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# AGRICULTURAL BY-PRODUCT AS A RENEWABLE ENERGY SOURCE

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***ABSTRACT***

*The energy consumption of the world, and thus of Hungary, is growing rapidly, and to date fossil fuels have had a major role. During agricultural production those kinds of by-products are generated the utilization of which is not organised effectively enough. The basis of biogas generation comes from agricultural by-products which could not be utilized in other cases, so its positive impact on the environment is beyond dispute contrary to fossil fuels. Alternative energy efficiency requirements in rural areas, besides the effects, have both economic and social benefits. The study looks for the answer to the question how the by-products produced in Hungarian agriculture and the sustainable development of the countryside are produced.*
Keywords: agricultural by-product, energy, biogas, rural areas, sustainable development, biomass

## INTRODUCTION

Among today's global challenges, the growing importance of energy supply focuses on the potential role of the agricultural economy. According to a study by Nobel Prize-winning researcher R. E. Smalley, which ranked the 10 most important challenges for humanity, places energy supply first, followed by water supply and food supply. All these challenges are affected by the agricultural economy. Hungary's agricultural economy has significant potential, in line with global challenges, in addition to the production of adequate quantities and quality of raw materials for energy recovery. This can help to promote regional development and sustainability aspects (*Dinya*, 2009). Transition to renewable energy is an indispensable condition for the energy supply of today's economy, the preservation of the natural state, the retention and further increase of occupation (*Dupcsák and Marselek*, 2013).

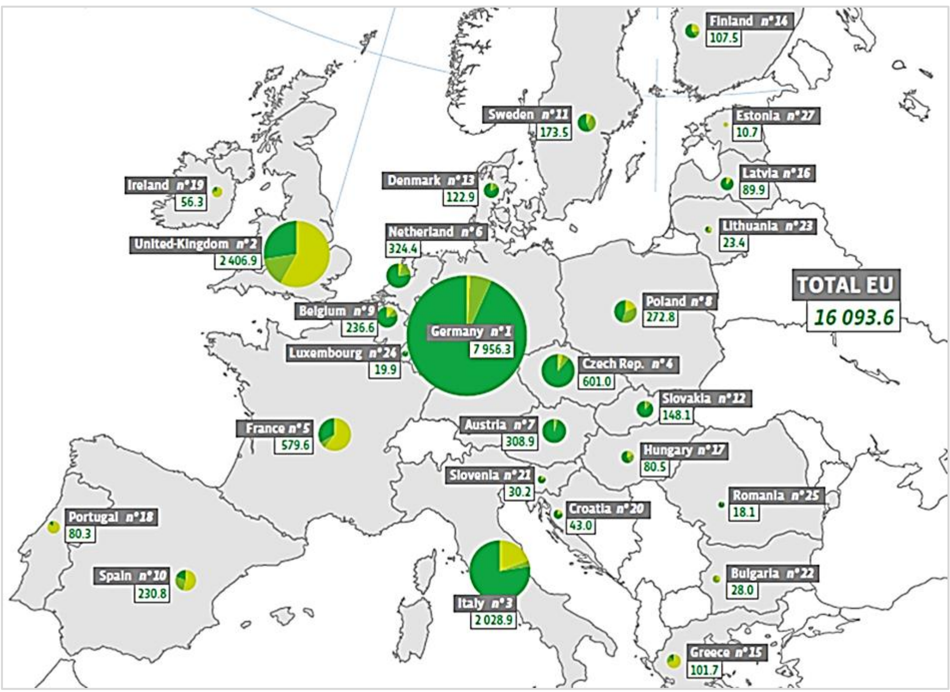
## LITERATURE REVIEW

In addition to the production of raw materials for the food industry, agriculture can also play a key role in the energy sector. For this purpose, the recovery of biofuels as fuel, the production of biomass and the fuels produced from it are excellent. Global warming caused by the greenhouse effect can be justified by the use of fossil fuels. In the case of renewable energy sources, this is irrelevant as the plant develops the same amount of $CO_2$ into its tissues during photosynthesis as it enters the atmosphere when it is burnt (*Fogarassy*, 2001). Biogas is a gaseous substance formed during anaerobic fermentation of organic materials, which is a good substitute for natural gas (*Bai*, 2013). It is produced by anaerobic fermentation of organic substances in a wet medium, called bio-methane development. The composition of biogas contains 60-70 percent methane ($CH_4$) and 30-40 percent carbon dioxide ($CO_2$). The advantage is that organic by-products from agricultural production are the basis of production. During the development of biogas, 50-60 percent of the organic matter can be decomposed, so the rest is solid or dilute compost, which can be utilized for nutrient replenishment in the production area (*Fogarassy*, 2001).

All Member States of the European Union have a biogas plant (*Figure 1*), but 75.8% of the total energy from this is from three countries: Germany, the United Kingdom and Italy (*EurObserv'ER*, 2017b). In Hungary, only 16 percent of biogas production per capita is the EU average. The number of biogas plants in the European Union renewable energy sector is developing the most dynamically (*Bai*, 2013). In the European Union, biogas plants, especially in Germany, have comparative advantages over domestic plants. The German state provides significant support for investments and regulates the takeover prices in a complex manner, and compliance with the regulations for the management and storage of waste is extremely costly, thus shifting their utilization towards biogas plants (*Bai ed.*, 2005). If we examine the spatial location of biomass plants, we can see that their distribution is more even than in the case of biogas plants.

**Figure 1.**

**Biogas production in the European Union at the end of 2016**

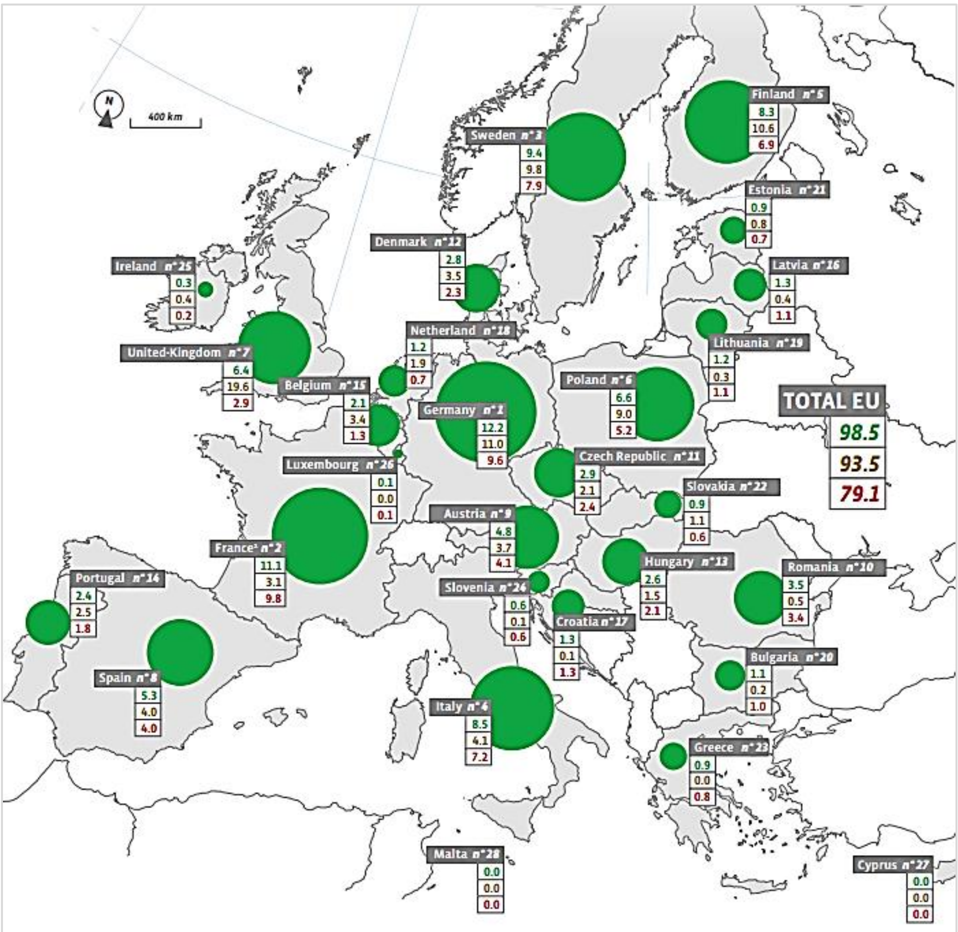



Source: *EurObserv'ER*, 2017b 12. p.

*Figure 2* shows that all Member States of the European Union have biomass production (*EurObserv'ER*, 2017c). The upper value shows gross inland consumption, the middle value is gross electricity and the lower value is heat consumption. The most notable users are Germany, France and Sweden.

**Figure 2.**

**Gross inland consumption, gross electricity production and heat consumption from solid biomass in the European Union in 2016**




Source: *EurObserv'ER*, 2017c 12. p.

## MATERIALS AND METHODS

The primary objective of the study is to study the complex use of agricultural by-products for energy purposes. The study looks at how an accumulated agricultural by-product can determine social, natural and economic aspects. The study is based on secondary data, based on secondary data. It processes and summarizes national and international literature. The data is based on data from *EurObserv'ER* (2017a), *Eurostat* (2018) and the *Hungarian Central Statistical Office* (2018). Only descriptive statistics were used in the analysis and time series were illustrated. The general characteristics of the available data sets are the research results for the utilization of agricultural by-products for energy purposes in Hungary. Detailed studies of green energy production provisions, biogas and biomass plant characteristics, take into account sustainability considerations. Only descriptive statistics were used in the analysis and time series were illustrated.

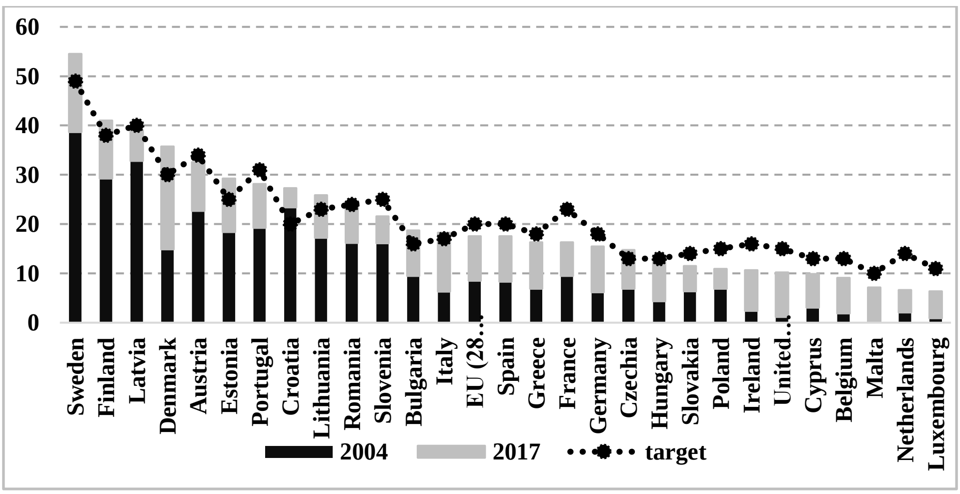
## RESULTS AND DISCUSSION

In the European Union, the share of renewable energy sources in gross final energy consumption at Community level should be raised to 20% by 2020, Hungary's target is 13%. Hungary's Renewable Energy Recovery Action Plan states that it wants to achieve a higher share of 14.65%. (*Popp et al.*, 2018).

The share of renewable energy in total gross final energy consumption was 14.5% in 2015, but in 2014 it was only 9.6%. This increase is due to changes in the statistical methodology. The Hungarian Energy and Public Utility Regulatory Authority has defined a new method for the use of solid biomass for residential use. Previously, firewood use was based on forestry statistics and is now calculated from household energy consumption data. The reason for the increase may be illegal logging (*Popp et al.*, 2018). Hungary has already met its target, but it does not occupy a high position in the European Union. *Figure 3* shows that Sweden, Finland, Latvia, Denmark and Austria are outstanding, while the share of renewable energy in the Netherlands, Ireland and France is considered low and far below the target.

**Figure 3.**

**Share of renewable energy in gross final energy consumption**



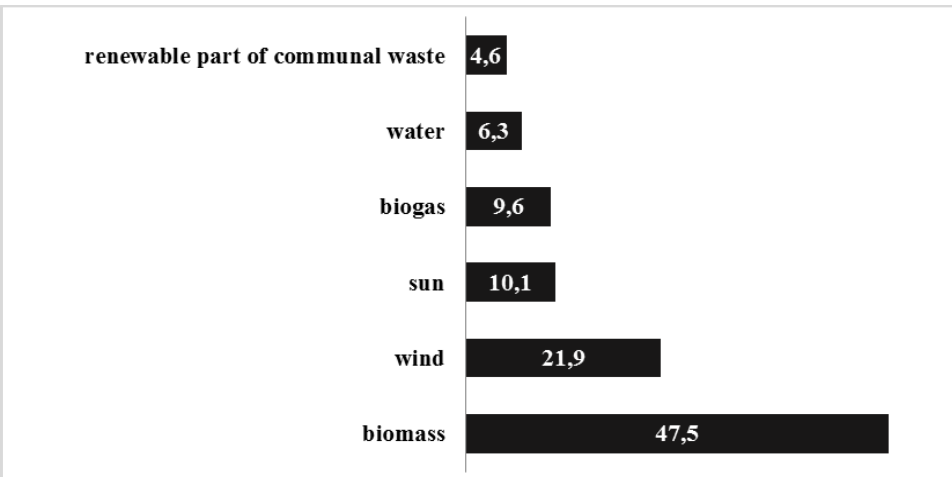

Source: Based on *Eurostat*, 2018

Biomass (47.5%) accounts for a major proportion of renewable energy sources and waste, with a share of 21.9%. The proportion of solar energy has grown dynamically in recent years, with 10.1%. The share of biogas plants is 9.6%. *Figure 4* shows that more than half of renewable energy (57.1%) comes from agriculture. Within this, biomass is the most significant one. As a criticism of biomass-based energy production, energy crops reduce food-producing areas. However, it includes not only energy crops, but all organic matter of biological origin can be considered biomass. The raw materials that can be used are forestry timber, wood by-products, energy crops, agricultural by-products and other waste. The energy use of biomass can be varied, suitable for both hot water and steam production. In order to increase the biomass value of the biomass and to make it easier to handle, agricultural products can be produced by compression processes of various sizes of low-moisture fuels (briquettes, pellets) (*Pula*, 2018). The creation of bioenergy plants has a positive impact on employment and the support of related industries. Biomass is currently a tool for promoting sustainable development. It enables the spread of energy at optimal cost, can help mitigate climate change, develop rural economies and increase energy security (*Saad and Taleb*, 2018).

The establishment of biogas plants is extremely capital intensive, and its location is determined by the availability of raw materials. In general, they are located in the immediate vicinity of livestock farms or food processing plants. This ensures the storage and disposal of the by-products.

**Figure 4.**

**Share of electricity from renewable energy sources and waste in Hungary**




Source: Based on *Hungarian Central Statistical Office*, 2018

The investment cost of a small capacity 0.8 MW biogas plant is 1,093 million HUF, while a high capacity plant is worth 2,004 million HUF based on the calculations made by *Popp* and its companions (*Table 1*). Operating costs are reduced by increasing performance. The operation of a biogas plant is competitive only if we examine it in a complex way. The establishment of biogas plants has a direct relationship with state aid policy. In order to increase the number of these plants on the market, state aid policy must be predictable. In the European Union, there is a high dispersion in the prices of receipt, and in Hungary, subsidized takeover prices are low (*Popp et al.*, 2018). The lifetime of biogas plants is not affected by their capacity, so their expected useful life is equal to about 20 years. The labour input of raw material production is not affected by the size category of the biogas plant. The difference is in design, installation and operation. Small-scale plants require a higher workforce for planning and operating capacity per unit capacity. According to *Fogarassy*, the growing workforce is not clearly positive, because if we produce a particular product with high personnel costs, it is not necessary that the product will be market-oriented. However, this should not be an exclusive aspect, as maintaining the rural population is an important factor here (*Fogarassy*, 2001).

**Table 1**

**Investment and operational costs of biogas plants**

| Denomination | Low capacity | High capacity |
|---|---|---|
| **Technical characteristics** | | |
| Electricity installed | 0,8 MW | 1,76 MW |
| **Investment costs** | | |
| Investment costs (million HUF) | 1 093 | 2 004 |
| **Operating costs** | | |
| Changing energy costs (million HUF) | 77,3 | 156,0 |
| Other variable costs (million HUF) | 24,2 | 42,1 |
| Permanent costs (million HUF) | 35,0 | 75,5 |

Source: Based on *Popp et al.*, 2011

It is worth examining the establishment of biogas plants in a complex way. Following *Magda* (2011), *Fogarassy* (2001) and *Bai* (2007), *Table 2* was compiled to summarize the advantages, disadvantages and potential difficulties of biogas plants in terms of investment and operation in three main aspects. In terms of natural effects, it is of paramount importance to reduce the amount of fertilizers applied to the nutrient replenishment of the production areas by applying the fermentation broth produced by the biogas plant and to replace it with organic material. During its production, $CO_2$ emissions are reduced, thus reducing air pollution in social terms. The employment of people living in rural areas is of great importance nowadays, with the creation of biogas plants it is possible to create new jobs, thus improving the income situation of rural people. From an economic point of view, the capital requirement for the investment and its operation is costly, and its return is risky due to low takeover prices. It can contribute to the improvement of regional competitiveness. Soil is a renewable natural resource that, if utilized properly, does not lose its value. Application of the fermentation broth increases the number of microorganisms and at the same time stimulates the original micro population of the soil. The cost of fertilizing a unit area is 40-50 thousand HUF, while the cost of applying the fermentation broth is 9-10 thousand HUF. Its application has natural, social and economic benefits.

**Table 2,**

**The natural, social and economic effects of establishing biogas plants**

<table>
<tr><th>Natural effects</th><th>Social effects</th><th>Economic effects</th></tr>
<tr><td rowspan="3">Nitrogen application can be reduced</td><td rowspan="2">Reduction of air pollution</td><td>Financing (investment, operation)</td></tr>
<tr><td>Regional competitiveness enhancement</td></tr>
<tr><td>Income growth</td><td>Job creation</td></tr>
<tr><td>Eutrophication</td><td rowspan="3">Job creation</td><td>Risk of energy purchase prices</td></tr>
<tr><td>Acidification</td><td rowspan="2">The payback time is high</td></tr>
<tr><td>Falling $CO_2$ emissions</td></tr>
<tr><td>Use of organic material</td><td colspan="2">Expansion of infrastructure</td></tr>
<tr><td colspan="3">Application of fermented juice</td></tr>
</table>

Source: Based on *Magda* (2011), *Fogarassy* (2001), *Makádi et al.* (2007) and *Bai* (2007)

## CONCLUSIONS

In the world, as well as in Hungary, energy consumption has increased enormously over the past decades, which is largely based on energy recovered from fossil fuels. As a result, efforts should be made to prioritize the use of available renewable energy sources for sustainability. The use of fossil energy sources leads to the emission of significant amount of greenhouse gases, and their negative impact on the environment is indisputable. This trend may be offset by the growing production of green energy, which also has an economic stimulus effect. The depopulated rural society can have a positive impact, as production and production can take place in these areas. Renewable energies can be efficiently produced in rural areas and their recovery potential is excellent. In Western Europe, the majority of farmers produce renewable energy. The production of renewable energy in agricultural economy promotes the European Union's energy, waste, rural development and environmental policies.

## ACKNOWLEDGEMENTS

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