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The Characteristics of the Biomass Sector in Poland and Hungary

Abstract

Biomass is a limited resource and should be used in a possibly optimal way. It is argued that for many countries in Europe, especially Hungary and Poland, the best use of the existing potential is to produce electricity and heat by small co-generation plants and/or to secure space heating for buildings in rural areas from the locally available biomass. Presently, a hot debate is taking place in Hungary and Poland about the use of biomass for power generation in existing coal power stations (co-firing biomass with coal). Many politicians and experts strongly oppose this way of meeting the environmental goals of reduction of CO2 emissions. The arguments are of technological, logistic and foremost of economic nature. In this contribution, many arguments against the use of biomass for only power generation is presented. The aim of this paper is to set two ways of bio-mass power generation against each other with analysing the biomass sectors of the two countries mentioned above.

Key words

Biomass; Cogeneration; Local use of biomass; Heat; Electricity

1. Introduction

One of the biggest—still unsolved—problems of the humanity is the issue of the global energy systems. The exhaustion of fossil fuels and the intensifying climate change put more and more pressure on them to place these systems on new bases. Furthermore, the energy systems of the Central European countries are based on imported fossil fuels; hence, they are questionable from an environmental point of view, as well as from an economic and social one. However, the utilisation of their renewable energy sources is only incipient and often unsustainable. The aim of this study is to analyse the most significant renewable energy sector (RES), which is the biomass, its operational problems in *Poland* and *Hungary*, and give suggestions for their solutions.

2. Situation of the renewable energy sectors of Poland & Hungary

Energy production from renewable energy sectors in Poland has been growing: from 4,321 ktoe (181 PJ) (7%) to 7,449 (312 PJ) ktoe (10.4%) in 2004 and 2011, respectively (EUROSTAT, 2014a). In 2012, renewable energy sources in Poland contributed 11% to gross final energy consumption was which constituted 8,478 ktoe (356 PJ) *(Figure 1)*.

This increasing trend is driven by the need to achieve the targets set by the *European Union*. It is seen, that solid biomass has the largest share (82%) of the chart in the gross final energy consumption in *Poland*, followed by biodiesels (7%), wind (5%), hydropower and biogas (2%).

Compared with *Poland*, the Hungarian RES has the same sharply growing share in energy production: in 2004, 950 ktoe (40 PJ) were produced by the RES (5.1% of the total gross final energy consumption), in 2011, 1,857 ktoe (78 PJ) (9.1 %), which is 95% of growth. The main background cause of this increase is also the compulsory EU target. In 2012, the above mentioned ratio was 9.6 % (1,965 ktoe, 82 PJ). As in *Poland*, the solid biomass has the largest contribution (70.5%), which is smaller than in Poland by 12%. However, the potentials of the

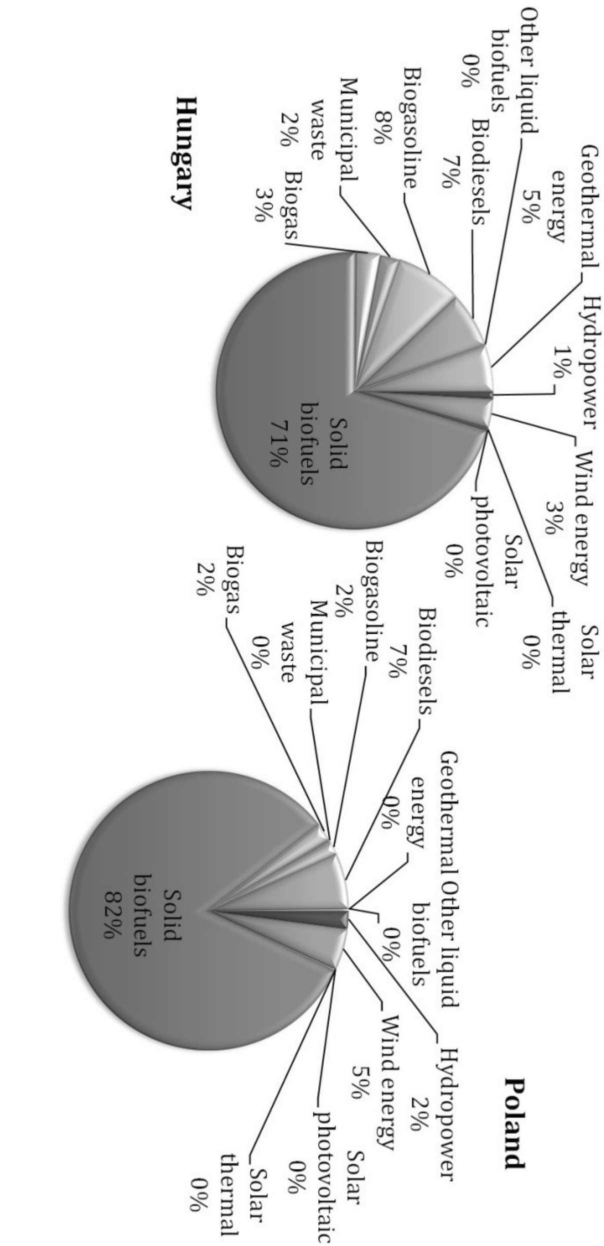

Figure 1 – The share of renewable energy sources (RES) of gross final energy consumption in Hungary (left) and in Poland (right)

Source: EUROSTAT (2014a); Edited by BOKOR, L. (2014)

other renewable sources could afford a more balanced energy mix (MUNKÁCSY, B. 2011). This amount is by 12% smaller than in *Poland*. On the other hand, in *Hungary*, the share is by 6% and 5% higher for biofuels and geothermal energy, respectively. The differences for other RES sectors between the two countries are below 2% (EUROSTAT, 2014a).

3. Potentials and forecast

Estimates of the potential of biomass vary depending on the assumptions concerning—for example—the acreage available for energy crops plantations, the permissible degree of extraction of wood from the forests, competition for straw for other uses, such as cattle bedding, mushroom production, etc. The technical potential of solid biomass in *Poland* is estimated at about 19–24 Mtoe/year (800–1000 PJ) (MINISTRY OF ENVIRONMENTAL PROTECTION, 2000; MINISTRY OF ECONOMY, 2007), although there are also lower estimates at the level of 2.4 Mtoe (100 PJ) (MINISTRY OF ENVIRONMENTAL PROTECTION 2000). On the other side, the *European Environment Agency* (hereinafter EEA) estimate (EUROPEAN ENVIRONMENTAL AGENCY, 2007) gives higher values: 14.5 Mtoe/y (608 PJ), 24.1 Mtoe/y (1,011 PJ) and 30.4 Mtoe/y (1,271 PJ) in 2010, 2020 and 2030, respectively.

The dominance of biomass in energy production is predicted to continue. According to the government document *Energy Policy of Poland until 2030* (MINISTRY OF ECONOMY, 2009) solid biomass will constitute the highest share in energy production (electricity and heat) from RES in the future, reaching 7.3 Mtoe/y (306 PJ) in 2030. Electricity generation by wind will follow with 1.5 Mtoe/y (63 PJ), and by biogas (electricity and heat) with 1.4 Mtoe/y (59 PJ).

The theoretical potential of solid biomass in *Hungary* is about 4.85–7.83 Mtoe/y (this estimate also includes the biogas potential, as calculated by the *Hungarian Academy of Science*) (IMRE L. – BOHOCZKY F. 2006). The technical potential is 3.96 Mtoe/y (also includes the biogas potential as calculated by the *Ministry of Environment and Water*) (FARAGÓ, T. – KERÉNYI, A. 2003). However, according to the analysis by the Hungarian *Eötvös Loránd University* research group, *Department of Environmental and Landscape Geography*, the technical potential is higher: 4.01 Mtoe/y (5.92 Mtoe/y if biogas is included) (HARMAT, Á. – MUNKÁCSY, B. 2011).

In the case of *Hungary*, the *EEA* estimates are lower than the national ones: 1.2 Mtoe/y, 2.2 Mtoe/y, and 3.1 Mtoe/y in 2010, 2020 and 2030, respectively (EUROPEAN ENVIRONMENTAL AGENCY, 2007).

According to the *Hungarian Renewable Energy Action Plan* (MINISTRY OF NATIONAL DEVELOPMENT, 2010), in 2020 solid biomass will contribute 0.23 Mtoe/y (9.63 PJ) and 1.225 Mtoe/y (51.29 PJ) for electricity and heat energy production, respectively. We can clearly observe that this target value is far below the estimated potentials, thus in long term a greater degree of utilisation is possible. In 2020, the planned renewable energy mix will be more balanced: the biomass will contribute 62% to power generation, heating–cooling and transport, followed by geothermal energy (17%), heat pumps (6%), wind and biogas (5–5%), solar energy (3%) and hydropower (1%).

4. Unsustainable use of biomass

The energy sectors of the two countries reflect their common history. In the socialist era, the self-sufficiency model appeared in the energy sector through the construction of the big coal-fired power stations that were established on local coal resources and dominated by delivering natural gas and refined crude oil from *Russia* (in those days from the *Soviet Union*). Both energy systems were centralised and characterised by large scale power stations. Nowadays, in both countries, the dominant part of the biomass-based electricity is still produced in those big power stations, by adding biomass to coal which decreases the overall efficiency of power generation and has a serious impact on the environmental, social and economic aspects. Moreover, those highly centralised systems generate energy hundreds of kilometres away from the consumers as opposed to the distributed power generation concept which will be discussed below.

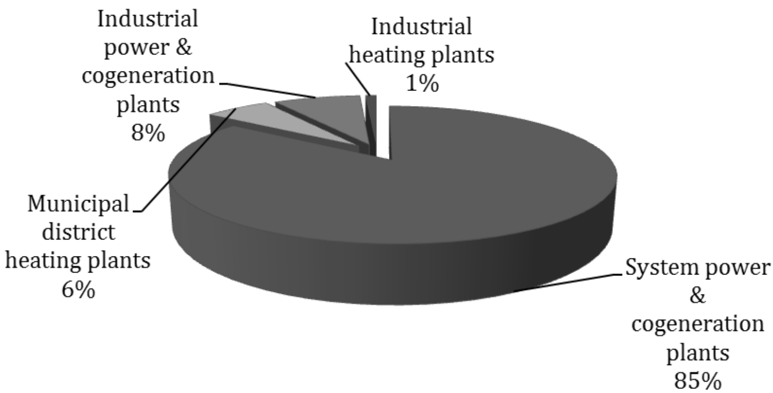

Figure 2 – Actual use of biomass for energy purposes in Poland

Source: GUS, 2013.

The chart in *Figure 2* illustrates the structure of the use of biomass for energy purposes in *Poland*. As it is seen, the lion's share constitutes power generation from biomass (93%) while heat plays a minor role. The dominant technology in biomass-based power generation is co-firing biomass with-coal in the existing pulverised coal boilers in the existing power stations. This policy and practice are increasingly criticised by environmental NGOs, experts and academics, both in *Poland* and *Hungary*, as well as in other European countries. This criticism is particularly strong in *Poland*, because of the scale of the investments in co-firing. One should mention, in particular, the spectacular Greenpeace demonstration during the COP19 in *Warsaw* in 2013 (GREENPEACE, 2013) and of *Greenpeace Poland* in *Turow Power Station* (GREENPEACE, 2012). The criticism is also expressed by the *Polish Biomass Association* POLBIOM, the members of which are experts in energy use of biomass. Furthermore, academics present strong arguments against biomass-based power generation and, in fact, against the use of biomass in installations requiring large deliveries of the biomass fuel. Serious reservations addressing this issue were expressed by industry representatives, in the presentations during the 2011, 2012 and 2013 editions of the *Forum of Biomass Combustion*, for example by representatives of *AGH University of Science and Technology* in *Krakow*, *Czestochowa University of Technology* or *Silesian University of Technology*.

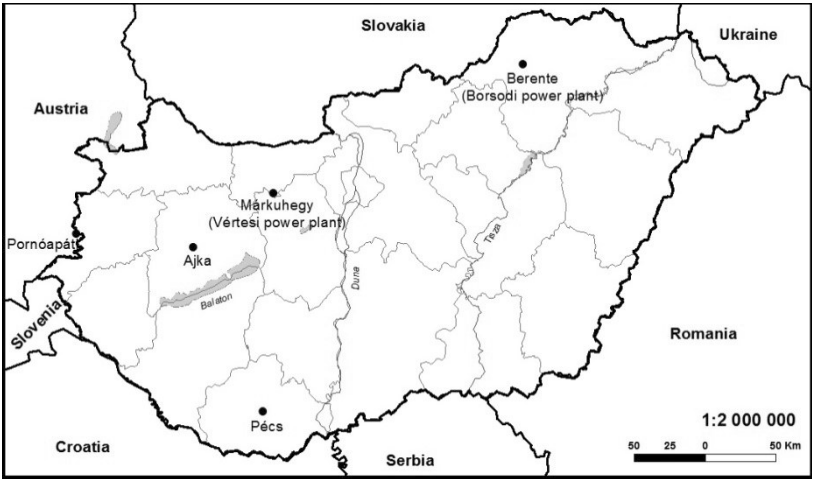

Figure 3 – Hungary and the places mentioned in this paper
Edited by HARMAT, Á. (2014)

The idea of using biomass to replace a fraction of coal in power generation sector is justified in terms of reducing emissions of carbon dioxide and sulphur dioxide to the atmosphere. The *European Union* directives put special emphasis on emissions from the power sector[6]. In *Poland* the main technology that has been chosen was adding bio-

[6] There are the same two directives in both (Polish and Hungarian) cases:
a) The Large Combustion Plant Directive 2001/80/EC (LCPD) is important in reducing emissions of SO_2, NOx and dust from combustion plants having a thermal input capacity equal to or greater than 50 MW.
b) Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity from renewable energy sources in the internal electricity market. The Member States which joined the EU in 2004 must apply the provisions of Directive 2001/77/EC on producing electricity from renewable energy sources. Their Accession Treaty sets national indicative targets for the proportion of electricity produced from RES (RES-E) in each new Member State the result of which is an overall objective of 21% for the EU–25.

mass to coal in the existing power plants, because it seemed to be the cheapest way to meet the targets imposed by the *European Union*. In *Hungary*, another reason was the stricter air quality standards. In 2004, three old coal-fired power plants (*Pécs*: 50 MW; *Borsodi:* 30 MW; *Ajka*: 20 MW *[Figure 3]*) should have been closed down because their air pollution would have been over the limit. Therefore, the power plants were converted to co-firing biomass with coal, instead of installing flue-gas cleaning system (Pappné, V. J. 2010).

From economic point of view the co-firing made sense, because building new installations from scratch could be avoided and the reporting effect could be achieved relatively quickly. This approach was stimulated by a system of the so-called green certificates (which is still in place), in which additional gratification is paid to "green" electricity producers in form of tradable certificates. For instance, in *Poland*, in this way for each MWh of "green" electricity the power generating companies received about three times more money than for the "traditional" (black, coal-based) MWh. On top of the price of a "black" MWh (ca. 35 EUR) they were rewarded by 70 EUR/MWh in form of green certificates. Incidentally, it should be noted that those costs are internalised in the electricity tariffs and are ultimately covered by the final electricity consumers.

There are three main problems in co-firing biomass with coal: 1. transportation of large volumes of biomass, 2. technological problems on the generation side and, last but not least, 3. cost of the "green" electricity.

4.1. Transportation of large volumes of biomass

Regarding transportation, one should note that, compared with coal, biomass is characterised by lower calorific value (about 50%) and lower bulk density (20–50%). Thus, the amount of energy contained in a given volume of biomass is only about 25% of the corresponding energy contained in the same volume of coal (Gula, A. *et al.* 2012). This obviously translates into the consumption of liquid fossil fuels and corresponding emissions, as well as other environmental and economic costs related to the life cycle of vehicles, attrition of roads, etc. This effect can obviously be minimised, if the biomass were used locally, i.e. possibly close to the place where it is produced. Moreover, the location of a coal power station is based on the easiest access to the fossil fuels. Therefore, its location is not suited to the biomass resources in its vicinity.

Decreasing the distance of biomass delivery to the location where it is used puts a limit on the output capacity of the energy production facility. This concerns, in particular, the use of biomass for electricity production, where the economics of power generation favours units of capacity of order of tens to hundreds of MW. Obviously, such units require large amounts of biomass which has to be transported from distant locations, such as from *America* or *South East Asia* (SLOWINSKI, P. 2011). On the other hand, according to the literature, the maximum economically justified transport distance with trucks is 15 km and 50 km for straw and wood, respectively (KPMG, 2010). In fact, current structure of biomass supply in *Poland* is: 70% domestic deliveries, 15% regional import (*Ukraine, Russia, Czech Republic, Slovakia*), 15% over sea import (WNUK, G. 2013). In *Hungary*, the international trade is also significant. As much as 7.9% of the produced firewood was exported in 2008, mainly to *Italy, Austria* and *Slovakia*, while 4% was imported from *Ukraine*, *Romania* and *Slovakia* (REGIONAL CENTRE FOR ENERGY POLICY RESEARCH, 2009).

One can conclude that, due to the energy consumption and emission during the biomass transportation, big capacity units are not the best solution from the environmental (and macroeconomical) point of view.

For illustration, let us consider an example of a hypothetical (still realistic) power plant of 400 MW located in *South East Poland*, which plans to add 5% of biomass for co-firing. This would require deliveries of ca. 500 tons of biomass per day. If one assumes that biomass comes from domestic sources located in the average radius of 100 km and considering, the kind of road in the area, this biomass would have to be transported by trucks of 10 tons load. Thus, in total, they would have to make 5,000 km each day, one way. It is perhaps shocking to realise that this is a distance from *Moscow* to *Lisbon*!

Meanwhile, as the exhausting of the fossil fuels, more co-firing power plants are converted exclusively to biomass firing. At the end of 2014, the last underground Hungarian coal mine, *Márkushegy* will close down. In parallel with the closure, the capacity of 240 MW-power-station will be supplied by biomass only. This expansion assumes the growth of the supply zone and the degradation of the forestry (ZÖLDTECH, 2013).

Transporting biomass from such distant sources is only one of the factors that bring dubious environmental benefits. The phytosanitary risk is another problem which recently attracts more and more attention (SMITH, A. L. *et al.* 2013). Namely, with the transported biomass there is a risk of transmitting plant diseases, pest species, fungi, bacteria, insects, etc., as well as seeds of invasive plants.

4.2. Technological problems on the generation side

Regarding the technological problems, adding biomass (especially agricultural biomass) to coal increases slagging and fouling due to the content of alkali compounds in biomass. Slagging and fouling hinder heat transfer in the smoke pipes and superheaters. Moreover, the flow of hot exhaust gases heating the upper parts of the superheater is also hindered by a layer of the fouling material fallen on the lower parts. Additionally, electricity consumption of the fans forcing the airflow increases due to higher aerodynamic resistance. When biomass is added to coal in pulverised coal boilers, the milling of biomass increases electricity consumption by 10–15% (SIWEK, T. – PANAS, K. 2011). Consequently, addition biomass to coal decreases the overall efficiency of power generation (SCIAZKO, M. *et al.* 2006), leading to decreasing the overall resource consumption. Moreover, the content of chlorine and sulphur in biomass increases corrosion of metal elements of the generation equipment, creating serious operational and maintenance problems (KROL, D. *et al.* 2010; SIWEK, T. – PANAS, K. 2011). Because the content of chlorine and sulphur in the agricultural biomass is higher compared with woody biomass (JENKINS, B. M. *et al.* 1998), corrosion of the boilers[7] and emissions of sulphur oxides are correspondingly higher. Furthermore, as practice shows, biomass creates fire hazards (also known in the case of coal) due to explosive properties of biomass dust or self-ignition of biomass stocks (BRADLEY, M. 2013). Only in *Poland* two biomass explosions occurred recently: *Dolna Odra* January 2010 (DRABINSKA, U. 2012), *Turow* August 2012 (PAP, 2012)—*Figure 4*.

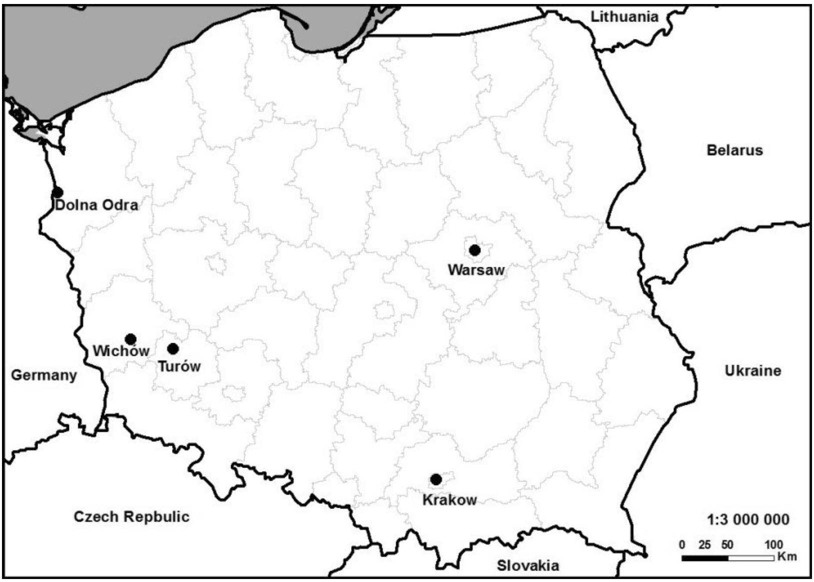

Figure 4 – Poland and the places mentioned in this paper
Edited by HARMAT, Á. (2014)

Another type of technological issue is efficiency of power generation in thermal power stations, where ~25–30% of the energy input is converted into electricity, while the remaining energy is released as

[7] This concern primarily the elements of the equipment exposed to high temperatures. In case of heat-only boilers where the temperatures are much lower the problem is much less significant and, as experience shows, it is not observed in practice. This is one of the reasons why we are advocating using biomass for heating purposes as discussed below in this article.

heat. It is a huge amount in a typical power station, and only a tithe fraction of it can be used as district heat, while the rest is usually emitted to the environment as an unutilised waste (FODOR, B. 2012).

4.3. Cost of the "green" electricity

To meet the assumed "green" electricity target *Poland* would have to produce 10 TWh/y of electricity from biomass (POLAND, 2005). Having in mind the aforementioned problems, one may wonder why power generation companies have invested so heavily in the co-firing technology. As mentioned above, this is due to the hefty support they have been receiving in form of green certificates. One should realise that the 70 EUR/MWh for the assumed 10 TWh/y amounts to 700 million EUR annually. In fact, the price of green certificates is changing depending on supply/demand situation in the certificates market. In 2011, according to information given at the Polish Parliament hearing (SZWED, D. 2012), energy companies received "only" 1.7 billion PLN (ca. 400 million EUR) due to aforementioned market variations. In 2012 (CZOPEK, P. 2013) the price of green certificates dropped to about 60 EUR/MWh and to 30 EUR/MWh in March 2013 (WNP, 2013). Actually, it is about 50 EUR/MWh. However, the Polish government plans (MINISTRY OF ECONOMY, 2014) to reduce the subsidies by introducing weight factors of 0.50 and 1.00 to co-firing and dedicated biomass power generation, respectively. In the authors' opinion this is a move in a good direction, because as shown in (GULA, A. – BARCIK A. 2009; GULA, A. 2011; GULA, A. – GORYL, W.– CIESLAK, J. 2012; GULA, A.– WAJSS, P. – GORYL, W. 2012) using the same amount of biomass for heating rural holdings would bring at least the same CO_2 reduction effect at much lower total subsidy cost (below 8% compared to biomass based power generation). In fact, the reduction would be much higher, because of avoided emissions in biomass transportation and processing.

Hungary uses the feed-in-tariff system for supporting RES. However, the result is the same, as it can be experienced in the case of the tradable green certificates system in *Poland*. Regarding the Hungarian feed-in-tariff system, there is almost no difference among feed-in-tariffs of the various renewable technologies, only the most competitive technologies could spread—the wind and the co-firing biomass. The technologies which have higher cost (modern biomass power plant, solar power plant) are not competitive with the present feed-in-tariff prices. Nevertheless, shortly the co-firing power plants will be removed from the supporting system, because their acceptance time—which determined by the *Hungarian Energy Office*, based on their payback time—will expire. This will lead to the reduction of the co-firing based power generation. A draft of the new supporting system was prepared in 2011 (called *METÁR*) which gives preference to smaller, decentralised biomass units. According to the draft, strict quality and spatial sustainability limits will be introduced for the supply of the wood fuel, and the maximum capacity will be restricted: in the case of biomass the limit is 10 MWe, and 20 MWe if the waste heat is used in district heating. The planned effective date of the new regulation has been postponed several times, and it is not likely that it will be introduced in the near future as taking into consideration the tendency of the Hungarian Government's nuclear power-supporting energy policy. As a result of this uncertainty, the investment in the RES has come to a stop (FODOR, B. 2012).

5. Towards a more sustainable use of biomass for energy

As one can see, the present energy utilisation of biomass is largely unsustainable. Considering the fact that a lion's share of the biomass is used in large scale power stations requiring deliveries from large distances, biomass should mostly be used for energy purposes in local scale units within decentralised energy systems, where electricity is generated by many small energy producers, close to where it is used, rather than at large power plants located far from the consumers. As mentioned above, in this way transmission losses and also the effects of possible outages of the power grid would be minimised. Additionally, under these conditions the energy production would be more efficient, since the waste heat could be used in a larger extent, due to proximity of the consumers.

Taking into consideration these facts, it is unquestionable that biomass—if to be used in a more sustainable way—should be used for energy purposes in local scale units within decentralised energy systems based on local biomass resources.

5.1. Benefits of decentralised energy systems

Compared to the centralised energy systems, the following advantages of decentralised systems can be mentioned:

- Environmental benefits: Through a more efficient energy utilisation, the demand for the firewood would decrease, contributing the conservation of biomass resources. This would lead indirectly to decrease of pollution and other environmental benefits, such as avoiding land degradation associated with coal mining, or the conservation of freshwater resources, since the large scale power stations require vast volumes of water for their operations.
- Economic benefits: In centralised energy systems there are expenses, which make them more expensive, compared with the decentralised systems: The cost of the high-voltage transmission and distribution networks is one of the major costs within the centralised electricity system. The centralised generation is inflexible with respect to sharp changes of energy demand. Hence, the output capacity must be oversised to counter this problem. Countries, where the RES has a significant role, the renewable energy systems are owned largely by communities. In that case, the community—who is the most appropriate decision-maker—is best suited to choose the most optimal and reasonable investment. Also, the resulting profit stays in the local place. In addition, in a case of a small biomass power plant, the entrepreneurs dealing with the production and supply of the firewood are able to join the energy market which leads to an indirect economic prosperity in a wide social scale.
- Security and supply benefits: In *Hungary*, according to the governmental statements, the rate of the energy dependence—the

net imports divided by the sum of gross inland energy consumption plus bunkers—was 52.3 % in 2012. However, energy production from the imported nuclear fuel in the statistics is qualified as inland production. Therefore, the real energy dependence is 62%. In this way, the energy supplies considerably depend on the energy policies of the foreign countries—mainly of *Russia* which is the main exporter of the natural gas, the petroleum and the nuclear fuel. The above argument applies also to Poland, although the corresponding number is only 30.7%, due to Poland's significant coal reserves (EUROSTAT, 2014b). In a decentralised energy system, the resources are available where they are used. Therefore, from the point of view of fuel supply it is a more secure system.

- Social benefits: Decentralisation contributes to the spatial convergence, since the cost of the energy production would be localised regionally more equally, thereby reducing the urban–rural development differences. In addition, the decision-making shifts down to the local scale, according to the subsidiarity principle which is one of the fundamental principles of the sustainable spatial development (GREENPEACE, 2005).

To achieve the realisation of the above mentioned benefits via building up a decentralised energy system, a fundamental change in the energy policy is needed. This should be supported by the government. Instead of this, the Hungarian government signed an inter-state agreement on co-operation with a Russian involvement in a new nuclear power station, with a 2400 MW built-in capacity. Nevertheless, at the local scale, with bottom-up initiatives we can move closer to a decentralised energy production. In the chapter below two good practice examples from *Poland* and from *Hungary* are presented.

5.2. Biomass heating boiler in a rural holding in Wichow, Poland

In many European regions, notably in *Poland*, there is a significant demand for space heating. This could be largely satisfied by biomass, primarily in rural areas, where biomass is locally available, in particular as agricultural residues. In *Poland* the main agricultural residue is straw which is often burnt uselessly in the fields. At the same time, it could become an environment friendly fuel for heating the rural holdings, if burnt in dedicated biomass boilers.

A concrete example is described and analysed below which is a small scale biomass installation for heating a typical rural house. The farm used for the case study is located in the village of *Wichow* in *Western Poland*. The village is a good representative of rural *Poland*. It is situated in flat agricultural area with dominant cereal production, so that straw is amply available. The area of the considered farm is 8 hectares used mostly for wheat production. On average about 10–15 tons of straw is harvested annually.

The building in question is a one storey, detached house of 200 m^2 inhabited by 4 residents. The building is relatively well insulated with modern double-glazed windows. Until 2010, the house was heated using a coal boiler, which in October 2010 was replaced by a dedicated straw fired boiler of 40 kW (EKOPAL RM 5) produced by *MetalERG Ltd*., a Polish private company. As straw burns quickly the heat is accumulated in a water tank of 5 m^3 and fed to the heaters by a controlled circulation pump. The cost of investment was ca. 5,000 EUR. The boiler is designed to match the needs of the farmers who harvest the straw in form of standard compressed cubical (80x40x40 cm) bales. It is suitable for farmers having their own straw in sufficient quantities and storing it after harvest in or near the house. The operating costs are then several times lower compared to coal and the payback time is about 4 years.

The only fuel which is used in the boiler in this farm is wheat straw which is harvested from the fields within the radius of about 1.5 km around the house. The bales are stored in a barn located next to the house. Therefore, the cost of the biomass fuel is practically free for the farmer.

Below, three different energy supply options in this farm are considered: (i) coal boiler for heating (heating season) plus electric water heater (whole year), (ii) biomass boiler (heating season) plus electric water heater (whole year), (iii) biomass boiler (whole year) for heating and domestic hot water preparation. The first option was in place until 2010, the second was until 2013 and the third is the present situation.

The output capacity of the previous coal boiler was 22 kW with 82% efficiency. The fuel was culm and hard coal. The boiler consumed ca. 6 tons of coal every year. Domestic hot water was provided by a 2 kW electric 50 litres water heater. In 2013, the electric water heater was replaced by a well-insulated 120 litres accumulation tank connected in parallel to the existing 5 m^3 tank of the biomass boiler system.

Our analysis showed that using coal (Option 1) is much more expensive (1,480 EUR/y) compared to the use of the biomass Options 2 and 3 (320 EUR/y and 80 EUR/y, respectively). The cost of provision of domestic hot water in Option 3 is so low, because now electricity is not used for DHW preparation. The payback time for Option 2 is 4.3 years. For Option 3, additional 250 EUR must be spent to cover the cost of the 120 litres heat exchanger and circulation pump. The corresponding payback time becomes 3.75 years.

As it can be seen above, conversion from coal to biomass in a farm with own straw resource can dramatically reduce the CO_2 emissions in a very cost effective way. Emissions from different options are presented in *Figure 5*. The CO_2 emissions in Option 1, 2 and 3 are 12,850 kg/y, 2,100 kg/y and 430 kg/y, respectively which means reduction by a factor of 6 and 30 for Options 2 and 3, correspondingly.

It should also be noted that biomass contains much less sulphur than coal. Thus, in the emissions of SO_2 are 69 kg/y, 16 kg/y and 14 kg/y, respectively. Also, less NO_2 is emitted to the atmosphere (Option 1: 20 kg/y, Option 2: 12 kg/y, Option 3: 11 kg/y). The situation is different in the case of CO (273 kg/y, 92 kg/y and 99 kg/y, correspondingly), where the lowest emission is for Option 2. This is due to the fact that in Option 3 straw is burnt also in summer leading to a small increase of CO emissions from the biomass boiler.

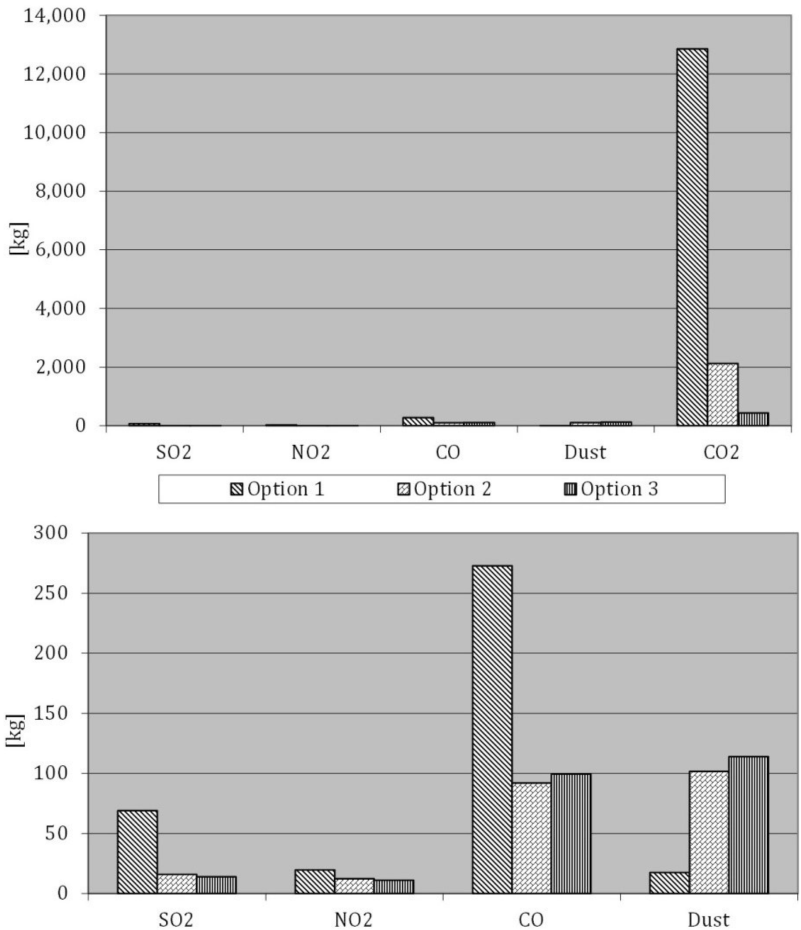

Figure 5 – Emissions from different options (bottom – rescaled, without CO_2)

Edited by GORYL, W. – HARMAT, Á (2014)

It should be noted that biomass combustion leads to relatively high dust emissions. In Option 1 (18 kg/y) dust emission is 6.5 times lower than in Option 3 (114 kg/y). It is necessary to use filters or dust precipitators to meet the standards. However, in sparsely populated rural areas the concentration of dust does not present a big problem, due to sufficient ventilation of the terrain. Recently, the *AGH University of Science and Technology* in *Krakow*, *MetalERG* (biomass boiler manufacture) and *DBFZ Deutsches Biomasseforschungszentrum gemeinnützige Gmb*H (from *Germany*) received a *KIC InnoEnergy Programme* grant to design and build a new straw feeding, filtering and drying system. Such system should significantly reduce the dust emissions to the atmosphere, which is also considered in the analysed holding.

In conclusion, a typical Polish farm of ca. 6–10 hectares, can satisfy its heating needs by using biomass supplies from an area of a small radius (about 2–5 km), so that the "embedded" transportation emissions are much smaller than is the case for large units such as power stations. Additionally, energy needed for densification of biomass to lower the transportation costs, are avoided. Therefore, such installations should be favoured when granting investment subsidies. It is very important to note that in the exploitation phase no subsidies are needed, because local (often own) biomass fuel is cheaper than coal, oil or gas.

However, in the Polish conditions a 5,000 EUR investment is very expensive for a typical farmer. To boost the demand for small biomass boilers financial support for farmers is needed. As mentioned above, this could be taken from the subsidies being given to co-firing by diverting only a small fraction (up to 8%) of those to cover a part of (ca. 40%) of the investment cost of conversion from coal to biomass (GULA, A. – WAJSS, P. – GORYL, W. 2012).

5.3. Biomass based village heating in Pornóapáti, Hungary

The local government of the municipality of *Pornóapáti (Figure 3)*—a Hungarian village next to the Austrian border—came to a decision concerning the heat supply system of the village at the beginning of the

2000s. Considering the good practise of the biomass heat plant of the neighbouring Austrian village, *Bildein*; the village (with 380 inhabitants) chose to build a 1.2 MW biomass heat plant instead of building up a natural gas network.

The total cost of the construction was 1,661 million EUR (~1,325 million GBP) (including the price of the pipeline system). The project was supported by the *Hungary–Austria Phare CBC Programme*, by the *Austrian Environmental Fund*, by the *West Transdanubian Regional Development Agency* and by the *Ministry of Interior Affairs*. A wide collaboration of international organisations was required for the project and, furthermore, the understanding and willingness of the village citizens were also necessary. The operation of the heat plant started in 2005.

The annual heat demand is entirely covered by the 2 biomass boiler with nominal capacity of 2*600 kW. 32.5 m^3 water is circulated per hour in the pipeline system which length is 3,900 running metres. The produced useful heat in the past years was between 4,100–4,800 GJ/heating season, the energy efficiency of the whole system (multiplying the efficiency of the boiler, and the efficiency of the heat transfer) is 50–52% (NÉMETH, K. 2011).

At the beginning, 86 residential and 11 public consumers connected to the heat pipeline. However, at this time the number of consumers is 67, and only 40 consumers used the district heating constantly during the last heating season. To detect the background of the reduction interviews were made in the village. According to the interviewees, there are two main reasons of the disconnections. On the one hand, the level of the heating service was exceptionable. The lack of the repairs in case of malfunctions and the outages during heating seasons were frequently experienced issues. In the absence of the relevant experience, during the construction sizing failures were made by the building contractor. On the other hand, the most frequently mentioned problem was the price of the heating service. Generally, the inhabitants who work and have fixed income use the district heating, but the pensioners and the unemployment inhabitants prefer to provide their own firewood, and use their individual heating. The new mayor of the village hopes that this negative process will stop since the operating company have been changed, and the inhabitants do not have the opportunity to collect logging waste in the area of the local forestry at a low price any more. Also, around 20 kW of solar panels have been installed on the roof of the heating plant which will reduce the operating costs.

The biomass consumption is between 380 and 420 tons per heating season. Three/four companies supply the heating plant with woodchips from the nearby forestry and with by-products from the building industry. The nearness of the Austrian border makes the purchase more difficult as in the other part of the border the price of the woodchips is double that of the Hungarian price. Therefore—considering the financial status of the municipality—the woodchips are generally purchased only for the next few weeks, thus there is no time for them to get dry and reach the maximum heating value.

The most significant environmental effect of such a small-scale biomass heat system is that it can replace the low-efficient, high-emission individual heat systems to an environmentally well-regulated central system. Thanks to the biomass heating plant, the annual CO_2 emission decreased by 1,168 tonnes and the heat demand of the village can mostly be supplied with local sources. According to the calculation of NÉMETH, K. (2011), if the natural gas network had been built up, the cost of the heating between 2006 and 2009 would have been 24,500 EUR – 29,500 EUR more. However, its economic benefit is overshadowed by the fact that more and more consumers disconnect from the heat network and change to individual heating because of its expensiveness. During the period under review, around 17,500 EUR stayed in the local area annually, contributing to the local economic development.

Pornóapáti is the first smaller municipality in *Hungary* which decided to create a new village heating system based on biomass. This project contributes to the environmental protection, the local economic development, and also improves the community's social thinking and their sense of common responsibility for the environmental values. Therefore, it is a good example for other small municipalities. However, considering that the available funds for this kind of project are limited and there are some known experienced operational difficulties, supporting the local use of renewable energy sources is inevitable by the state.

6. Conclusion

Due to the inappropriate support mechanism both in *Poland* and in *Hungary* biomass is used mostly in co-firing with coal in big-scale power stations in a centralised energy system which leads to huge technological problems (slugging, chlorine corrosion, fires, etc.) on top of costs and emissions of biomass transportation at large distances as well as huge amounts of heat which remains unused in thermal power plants. Since the energy density of biomass is low, its energy utilisation is transport intensive. Therefore, utilisation of biomass is most efficient if used locally, in small scale units, in frame of a decentralised energy system. Although both countries' energy policies do not support this kind of initiatives, we can make small steps against the big and powerful opponents. This was demonstrated by two examples described above. Such bottom-up projects illustrate the principle "think globally, act locally".

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