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EGYETEM

## New Energy Solutions in Carpathian Area



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### **Measuring the energy potential of biomass for firing purposes by statistical and geographical methods in the case of a hungarian settlement**

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#### **INTRODUCTION**

Among the renewable energies, the woody biomass can be one of the most important primary energy sources of the next century. In order to ensure sustainability, however, in addition to the increase in the exploitation of natural forests, it is now also important to pay attention to the use of agricultural by-products produced in fields and short-rotation woody energy crops.

Decentralised energy production units supplied with biomass exist around the world, which are able to meet the total energy demand of a settlement. Such facilities typically can be found within the

EU, especially in disadvantaged regions. The raw materials required for energy production are mainly derived from local resources, which, beyond providing job opportunities for local population, promotes local economic recovery. The operation and maintenance practice of these plants are already well-established and have a history going back many decades.

Hungary has several social and economic problems – especially in disadvantaged regions – which could be reduced by the decentralised use of renewable energies. In Hungary, similarly to the examples in the EU, the woody biomass-based energy

production, and the production and processing of raw materials required for operation can help the stabilisation - or even the slight catching-up - of the economic and social situation of rural areas. It provides sustainable jobs and can also reduce energy costs.

Before starting an energy investment using woody biomass, complex analysis must be performed, spanning a broad range of disciplines. It is important to consider whether the natural conditions of the region are suitable to provide long-term and sustainable fuel supply for the planned energy producing unit. Beside forestry woody biomass and agricultural by-product potential, account must be taken of the possibility of cultivating short-rotation woody energy crops which can be grown in fields, since this may be the key to sustainable energy supply. In order for its real potential could be taken into consideration, it is essential to obtain the local farmers's opinion and their investment decision-making mechanism. The energy demand of the settlement needs to be assessed, finally, analyses and plans must be performed, which help the decision-makers of the given region to make the investment decision.

It is therefore appropriate to complexly examine the possibilities of the heat energy utilization of phytomass at both municipal and household level, and its social and economic impacts.

### **AIMS**

Our main aim was, by involving multiple disciplines, to assess that in a chosen settlement what would be the suitable conditions, raw materials, operating scale, technology to implement the biomass-

based heat supply, and what its expected impacts are at farmers's, local and regional levels.

In order to achieve our major aim, I have made an attempt to prove five hypotheses:

- **Hypothesis No. 1:** With respect to social and economic geography, the town of Ibrány is suitable for carrying out a village heating plant investment.
- **Hypothesis No. 2:** The total heat energy demand of the studied settlement could be met by the agricultural by-products and woody biomass produced every year within optimal transport distance.
- **Hypothesis No. 3:** Although the farmers of the demarcated area are familiar with short-rotation woody energy crops, they do not establish such plantations yet due to uncertain market conditions.

In order to achieve our objectives and support my hypotheses, the (sub)tasks to be addressed were the following:

- To carry out a social and economic geographical analysis and evaluation of the chosen settlement based on statistical data.
- To demarcate the zone of the town which is suitable for fuel supply, to conduct a cartographic illustration and analysis of its location, infrastructural conditions and land-cover factors.
- To make a biomass potential estimate in the demarcated area of the annual agricultural by-products, woody biomass, and short-rotation woody energy plantations which can be grown in fields.

- To conduct personal interviews and surveys asking the agricultural entrepreneurs engaged in crop production in the region, and to compare the results with a similar study published in the domestic literature and with my former research results.
- To identify which conditions would need to be changed as a way to encourage the local agricultural entrepreneurs to plant short-rotation woody energy crops and the areas where they would plant them.
- To carry out economic analyses concerning how the energy demand of facilities operated by the municipal would be met by a major project, and to examine the conditions under which this could be economical, finally to determine the critical values of sustainable operation.
- To present the energy modernising investments available for the local population, to define their economic efficiency, and to present the most significant economic key figures.

## **MATERIAL AND METHOD**

Methods used to select and delimit the research area

The selection and delimitation of the settlement examined in the dissertation were made based on the data of the National Regional Development and Spatial Planning Information System (TeIR), following own assessments, comparing with the results of domestic literature.

Methods used to estimate the biomass potential

The assessment of the biomass potential from agricultural by-products of the demarcated area around Ibrány was made based on the data as of two thousand nine to two thousand eighteen of the Hungarian Statistical database of the counties and regions of the Hungarian Central Statistical Office (KSH-MRSTAR), and the KSH General Agricultural Census (ÁMÖ) as of two thousand ten, using own calculations.

To assess the woody biomass potential of the settlement, the forecasts of WWF Hungary (World Wildlife Fund) and the Agricultural Administration Office (MGSzH) for the forestry cycle as of two thousand fifteen to two thousand nineteen were used.

The examination of the extent and geographical distribution of regions suitable for the cultivation of short-rotation woody energy crops were made based on the database of the WWF Hungary.

Methods used to conduct questionnaire survey

The survey on the local agricultural entrepreneurs' opinion and information base about short-rotation woody energy crops was carried out by personal interviews and questionnaires.

Questionnaire survey was conducted in the research area on two occasions in two thousand eleven and in two thousand fifteen. The aim of the survey in two thousand eleven was to assess the agricultural entrepreneurs' knowledge, overall approach, and intention to plant in relation to short-rotation woody energy

crops. The second sampling was conducted because of the changes in biomass-based energy production between two thousand eleven and two thousand fifteen.

The summary of the new and partially new scientific results

Several questions had arisen during the literature analysis and the research, which were answered by performing the tasks of the dissertation. During these tasks, I drew the following

## CONCLUSIONS

Thesis No. 1:

With respect to social and economic geography, the town of Ibrány is suitable for carrying out a village heating plant investment.

The social and economic geographical analysis confirmed the hypothesis that the town of Ibrány may be suitable in many ways for the establishment of a village heating plant supplied with biomass. Although based on Tóth Tomas's (2013) settlement matrix, Ibrány is not optimal in all respects to establish a bio-heating plant, the town could be classified as a primary settlement with regards to social and economic geography (Fig1.).

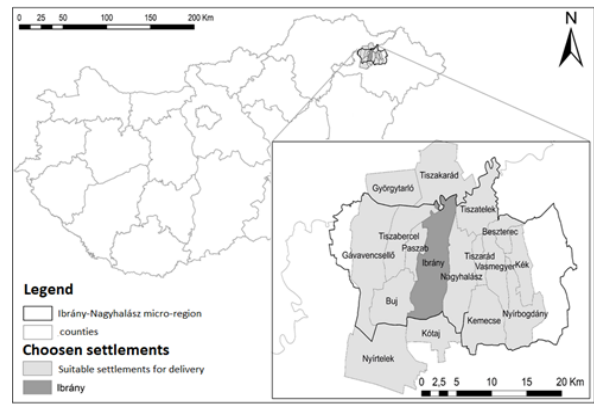


Fig. 1. The research area

It has a population of seven thousand thirty-four people, with a rising tendency in the long run. The age structure is young in the domestic context, since the age rate among men over sixty is lower by five point seventy-four %, while among women it is by seven point sixtyseven % compared to the national average. Between zero to fourteen years, the age rate among men is higher by three point fiftyone %, while among women it is by three point ninetyfour % compared to the national average (Fig. 2.).

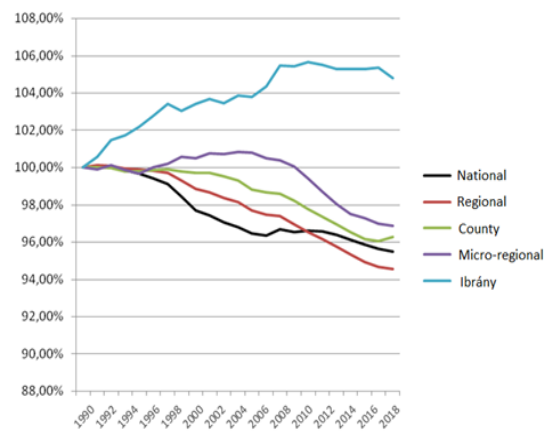


Fig. 2. Changes in the permanent population of Ibrány compared to 1990 in the light of national, regional, micro-regional and county data (1990-2018)(own results)

The dwelling stock is two thousand three hundred eighty-four houses, which is favourable, since the number of potential customers is high, and they use gas at a larger percentage seventy-one point ninety-four (71.94%) compared to the national average sixty-two point thirty-nine (62.39%).

All of these factors together would provide a favourable environment for the establishment of a village heating plant, since the fact that the population is growing, and the age structure is getting younger means a constant number of customers, while the high proportion of gas users demonstrates that the population has not switched to other heating methods yet.

In two thousand sixteen, the unemployment rate of the working-age population in Ibrány was ten point fifty-nine %, which is considered to be high compared to a national average of nine point fifty-five%. The town's employment problems could be slightly alleviated by a complex bio-heating plant investment similar to the one in Bollewick presented in case studies, since, as suggested in the international literature, the utilisation of renewable energy sources is one of the methods for the catching-up of underdeveloped areas. The number of inhabitants supported by active employment policy instruments is three hundred thirty-four, who could also participate in the operation of the village heating plant, the fuel feedstock production and processing, by being engaged in useful, value-creating work.

In order, however, to establish a

sustainable village heating plant, a comprehensive support and development system is needed, which is not only available for the chief towns of the counties (see TOP-6.5.1-16), but also helps indirectly to preserve the conditions of the surrounding lagging settlements by providing investment opportunities for small towns like Ibrány. During the development of the support and control system, using experience of existing and operating examples (village heating plan, institution heating), a mechanism should be developed which could be available for more settlements like Ibrány.

Thesis No. 2:

The total heat energy demand of the studied settlement could be met by the agricultural by-products and woody biomass produced every year within optimal transport distance.

Since the plot was found to be suitable for the establishment of a heating plant supplied with biomass in respect of economic and social geographical indicators as well, it was reasonable to examine the potential of the fuel available in the region. This required to delimit those areas from where fuel supply could be economical. Following Pintér's (2016) research, with the help of ArcGIS 10 software, a ten point fifty eight kilometer and a thirty-two point one km radius zones were demarcated, from where, in the first case, agricultural by-products, and in the latter case, woody biomass could be transported economically (Fig 3.).

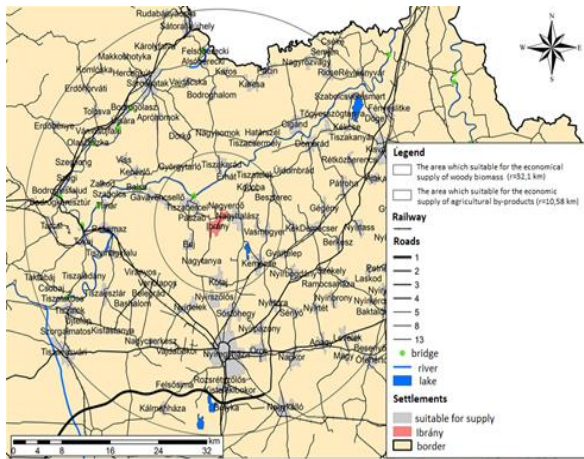


Fig. 3. The demarcating the area

After demarcating the area, first the potential of the agricultural by-products was needed to be measured, which was carried out in the absence of a municipal-level database with the help of a crop structure model. It can be said that the theoretical potential is huge, about seven hundred seventy-eight TJ/year, although for energy purposes only one hundred thirty-five point fifty two TJ/year can be taken into account after the deduction of straw used in animal husbandry and other by-products which cannot be collected (Fig. 4).

Type of agricultural by-product	Estimated sowing structure ha/year	Specific quantity to be harvested t/ha/year	Amount of by-product formed t/year	Heating value u = 25% GJ/t	Energy content TJ/year
Straw (wheat, triticale, barley, oats)	4 258,52	3	12 775,56	12	153,31
Rape straw	499,96	2,5	1 249,91	13	16,25
Corn stalk	7 542,18	5,5	41 482,01	11	456,30
Sunflower stalk	3 885,79	2	7 771,58	13	101,03
Grape stalk	69,78	2,5	174,46	14	2,44
Fruit tree pruning	2 327,16	1,5	3 490,73	14	48,87
<b>Theoretical potential</b>					<b>Σ = 778,20</b>
<b>Can be mechanized / delivered</b>					<b>220,87</b>
<b>It can be used for energy purposes</b>					<b>132,52</b>

Fig. 4. The potential of the agricultural by-products

Based on the WWF database concerning micro-regional forestry biomass potential and the cartographic analyses of my work five hundred forty-nine thousand five hundred ninety-two ton/year woody biomass can be produced in the

demarcated zone around Ibrány in the forestry cycle as of two thousand fifteen to two thousand nineteen, of which the energy yield is seven thousand six hundred ninety-four TJ/year (Fig 5.).

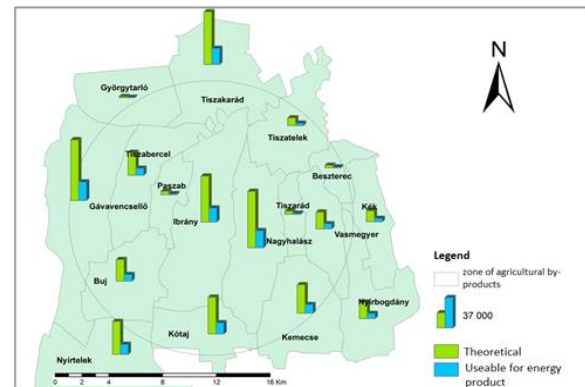


Fig. 5. Biomass potential of the demarcating the area

Based on the WWF database altogether seventeen thousand three hundred ninety-six ha area suitable for the production of short-rotation woody energy crops can be found in the demarcated zone, where altogether one hundred sixty-four thousand four hundred seventy-two ton/year fuel feedstock could be produced, of which two thousand three hundred three TJ/year energy yield could be realisable.

The actual heat energy demand of the town of Ibrány was seventy-six point ninety two TJ on average between two thousand ten and two thousand thirteen. The greatest heat energy demand of the town arose in two thousand ten, when the actual heat requirement was one hundred three point sixteen TJ. It can be said, that the annual agricultural by-product yield (one hundred thirty-two point fiftytwo TJ/year) estimated during the biomass potential assessment would not cover the settlement needs reliably every year, since if the heat demand of the settlement is one

hundred three point sixteen TJ and this energy is intended to be produced by a biomass boiler with an average yearly energy efficiency of eighty %, one hundred twenty-eight point nintyfive TJ fuel feedstock would be needed. Since losses are incurred during heat transfer, it is very uncertain if the volume of agricultural by-products available in the region (one hundred thirty-two point fiftytwo TJ/year) would cover the heat requirement of the town fully. Thus, establishing an energy producing plant supplied by herbaceous biomass exclusively to satisfy the total heat energy demand of the settlement is not recommended. At the same time, the woody biomass yield produced annually in the ideal transport area (seven thousand six hundred ninety-four TJ/year) would fully cover the total heat energy demand of the settlement even in the year of the greatest energy consumption.

### Thesis No. 3:

Although the farmers of the demarcated area are familiar with short-rotation woody energy crops, they do not establish such plantations yet due to uncertain market conditions.

The short-rotation woody energy crops produced by the local farmers can play a significant role in the sustainable and stable fuel supply. Based on surveys on short-rotation energy crops carried out among farmers in two thousand eleven and in two thousand fifteen, several new and important conclusions have been drawn

In two thousand eleven, fifty two % of the farmers around Ibrány had already heard of the short-rotation woody energy crops, furthermore, thirty four % of them had

been informed of the support possibilities available in the year the survey was carried out. In spite of this, only eight % of them had a plantation.

The personally conducted questionnaire survey revealed that although thirty four % of the farmers around Ibrány know the short-rotation woody energy crops well, they do not use such crops due to uncertain market prospects.

The results of the dissertation and the experience of similar questionnaire surveys carried out by two authors, Szecsei and Salamon (2010) in the Western Transdanubian region altogether underpin that the agricultural journals, conferences and technological demonstrations contribute significantly to the more widespread recognition of the short-rotation woody energy plantations. These are the most important methods of information dissemination and communication toward farmers.

We have concluded that the factors directly and indirectly affecting profitability, furthermore, the solid sales opportunity are the primary concerns during the decision-making process concerning the farmers' plantation investment.

Between two thousand eleven and two thousand fifteen, the woody energy plantation area on the plot decreased from twenty four point five hectares to thirteen point nine hectares. The reason behind the decrease can be explained mainly by the market changes in recent years and uncertainty. The biomass power plant in Szakoly was shut down, the biomass power plant investment in Beszterec (due to energy policy changes) was rejected. All of these events led not only to the failure of

new installations, but in many cases, to the clearing of the existing plantations as well. The farmers of the plot are not willing to plant short-rotation woody plantations again until the uncertain market conditions are resolved.

## **CONCLUSIONS AND RECOMMENDATIONS, RESULTS USEFUL FOR PRACTICE**

The role of renewable energy sources in the world energy production will increase continuously. In the near future, biomass in general and dendromass for heating in particular will play the decisive role among renewable energies. Heating plants providing decentralised heat energy production, using dendromass will play an increasingly significant role in Hungary, similarly to the EU. These plants will use fuel produced and processed locally to meet the energy requirements. Such units will play a key role in alleviating the problems of the country's disadvantaged regions, since they will provide new workplaces for the rural population. The production, transportation, processing of fuel and the operation of the heating plant provide job opportunities both for the people living in the settlement and for those who live in the ideal transport zone.

In our study, I developed a method which is suitable for assessing the biomass potential of any Hungarian settlement based on statistical databases supplemented by cartographical analyses. Although the method is not the most accurate in the absence of settlement data, it still provides an excellent approach for

the investors of the market sector in conducting the sustainability study of a potential bio-heating plant investment.

Since continuous fuel supply is very important in the case of a biomass boiler, local farmers should be involved in the production of raw materials. For this, however, as I have pointed out in my dissertation, an intermediary body will be needed, which will lay down the foundations of fair cooperation in the best interest of both the agricultural entrepreneurs and the energy sector.

In the course of my research, I have concluded that the heating plant investment satisfying the total heat energy demand of the town's population would be risky due to the long power line, the number of uncertain connections, and the subsequently unexpected disconnections. Therefore its investment-economic analysis has not been carried out. However, I have examined the possibility of the biomass boiler investment meeting the heat energy need of the municipality. During the analysis I have confirmed that this possibility may be economical for investors or the municipality if tenders available in 2017 are involved. I have also determined the key figures of the economical operation, which will help greatly the potential investors in the process of further plannings and possible implementation.

Finally, we have analysed the possibility of biomass utilization at household level. It is a result useful for practice that I have determined the critical values when other fuels are worthwhile to be used. Furthermore, I have pointed out whether it might be economical to switch to a modern



condensing gas boiler or an equipment supplied by biomass from a low-efficiency heating system. It is also a useful result for practice that I have examined the residential investment supports available in 2017 and their impacts as well.

## REFERENCES

PINTÉR G. 2012: Egyes mezőgazdasági melléktermékek energetikai hasznosításának lehetőségei Magyarországon, Ph.D értekezés, Pannon Egyetem, Keszthely. pp. 50-82.

PINTÉR G. 2016: Biomassetransport zur Kraftwerke, Elhangzott: Energietag,

Wienerneustadt, 2016.04.14.

REN21 2017: Renewables 2017, Global Status Report, pp. 29-30.  
URL.:[http://www.ren21.net/wp-content/uploads/2017/06/17-8399\\_GSR\\_2017\\_Full\\_Report\\_0621\\_Opt.pdf](http://www.ren21.net/wp-content/uploads/2017/06/17-8399_GSR_2017_Full_Report_0621_Opt.pdf) (2017.06.29)

SZECSEI T.-SALAM ON L. 2010: Az energetikai célú növénytermelés megítélése, Gazdálkodás: Scientific Journal on Agricultural Economics, 54 (7) pp. 750-756.

TÓTH T. 2013: A megújuló energiaforrások társadalmi háttérvizsgálata a Hernád-völgy településein, különös tekintettel a dendromassza-alapú közösségi hőenergia-termelésre, Ph.D értekezés, Debreceni Egyetem, Debrecen, pp. 3-108..



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