 2007, 2009 and 2010 respectively [1], [2]. In Table 1 the values of electricity produced (GWh) from renewable energy resources are indicated including hydro-, wind power and bio-based energy produced for the period of 2000-2010.

In the period of 2000-2003 the share of hydropower was dominant (60% in average), and was gradually replaced by biomass (74% by 2006), presumably due to the propagation of the co-firing. From 2000 to 2010 the increase in electricity production from renewable resources increased significantly. Electricity generation based on wind power and biomass/biogas developed rapidly by 2010 (527 and 2488 GWh respectively) from very low figures in 2000 (0 and 10 GWh respectively). The growth in the contribution of electricity from hydropower was much lower (from 178 to 188 GWh). The contribution of electricity from renewable resources in the total electricity consumption accounted for 1.1% in 2003, and increased up to 4.6% by 2006. It means that Hungary fulfilled its obligation towards EU to reach 3.6% share for renewable electricity generation by 2010 [3].

TABLE 1 - Electricity produced (GWh) from renewable resources in Hungary [1].

Energy type	2000	2002	2003	2004	2005	2006	2007	2008	2009*	2010*
Hydropower	178.0	194.0	171.0	205.5	202.0	186.0	210.0	213.0	228.0	188.0
Wind power	0.0	1.2	3.6	5.6	10.1	43.5	110.0	205.0	331.0	527.0
Energy produced in incinerators	91.3	59.0	67.0	54.0	118.0	187.0	282.0	222.0	n/a**	n/a**
Biomass and biogas based energy	10.0	17.2	127.4	700.1	1610.0	1208.1	1426.0	1826.0	2452	2488
Total GWh / PJ:	279.3 /1.01	271.4 /0.98	369.0 /1.33	965.2 /3.48	1940.1 /6.98	1624.6 /5.85	2028.0 /7.30	2466.0 /8.878	3011 /10.84	3203.0 /1.524

* data published in [2];** n/a- data is not available

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TABLE 2 - The theoretical Hungarian potential of renewable energy, energy produced in 2009 and planned production for 2010 and 2020 [7].

Renewable Energy source	Theoretical potential of Hungary PJ/year	Produced in 2009 PJ/year	Planned for 2010 PJ/year	Planned for 2020 PJ/year
Solar energy:	**417,600**	**0.29:**	**4.50:**	**19.84:**
-Heat production		*0.26*	*4.00*	*15.00*
-Photovoltaic		*0.03*	*0.50*	*4.84*
Hydro power for electricity generation	**100**	**0.82** *(0.80*)*	**2.30** *(0.70*)*	**2.30**
Wind energy electricity and heat production	**36,000**	**0.86** *(1.20*)*	**15.50** *(1.90*)*	**12.10**
Geothermal energy:	**102,180,000**	**4.5:**	**29.15:**	**29.10:**
-Power station		*4.25*	*13.15*	*13.00*
-Thermal station		*0.25*	*10.00*	*10.00*
-Heat pumps		*0*	*6.00*	*6.10*
Biomass:		**54.96** *(77.7*) :*	**167.30** *(84.2*):*	**185.5:**
-Solid and fuel biomass for heat and electricity production	**420-500**	*52.0*	*150.00*	*158.00*
-Biogas		*1.20*	*13.00*	*23.20*
-Biomass from waste		*1.76*	*4.30*	*4.30*
Total:		**61.43**	**218.75**	**248.84**

* produced energy [2].

The rate of renewable energy production in 2009 shows different patterns according to different surveys [2, 4-6] varying from 5.7 % to 6.7% related to the total energy production. According to the statistical data published by the Hungarian Energy Center Information Office the share of the renewable energy resource and biomass in the total energy consumption reached 7.0% (84.2 PJ) in 2010 [2]. More than 80 % of the renewable energy is generated by four power plants in Hungary adapted for biomass firing (Pannon Power Holding, Bakony Power Plant, AES Borsod Power Plant and Vértes Power Plant). These plants generally produce electricity, heat for domestic/industrial use and steam mainly for industrial use.

In Hungary the most important renewable energy resource is the biomass, accounting for nearly 90% of all renewable energies [2-3,7]. Biomass is followed by geothermal energy, wind -, hydro- and solar power but these resources significantly fall behind the biomass utilization (Table 2).The Ministry of Agriculture and Rural Development made estimates on the Hungarian biomass potential (258.76 PJ) available and on the utilizable portion of the biomass in the middle run (7-15 years). These estimates focused on three areas: biofuels represents 45.5 PJ (from which bioethanol amounts to 36 PJ, biodiesel amounts to 9.5 PJ); solid biomass amounts to 188.26 PJ; biogas amounts to 25 PJ [3].

The annual biomass potential (203.2-328 PJ) from the Study Prepared by the Renewable Energy Sub-committee of the Hungarian Academy of Sciences defined four main categories: *wood mass* (56.5-63 PJ); *plant biomass and by-products, waste* (74-108 PJ); *secondary biomass* (18.7-23 PJ) such us liquid manure, wood-processing*; tertiary biomass* (54-134 PJ) such as food waste, sewage sludge [8].

The domestic biomass potential was evaluated as well and a forecast was prepared on the energy issues of agriculture and the available resources until 2030. The analysis estimated the total biomass stock of Hungary to be around 350-360 million tons, of which primary biomass of 105-110 million tons is annually reproduced and mostly utilized. According to the report 171-193 PJ can be produced from biomass on the supply side in 2020, representing 14-16% of the present energy use [3].

Energy crops can be classified into those providing: (a) solid fuels for direct combustion, thermal processing (to yield solid, liquid and gaseous fuels) and electricity generation; and (b) liquid fuels, notably bioethanol and biodiesel. Bioethanol is derived from the fermentation of sugar, starch or, potentially, cellulosic crops. Biodiesel refers commonly to transesterified vegetable oil derived from oilseed rape or sunflower. Solid fuel crops include energy coppice, miscanthus and whole-crop cereals.

The objective of this work is to give an overview on the available main biomass resources in Hungary such as wood, crops, straws, biogas and on the present and future utilization tendencies in order to fulfill the obligations of Hungary towards EU to reach a share of 13% for renewable energy resources by 2020 [9]. Statistical, research data from Hungarian governmental and non-governmental organizations were analyzed.

2 MATERIALS AND METHODS

This article is based on the overview of relevant information and data on renewable energy source prepared and published during the last decade by different sources, namely, Environment and Energy Information Agency Non-profit Limited Company in Hungary [3]; Hungarian Central Statistical Office [1]; Hungarian Academy of Sciences; Hungarian Energy Office [2]; Ministry of Environmental Protection and Water Management [6]; PYLON American-Hungarian Limited Liability Company of Constructions and Commerce [7].

3 RESULTS AND DISCUSSION

3.1 Utilization of solid biofuels

The establishment of short rotation energy plantations for fuel production has been of international interest for many years. Energy plantation experiments in Hungary have been conducted for a longer period of time. In Hungary the black locust is one of the most important stand-forming tree species, covering approximately 23% (or 410,000 ha) of the forested land and providing about 19% of the annual timber output of the country. This fast growing species (2-6 cm/day) seem to be the most suitable for energy plantations as well [10]. In addition to these willows, elm and mostly poplars have been also established to be appropriate for short rotation biomass plantations to produce a renewable raw material for energy and industry (Fig. 1.).

Based on a program of the Ministry of Agriculture and Rural Development it has been postulated that up to 300,000 ha are suited to short rotation biomass plantation. Biomass productivities of 12 to 24 dry t/ha/yr have been achieved in existing small scale trial plantations. On the basis of the evaluation of these trials, it has been found that the quantity of biomass mostly depends on site quality, species and cultivars, as well as on the initial spacing (plants per hectare) [10].

Straws are by no means free sources of fuel and the costs of delivery can be relatively high in Hungary. Generally straw in the field costs around 6-8 USD/t but by the time it is baled for on-farm use this has risen to 10-15 USD/t including transportation costs for industrial use. For farm-scale combustion system (up to 100 kW) straw at on-farm price can be competitive with gas.

The conversion of fast-growing biomass via gasification into hydrogen seems to be an attractive route for energy supply (in addition to direct heating or cogeneration), considering the restrictions conditions for limited CO_2 emission. The first economic calculation shows that biomass gasification is the most economical route for the production of non-fossil hydrogen. The basis for the calculations is the use of Miscanthus *(Miscanthus Sinensis or Giganteus)* as a fast growing biomass with a production rate of 30 t (minimal) dry straws per year and hectare (University of West Hungary, Sopron) [11].

Most of the biomass produced is consumed for energy purposes. Briquettes („bio-briquettes") are mainly utilized in the domestic sector, in central heating systems, as a substitute of wood logs. Nowadays the demand for bio-briquettes is increasing in Hungary. At the same time the biomass pellets find the most important energetic utilization in the industrial sector (bakeries, fine chemical industry, etc.). Presently, the use of biofuel products for the substitution of coal and wood in the domestic sector is on increase in Hungary.

3.2 The liquid biofuels

There are two main types of liquid biofuels, the biodiesel and bioethanol. The energy efficiency of the liquid energy-carriers is generally good, but the final energy input-output factor of the bio-ethanol production hardly exceeds the value of 1.0-1.2 [12]. As an example, the energy input of the oilseed rape production is about 200-250 kgoe/t (kilogram of oil equivalent), while the energy requirement of traditional bio-ethanol crops (e.g. maize or corn, wheat, Jerusalem artichoke and sugar beet) is about 285-300 kgoe/t. The final energy input-output factor of the oilseed rape production is 2.1-3.9, which can be increased to 4.5-9.0 by the energetic utilization of the by-products (e.g. rapeseed meal, straw) [13]. The primary input-output factor of bio-ethanol production can be increased to 1.8-2.1 with a careful choice of technological parameters and considering the biological utilization of byproducts the final energy input-output factor can be increased up to 2.3-2.5 as well. For comparison the input-output factor of "traditional" fuel like gasoline has a value of 1-4. At the same time the greatest environmental advantage of biofuels is that their use does not result in extra carbon dioxide emission because during the reproduction of the plant it is consumed [14].

a) b) c) d)

FIGURE 1 - Potential biomass plantations in Hungary: a-black locust (*Robinia pseudoacatia*), b-willow (*Salix alba*), c-elm (Ulmus pumilla), d-poplars *(Populus Cv. Sp*)

According to the Directive 2003/30/EC of the European Parliament and the European Council on the promotion of the use of biofuels or other renewable fuels the emission of greenhouse gases can be significantly reduced by using biofuels [15]. The Hungarian Governmental Decree 2058/2006 (III. 27.) has an aim to meet the target value for the use of biofuels for transportation as specified by Directive 2003/30/EC. The biofuels used for transportation marketed should reach a share of 5.75% by 2010 [16].

The Government also proposed that a national standard should be introduced regarding the E-85 fuel [3]. It is a mixture of 85% bioetanol and 15% of conventional gasoline [5,14]. To meet the above mentioned objective from 1st of July, 2007 only gasoline with at least 4.4% bioethanol content is allowed to be commercialized in Hungary. In addition to that from 2008 the Mol Hungarian Oil and Gas Share Company has been producing the “E” type gasoline and biodiesel with 4.7% biofuel content [14]. It should be noted that the fuel E-85 is cheaper by 25 % than the other commercialized gasolines [17]. The use of biofuels is promoted by the state through tax exemption, duty refund and tax differentiation policy [3].

The production of vegetable oil based bio-fuels can be profitable in West-European countries, if the farmers either receive the usual agro-production subvention/ subsidy for energy plant production, or the state waives taxes for commercial fuels for supporting agricultural sectors, or assures public support for the establishment of bio-fuel refineries.

The profitability of bio-ethanol production depends on the plant production and processing costs as well as on the fluctuation of the commercial fuel prices and weather conditions in the majority of West-European countries. The situation is getting worse with bad weather conditions leading to decrease in plant production and increase in the price of the raw plant.

Due to unusual wet weather in Europe experienced in 2010 a significant decrease by about 11% was observed in amount of the agricultural production in Hungary in comparison with 2009. The production of the main crops, cereals dropped by 8 % in 2010. Industrial plants, oil seeds (sunflower, rapeseed), covered a territory of 760,000 ha in 2010. This territory in 2010 was smaller by 16% than in 2009 and plant production decreased by 8% in comparison with value of average production for the last 5 years in Hungary. Sunflower production in 2010 was 987,000 t from the territory which was smaller by 6% than in 2009 [18]. Oilseed rape covered similar territory (259,000 ha), however, production decreased by 3 % comparing with the previous year. Growth has been recorded in the Hungarian production of sugar beet. This industrial plant was collected from a territory of 13,000 ha in amount of 754,000 t in 2010, which means 2 % of increase in comparison with the previous year. Crop prices decreased by 9.5 % in 2009 year followed by 17 % increase in 2010. For example price for the cereals and industrial plants increased to 33 and 11 %, respectively [18].

According to the research carried out by the Budapest Technical University, it further developments in the biological fundamentals and technological processes result in more effective species or technologies, or the international oil-prices reach the recent years’ level again, then the biomass based energy production can be profitable as well [19].

3.3 Thermal bioenergy sources

According to the year 2009 Environmental Report of Hungary the renewable energy resources in 2007 (59 PJ) were utilized mainly for heat energy production (64 %) and for electric energy generation (33 %) and only a small amount of the resources was used for biofuel production (3%) [1]. In the renewable Energy Strategy of Hungary for 2020 the heat energy production will continue to have the highest share 46.7% in the total use of renewable energy (186.7 PJ). For comparison the bio-based electric energy production and bio fuel production are set to be 42.75 and 10.5% respectively by 2020 [3].

The biogas is utilizable by-product of anaerobic treatment. This gas can be used to replace the traditional energy resources that are expensive and are non-renewable natural resources. The contemporary energy situation in Hungary indicates unambiguously that energy-saving steps are essential and that new non-traditional energy resources must be sought. One of these resources is the anaerobic fermentation of barnyard manure with the production of biogas. This method defines the biogas as a side product of the fermentation process. This is because no attempt has been made to achieve maximum production of biogas by the decomposition of organic matter (as for example in case of sewage treatment technology or manure treatment), but rather this biogas is considered to be a byproduct of the system designated to improve manure quality. However, the production and use of biogas is decisive in the economic efficiency of these units. For example the annual yearly production of biogas in case of an average farm with 500 cattles is 80,000 m^3 which corresponds annually to 1.1 GWh or to 0.004 PJ.

Environmental improvements can be expected on the basis of replacement of other types of fossil fuel. The utilization of liquid manure through methane fermentation has been developed within the framework of EUREKA program by IBMER – the Institute for Building, Mechanization and Electrification of Agriculture (Poland), BOIMET (Sweden) and Biotechnology Institute (Hungary).

Biogas, electricity and compost may be produced as a result of this technology.

4. CONCLUSIONS

Biomass can be considered as a strategic resource since it is not only renewable, but it is also available everywhere and can provide products of vital importance for economic sectors exhibiting strong external dependence (i.e. fuels for transportation, electricity, chemicals etc.). The utilization of the biomass is also important because it could result in benefits for the environment and for the socio-economic development, particularly in rural areas. Different types of biomass (solid, liquid, gas) offer the opportunity to develop integrated schemes from primary production through conversion to energy and industrial products [20].

Among the various alternative energy resources, the agricultural and forestry biomass should be considered as the most efficient and promising renewable energy resource for and from the rural sector. The biomass potential in Hungary is far enough to cover energy demand of the rural areas including the needs of the sustainable development of the national agriculture (e.g. recycling crop waste, livestock manure). There is a wide range of technologies for processing biomass, however, the technical-economical effectiveness of energy production and conversion technologies request further improvements. The infrastructure development is hindered by the unstable prices of the biomass market in Hungary. During the past several years there is a tendency for price increase of the biomass as raw material. European and national environmental regulations as well as implementation of different research and development programs supported by the government and EU provide a basis for positive change in the bioenergy related investments.

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