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GREEN ELECTRICITY FROM WOOD
BENEFITS AND LIMITS IN HUNGARY

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Abstract

Renewable resources provide approximately 3.6% of Hungary's energy consumption. Although 83% comes from the utilization of biomass its level of utilization is relatively low compared to the available amounts. The accessibility of renewable sources is considerably limited in Hungary. The greatest opportunity for the progress in Hungary lies in the utilization of biomass (firewood and fuelplant). 1MW electrical output needs 20 km^2 of a 100-year old forest (oa with continuous renewing afforestation. In this paper we observe whether that endangers the forestry of Hungary, which is only about 20% of the total area. We also dicuss the possibility to increase our 3.6% energy share in renewable energy based on forest. Minor plants based on woody chips and pellets with some MW output, might be well integrated into the rational lumbering. Large amounts of plant grown for energetic use can be realized in plant growing areas of the food industry that will be freed as a result of the EU accession.

Keywords: electricity from wood, renewable energy, biomass firing.

1. Introduction

1.1. Renewable Energy Policy and Consumption in the EU

The European Parliament and Council passed Directive 2001/77/EC on the 27th of September 2001 on the promotion of electricity produced by renewable energy sources in the internal electricity market. Directive 2001/77/EC lays down for the members of the European Union to increase the share of electricity production on renewable energy sources from the current EU average of 13.9% to a total of 22.1% by 2010. The objective of the directive is to encourage a higher contribution of renewable energy sources to energy production in the internal electricity market. The target is broken down to member countries for the next few years (*Fig.1*.), for example, 78% in Austria, 60% in Sweden, 29.4% in Spain, 12.5% in Germany and 5.7% in Luxembourg of the total electricity production is to be based on renewable energy sources. In Hungary, 0.7% of the current electricity is produced on renewable energy sources and this rate will have to reach 3.6% by 2010 [1].

Renewable energy sources means non-fossil energy sources (wind, solar, geothermic, wave, tidal, hydraulic and biomass energy as well as the energy of biogases produced at waste deposits and wastewater treatment plants).

Member state authorities may apply support systems of various levels to promote electricity producers directly or indirectly, such as green certificates, investment subsidies, tax exemption, tax allowance, tax reimbursement or direct price support. Investors' trust is to be kept by guaranteeing the adequate operation of systems [3].

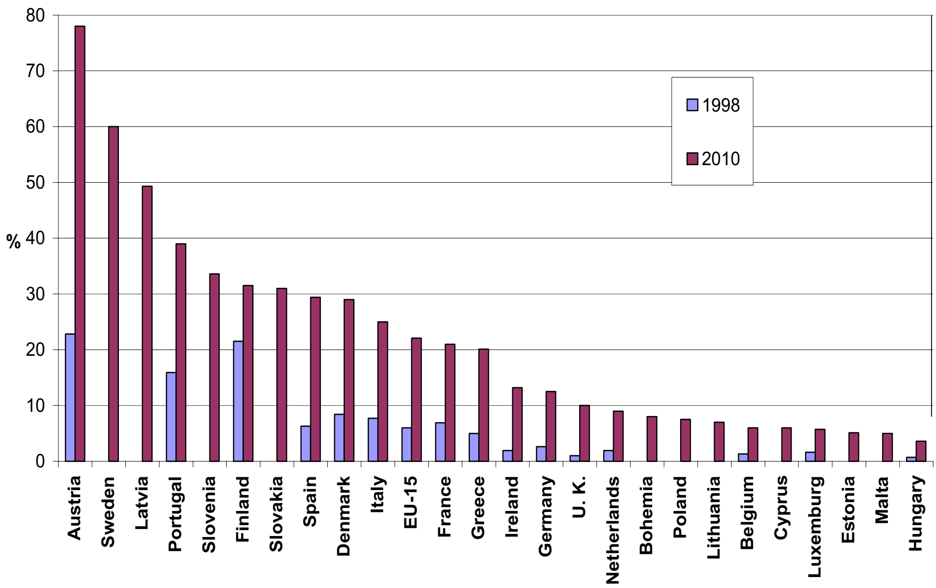

Fig. 1. The share of renewable energy sources in the electricity production in 1998 and in 2010, in the EU Country Profiles [2]

1.2. Renewable Energy Consumption in Hungary

As we joined the EU the required share of utilization of renewable energy sources has to be drastically increased. In the EU the share of renewable energy sources within the total energy production is to be increased from the current 6% to 12% by 2010. This share in Hungary is 3.6%, which the energy policy expects to double by 2010.

According to the realities in Hungary, due to the geographical situation (mainly Lowland in the Carpathian basin, cloudy in winter), the usage of wind, hydro and solar energy is limited. *Table 1* shows the share of electricity produced by renewable energy sources in Hungary.

Table 1. Electricity produced by renewable energy sources in 2003 [4]

	GWh	Rate of the total electricity production (%)
Hydro	161.00	0.48
Biogas	19.51	0.07
Wind	3.295	0.01
Biomass	82.591	0.25
Total from renewable sources	266.396	0.81
Total electricity production	33047 GWh	

According to the volume of produced GWh energy it seems that the efforts must be concentrated on biomass energy. Biomass produced in Hungary, as dominant factor of renewable energy sources, can be a foundation for the growth opportunity, although currently firewood has the greatest share.

Renewable resources provide approximately 3.6% of Hungary's energy consumption. Although 83% of that comes from the utilization of biomass (mainly wood), its level of utilization is relatively low compared to the available amount. (Community and industrial waste of 25–30 million tons per year, plant growing of 4–4.5 million tons per year and sylviculture of 3–4 million tons per year provides mass availability for biomass energy.) Biomass energy is currently utilized for direct heat production (e.g. district heating, heating of industrial establishments).

Naturally, woodworking plants in the country provide the majority of their own heat requirement from the accumulating waste during production, but the electric power production by wood gasification is not solved yet, although it would improve the efficiency of the system.

A favourable process was begun in this field (*Table 2*). A container boiler with a capacity of 2 MW was installed in Szigetvár in 2002 using wood chips for district heating. It uses 2.200.000 kg/year biomass and produces 23 TJ energy. The district heating system in Szentlőrinc is being converted from oil to biomass firing. In Mátészalka, Körmend and Szombathely the scope of district heating has been expanded with a small capacity boiler.

A part of the existing coal-fired power plant is converted to use wood in the AES Borsod Power Plant (Kazincbarcika). Currently, the experimental process has begun and sawdust is also being burnt. There has been a conversion to wood-based fuel at an experimental stage in the power plant in Pécs to produce 150 MW heat and 49 MW electric outputs. Since the conversion, it requires more than 300 million kg of wood-based biomass for operation. The Ajka power station of Bakony Power Plant Inc. produces electric power in a mixed wood waste and coal-fired hybrid fluid boiler.

The greatest opportunity for progress in Hungary lies in the utilization of

Table 2. The biomass demand of power and heating plants in Hungary, 2004–2005 [5]

	Biomass consumption		Allocation	
	Wood ∗1000kg/year	Waste[1] ∗1000kg/year	Capacity MW	Efficiency %
Power plants				
Pécs	360 000	–	49	33
Kazincbarcika	270 000	57 000	25	25
Oroszlány	40 000	–	n.d.	n.d.
Ajka	300 000	–	n.d.	n.d.
Mátra	–	547	n.d.	n.d.
Communal heating plants				
Szentendre	8 000	–	6	80
Tata	7 000	–	6	90
Szombathely	6 500	–	7.5	86
Mátészalka	7 000	–	5	n.d.
Körmend	7 000	–	5	n.d.
Szigetvár	2 200	–	2	n.d.
Industrial heating plants				
Lenti	–	6 000	4	80–90
Zichyújfalu	–	9 000	8	80–90
Gyöngyös	–	7 000	5	80–90
Papkeszi	10 000	–	5	n.d.

[1] e.g.: wastewater sludge, sawdust, cuttings, meat scrap

n.d.: no data

biomass within renewable energy sources, more precisely in the field of fuel plant cultivation. Large amounts of plant grown for energetic use (not food purposes) can be realized in plant growing areas of the food industry that will be freed as a result of the EU accession.

2. The Advantages of Biomass Firing

From an environmental aspect the appreciation of the different fuels is determined by the composition and the pollutant content of the untreated flue gases emitted during their combustion. Flue gas compounds and concentrations from different fuels are shown in *Table 3*.

2.1. Gaseous Pollutants

The energetic utilization of biomass can be characterized as *carbon dioxide* neutral because the amount of carbon dioxide produced upon combustion is equal to the amount the plant uses during photosynthesis. This way, biomass-based energy production provides a possible solution to reduce carbon dioxide emission causing greenhouse effect.

Because of the high sulphur content of the coal, the *sulphur dioxide* emission is very significant in case of coal firing. This quantity is about 25 times higher than in case of biomass firing (*Table 3*).

Table 3. Air pollutants guessed in the untreated flue gases of different fuels

Pollutant	Coal firing $(mg/m)^3$	Gas firing $(mg/m)^3$	Biomass firing $(mg/m)^3$
SO_2	5500	35	200
NO_x	650	350	300
CO	150	100	250
Particulate	350	5	30

The amount of the generated NO_x in respect to wood and wood chips to be burnt is below the emission of the two other fuels (*Table 3*). The explanation lies in the calorific value of biomass, which is relatively low compared to the others. The low calorific value causes lower flame temperature in which less thermal NOx is expected to occur.

Regarding the dust content of the flue gas, in case of biomass firing the amount of the occurring dust is low (less than 10% of the coal firing amount).

2.2. Solid Pollutants

The great advantage of biomass firing is that less solid waste occurs. This amount is less than 10% of the dust of coal firing.

There are two main types of solid wastes occurring during biomass combustion, *wood-ash* remains in the container boiler, while *filter ash* comes from the solid content of the flue gas. The electrostatic dust separator keeps the particulate matter content of the flue gases below the permitted limit.

On average 0–10% of the whole ash quantity is discharged from the boiler installation and 90–100% from the electric filter.

According to regulation No. 16/2001 (VII.18.) of the Ministry of Environment on the list of waste, wood-ash (of untreated wood) is not considered as hazardous waste.

At present wood-ash is well used as amelioration material, due to its high K, Na and P content. However, it gives pH 12 in water matrix, what highly alkalifies the soil, limiting its large scale use in agriculture.

The solid waste which comes from the electric filter can be recycled as raw material for cement works.

3. The Limits of Biomass Firing

3.1. Gaseous Emission

It is important to note – though less *sulphur dioxide* is formed in case of biomass firing, than in case of coal firing – that the biomass is not sulphur-free, therefore sulphur dioxide is present in the flue gases in a much higher quantity than in case of gas firing (*Table 3*).

As the calorific value of the wood is relatively low compared to the others, combustion takes place at a low temperature that promotes the formation of *nitrous oxides* increasing the greenhouse effect [6].

The explanation of the high *CO* content of the flue gas of biomass firing is that during the pyrolysis period the wood gasifies very quickly and this can generate – depending on the mixing degree of the blown air – oxygen deficient areas where CO formation is preferred. Besides, the low combustion temperature of the wood is also a contributing factor in CO production.

Since wood contains chlorides and has a relatively low calorific value, *dioxins* appear in certain quantity during the biomass combustion. In the flue gas of the biomass firing an average 0.019–0.214 ng/Nm^3 dioxin occurs [7, 8, 9]. Though, they appear in small quantity, it only needs a few ng/Nm^3 to have a carcinogenic affect and cause endocrine disruption.

Dioxins are members of the deadly dozen air pollutants, however, at present only the combustion of materials of anthropogenic origin (domestic waste, hazardous waste) has dioxin limit, while materials of natural origin do not. This does not mean that the flue gas of biomass burning is dioxin-free.

3.2. The Feedstock Demand

In 2000 a 50 MW electric power plant based on firewood chips has been put into operation, requiring 50 000 kg/h wood to operate. Does this endanger the forestry of Hungary, which covers only about 20% of the total area?

Optimists say that the annual growth accommodates forest demand of the power plants. The forest stock of Hungary was 12% of the total area in 1945. As a result of forestation work recognized worldwide, 19.4% (18 000 km^2) of the country is recently covered by wood. This rate is relatively low compared to other European countries, but it should be noted, that since 1925 the growth is continuous.

The amount of wood, which is generated in half an hour can cover 150 families' district heating demand. The annual product is 12 million m^3, of which 9 million m^3 can be harvested annually. Whereas, until now – according to the demand – the forestry could sell only 7 million m^3 wood meaning that 2 million m^3 wood has not been harvested. Therefore, rational land use and landscape rehabilitation allow for further harvesting [10].

Calculations similar to the one mentioned above may be misleading, because a discrete forestland is used for combustion, not the annual growth. According to pessimistic calculations, 5% of Hungary's forest stock is needed to ensure the continuous operation of a power plant of 50 MW capacity (*Table 4*). There are two possible ways to cover the feedstock demand of a power plant based on wood. One is to burn natural forests, while the other is to use special wood, grown only for economic purposes. The first column shows the size of the forest area, which covers the annual feedstock demand of the 50 MW plant. However, continuous operation can only be achieved by continuous re-plantation of these forests. For this reason we made calculations to estimate the total cultivated area, where the plantation and the wood harvest is continuous.

Table 4. Feedstock and forestland area demand to supply a 50 MW electric power plant based on wood

	Area (km^2/year)	Cycle time (year)	Total cultivated area (km^2)	Share of Hungary's forest stock (%)	Share of Hungary's total area (%)
Energy forest	~ 350	$\sim 5-6$	$\sim 1800-2100$	–	$\sim 2-2.5$
Natural forest	~ 10	$\sim 100-120$	$\sim 1000-1200$	$\sim 5-6$	$\sim 1-1.5$

Calculations are based on the followings:

- a 50 MW plant needs 50 000 kg/h biomass and continuous operation has been assumed in whole year,
- wood harvest production (energy forest): 1.200.000 kg/km^2year (source: MECSEK FORESTRY Co. Ltd. (Mefa))
- wood harvest production (natural forest): 46.000.000 kg/km^2year (source: MECSEK FORESTRY Co. Ltd. (Mefa))

(The MECSEK FORESTRY Co. Ltd. is a significant unit of Hungarian forestries. The company's responsibilities include the management of state-owned forests in Baranya County located on the plain of the river Dráva and in the Mecsek Hills. The forestry is conscientious in managing the stands of silver linden-trees associated with beeches in the Zselic region, the stock of peduncular oaks in the Ormánság region and the beech forests of the Mecsek Hills.)

It is apparent from the table that though the fuel plant's cycle time is much shorter than that of the natural forest, since its harvestable amount in a km^2 is lower, it needs twice as big share of Hungary's forest stock.

Suggesting that a 50 MW plant needs about 1100 km^2 forestland, it takes 5.5% of Hungary's forestry to cover its feedstock demand. Because of the delivery costs it is mainly the surrounding woody region which is taken into consideration. In this approach to ensure the continuous operation of the 50 MW power plant even the whole area of the surrounding forestry would not be sufficient.

Short rotation forest seems to be the most economical possibility for use of output from the agricultural production. The energy yield depends on the kind of trees and the situation and quality of the land. The short rotation energy plantation (e.g.: wattle, aspen) can be economic only in large scale. [11]

3.3. Renewable Energy for the Future

Could we increase our 3.6% energy share in renewable energy based on forest? Calculation of the feedstock and forestland area demand to supply a 50 MW electric power plant (Chapter 3.2) shows that 1 MW electrical output needs about 20 km^2 of a 100-year old forest (oak, beech) with continuous renewing afforestation.

In case of 500 MW – which is about 10% of the total electrical output of Hungary – it would require 55% of the Hungarian forestland (*Table* 5).

Table 5. Raw material demand of a 500 MW plant

	Area (km^2/year)	Cycle time (year)	Total cultivated area (km^2)	Share of Hungary's forest stock (%)	Share of Hungary's total area (%)
Energy forest	~ 3500	$\sim 5-6$	$\sim 17000-20000$	–	$\sim 18-20$
Natural forest	~ 90	$\sim 100-120$	$\sim 9000-10500$	$\sim 50-55$	$\sim 9.5-10$

In case of fuel plant growing 1 MW output needs about 35 km^2 of a 5-year old fuel plant (e.g.: wattle, aspen) with continuous renewing afforestation and 500 MW electric output needs about 18 000 km^2, which takes about 20% of Hungary (93 000 km^2).

3.4. *The Forest is not only an Energy Source*

When making calculations on wood harvesting and determining the yields of the forests, it must be taken into consideration that the purpose of a forest does not only lie in its utilization for energetic purpose (*Fig. 2*). The permitted yields of harvesting are the functions of the purpose of a forest.

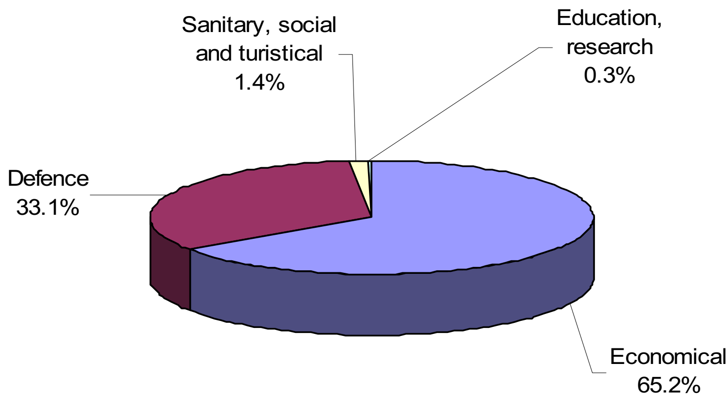

Fig. 2. The distribution of Hungary's forestry according to its use [5]

Nowadays, social demands for forests have grown and become manifold. In the course of this change, the social welfare, environmental and landscape protection requirements have become more pronounced in addition to the emphasized timber production function. In this situation, sylviculture is to meet a dual demand: on one hand, national economy requires quality timber; on the other hand, society needs forests.

Rational land use involves the allocation of the residues, which are not adequate for being utilized in the furniture industry. This part can be combusted for energetic purposes. According to its volume it can only cover the feedstock demand of minor plants with a few MW output.

It should also be noted that biomass firing does not exclusively mean firing by using pellet or wood as raw material, but communal and industrial waste and plant growing can also be used to obtain biomass energy.

4. Conclusions

In recent years there has been an increased awareness of environmental issues in the scientific community, among decision makers and in general public. Today a sustainable energy supply is of highest priority to most people on this planet. In Europe as well, the European Union, national governments, industry and energy and oil companies are actively developing renewable energy sources, technologies and infrastructure. Nevertheless, oil and fossil fuels dominate by far the world's supply of energy.

The advantage of biomass firing is that it results better pollutant composition, than coal firing with respect to the untreated flue gases regarding the amount of produced carbon dioxide, which is equal to the amount used through photosynthesis. A further advantage lies in the fact that less than 10% of the dust of coal firing is produced in the case of biomass firing. Though the control of the most important pollutants is solved (electrostatic precipitator, flue gas desulphurization), the emission limits of a flue gas with a favourable composition with regard to the quantity of the air pollutants can be met at a significantly lower price. It should be noted that the harvest of biomass is not pollution free either.

Unfortunately, according to the calculations wood-based electrical plants with high capacity might be a danger to the surrounding forestry. Because of the transportation costs it is mainly the surrounding woody region that is taken into consideration. Minor plants with some MW output based on woody chips and pellets might be well integrated into rational wood harvest. Large amounts of plant grown for energetic use can be realized in plant growing areas of the food industry that will be freed as a result of the EU accession.

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