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THE POSSIBILITIES OF ENERGETIC APPLICABILITY AND ECONOMIC EVALUATION OF GRAPE IN THE SZENTANTALFA TOWNSHIP

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Abstract: Energy production has become one of the key problems in the recent years. Hungary is lacking fossil fuels, but could play a leading role of biomass utilization in Europe. In the concept of biomass not only main-, but by-products (e.g. grape) are be included. Since farmers face a variety of difficulties in disposing of garpe from plantation sites it would be beneficial to encourage grape use in energy production. In our opinion due to varying transportation costs it is crucial to investigate the amount of potentially usable grape both for the whole country and in local township levels. Our economic studies were done on the Szentantalfa Township's Balatonfüred-Csopak Vine Region. According to our findings the total amount of grape generated in the township theoretically amounts to 5.28 TJ exploitable that would operate a 360 kW boiler for a whole heating period (6 months). In our opinion the appearance of local energy production based on grape could significantly raise the ability of the future potential income of townships.

Keywords: grape, wine county, energy, agricultural byproduct

Introduction

Energy production based on biomass in Hungary

Most of the currently operational coal power plants in Hungary were built in the 1950s shortly after the Second World War. A large fraction of those power plants was meant for processing high sulfur content coal mined in Hungary. Using locally mined coal was preferable for self-sustainability, decreased unemployment rates, but in the same time was heavily polluting the air. After the breakup of the Soviet Union and the democratic change in Hungary due to globalization self sustainability became less important. Instead, first economic sustainability and later, due to Hungary's EU membership, the environmental impact was more central. As a consequence, coal mines were shut down one after another in Hungary. Almost 50 years old power plants built with obsolete technology had to be either modernized or shut down. Internalization of external costs and the introduction of carbon dioxide quotas had a large economic impact on the faith of coal plants. Changing to biomass fuel on the other hand gave a new hope for these old facilities.

After the turn of the millennia due to developments forced by economical and legal regulations caused the massive use of wood chips, sawmill shavings and even sawdust as fuel. Due to increasing fuel consumption in power plants the interest and demand in solid biomass type raw fuel has increased and so did their price.

In the second half of 2003 the Ajka plant of the Bakonyi Hőerőmű Plc switched to biomass-fuel with two boilers. This step wasn't unique in Hungary, since the Mátravidék plant started mixed fueling with lignin and biomass, the Pannon CHP (formerly Pécsi CHP), the Borsodi CHP in Kazincbarcika and the Tiszapalkonyai CHP in Tiszaújváros also started burning biomass. Reasons were subsistence and diversification of operations as the power plant emission requirements were substantially stricter. These plants currently buying fuel from neighboring forestry industries, but the providers' circle and the utilized fuel types are widening.

The main potential clients for providing biomass are forestry industry, agricultural farming and local governments, but some sawmills and furniture manufacturers are considered as well. Utilizing the following byproducts can provide an opportunity for decreasing costs for those in the fields as well as a small increase in wages. Byproduct utilization however could not only generate income for farmers, but also for other biomass providers, like local governments.

According to the 2001/77 EU directives as part of the battle to minimize the effects of global climate change the strategy of Hungary in using renewable sources for electric power production was described in the Electric Power Law of 2001 and The Central Heating Law of 2005. According to the related 56/2002. (XII. 29.) GKM regulation it was mandatory to purchase available electric power generated by using renewable sources and this wasn't changed in the new law passed in 2007.

Agricultural byproducts

Hungary has excellent natural resources for agriculture. We produce large amounts of plant-based biomass every year. Thus, there is a production of a variety of related byproducts, which should be utilized for energy production. Currently there are contradicting estimates for the amount of agricultural byproducts: Bai (2001) claims 7–8 million tons yearly, while according to Gyulai (2007) this number could be as high as 10 million tons/year of which 40–45% is usable for energy. Nevertheless the same conclusion can be drawn from the various estimates: Hungary produces a significant amount of agricultural byproducts.

Agricultural byproducts can be categorized according to the goals of their utilization (e. g. forage, fertilization, utilization in energy production, etc.). It is practical to further divide the category of energy production capable byproducts into two subcategories based on their burning-properties: arboreals and non-arboreals. Woody plants can be burned together with regular firewood, while non-arboreals require specialized burners and boilers. Further, it has to be taken into consideration whether their usage is appropriate with the current technology or that will be available through future developments.

Grape, as an arboreal agricultural byproduct can be burned together with biomass. In our opinion a country, like Hungary, in need of energy import can't afford to consider biomass usage solely for main products. In Hungary it is a strategically important goal to utilize byproducts within biomass as well. Since those materials are not the main targets of production without interest they are considered unnecessary waste and their disposal creates extra cost for the farmers.

In case interest materializes toward agricultural byproducts for their utilization in energy production it is already a benefit if the farmers don't have to dispose of them as this cost-lowering factor can appear as profit.

Wine grape farming in Hungary

In order to secure its own well being, the expectations of the ever-growing humanity are constantly increasing towards nature. Today, besides food production and supply energy production and supply comes into focus. Hungary is poor in fossil fuels, but capable of rich biomass production. In Central-Europe our country could bear a potential leading role in biomass production not only considering main, but also byproducts. Without adequate interest in the materials generated besides the main products, i.e. not byproduct but waste is produced, farmers' aim at cost effective disposal. According to our study, currently vine is widely considered as waste instead of falling into the byproduct category.

The main goal of the authors is to determine the amount of usable vine locally, for a particular township under investigation.

Wine grape farming is one of the successful branches of the Hungarian agriculture. Its success originates from environmental factors; historical vine regions in Hungary are well or excellently suited for wine farming. If we consider the individual wine regions and townships, we can conclude that the variety provides the appeal of main products. Besides the excellence of the agro-economic potential, however, there are societal challenges waiting to be dealt with. The production of wine grape is connected with human factors in a variety of aspects. The need for human labor and capital funding is high, the monetary fund lockup, investing time and potential return time is long, markets are unpredictable and highly variable and finally the legal regulations frequently change. The township system formed by the directive of the EU regulates the production, handling and selling of the main products (grape and wine) and the disposal of subsequently produced byproducts (rape, tartar, etc.). In wine grape farming and production however a significant amount of vine is realized of which handling and disposal regulations are less elaborated. In regards of plant material (vine) handling obtained during pruning it is rather prohibitions that are currently in effect. As derived from cross compliance rules it is forbidden to dispose of vine at the end of the fields.

Even experts in the production line of winemaking have no clear understanding of the amount of vine (by)produced, not to mention that the literature almost never mentions it.

The amount of vine and the yield of wine grape are positively correlated, as it is recognized by traditional folk wisdom in proverbs. However this correlation is not simple as multiple factors (geographic location, age of the plantation, actual rainfall, etc.) influence the yield of wine grape making it difficult to quantify.

Handling and disposing of vine

Vine produced during the pruning process has to be removed for its interference with production as well as the potential cause of plant health issues. Removal of one is practical before the period of germination or sprouting to avoid physical damage to plants.

There are three basic routes for vine disposal, all three having some associated costs.

- Mixing in with the soil: the vine is shred and spread over the plantation and mixed in at the next phase for replenishing nutrients. Besides the cost of shredding, the drawback of this method is the potential for creating a preferred environment for bacteria and viruses to overwinter and reinfect the plantation.
- With storage: this method replaced the widely utilized, but now forbidden burning of vine. The farmer disposes of the vine at an unused location, which biodegrades in a few years time. Cheap (no shredding cost), but requires relatively big space.
- The farmer could sell or utilize (provided the availability of proper equipment) the produced vine for energy production. In this case the vine is transported trussed or shredded.

According to Pintér's (2012) related calculations in the 22 wine regions of Hungary approximately 132.5 thousand tons of vine is produced yearly. This would mean about 2 million GJ energy (as a comparison 43 GJ/year is used for heating an average 50 m^2 apartment (FŐTÁV 2013), thus the estimated energy would be enough for heating slightly more than 46500 households). Clearly, it would be impossible to utilize all the produced vine, but even then the potential benefits of biomass burning should not be neglected by a country in a „fragile energy situation" needing energy import (Tóth 2004) and for which biomass represents the most significant energy production potential (Gilber 2006).

Due to the cost of transportation only well connected wine regions should be considered for potential energy production. The problems arising from the fragmented land ownership could be mitigated by proper organizing of the contributing farmers.

The most important statistical data on the 22 wine regions of Hungary are summarized in the following table.

Materials and methods

At this stage of our research we are looking to find out the amount and routes of utilization of vine produced in a township or a smaller region in a way to conform environmental regulations.

In the following we describe the three main strains of wine out of the five under investigation:

Italian Riesling

16.5% of vitaceae plantation of Hungary is located in the Balatonfüred-Csopak wine region out of which 6% is in the Szentantalfa township. All four wine regions of the Balaton uplands produce quality wine with characteristic, rich tasting, mildly reseda scented, resembling a bitter almond taste with an elegant level of acidity. Yields are quite steady and reliable. The vine is about 5mm thick, the amount of arboreal content is considered to be good.

Müller-Thurgau (Vitis vinifera)

This strain is popular in the region of our study for its early ripening, smooth tannins and kind, not intrusive scent. With moderate pruning it is easy to achieve good quality, however the yield can be varying. The vines are thicker (5–10 mm), but the lateral shouts are quite underdeveloped. In years with higher precipitation the vine are stronger, with higher kernel ratio, looser tissue structure and lower freeze tolerance.

Table 1. Statistical data of Hungary's wine regions

Name	Area[1] [ha]	Amount of vine produced[2] [t]	Total cadastral land are associated with the wine region[3] [ha]	Ratio of area utilized for wine production in the cadastral land[2]
Csongrádi	1533	2760	14000	11%
Hajós-Bajai	1967	3541	14700	13%
Kunsági	22950	41310	93600	25%
Neszmélyi	1643	2958	5700	29%
Badacsonyi	1613	2904	3900	41%
Balatonfüred-Csopaki	2232	4017	6350	35%
Balaton-felvidéki	1035	1863	4970	21%
Etyek-Budai	1750	3150	5620	31%
Móri	753	1355	2000	38%
Pannonhalmi	619	1114	3900	16%
Nagy-Somlói	598	1077	1140	52%
Soproni	2297	4134	4290	54%
Balatonboglári	3567	6420	9900	36%
Pécsi	826	1488	7000	12%
Szekszárdi	2333	4199	5700	41%
Villányi	2574	4632	4792	54%
Bükki	1052	1893	17600	6%
Egri	5511	9920	21300	26%
Mátrai	6324	11384	32300	20%
Tokaji	5992	10785	11100	54%
Zalai	1684	3032	5820	29%
Tolnai	2851	5132	11160	26%

[1]Source: HNT, 2012
[2]Source: our calculation
[3]Source: Nemzeti Kulturális Örökség Elektronikus Oktatási Könyvtár, 2011

Irsai Olivér (Vitis Vinifera Linné Subsp. Vinifera)

One of the earliest ripening double use strain. The wine resembles fresh fruit scent, which becomes heavier when over ripened; light, kind and smooth tannins. The vines are loose but strong strongly dependent on the amount of precipitation.

We selected the Nivegy valley located in the Szentantalfa township as the focus our study. This township serves as the example to analyze the possibilities for vine utilization in energy production. The study is based on the data (vine yield) from 2012 that was a very dry year, thus our result is a pessimistic estimate.

We examined five different wine strains (but two types from Olaszrizling: SzJ, and MOR and two from Rizlingszilváni: J, and D) in the Nivegy valley during the 2012 spring pruning in March. In every field participating in the study (also resembling a separate wine strain) we analyzed 2% of the wine plants. Thus in one hectar field with 4000 wine plants we randomly selected 8 different sample regions.

For the energetic calculations two types of facilities were considered in this study:

a) Year round operating, estimated uptime 8000 h. The produced heat can be utilized for water heating and/or industrial use (produce drying, etc.)

b) A facility that operates only for 6 months, estimated uptime 4000h. This type of power plant would operate only in the heating season and would sell 100% of the produced energy.

We considered 25.25 m^3/m^2 gas use based on the data publicly available by FŐGÁZ Zrt.

Table 2. Vine strains in this study in the Nivegy valley

Strains	Farmed area [ha]	Vine yield after air drying [kg/ha]	Vine yield average [kg/ha]
Olaszrizling			636
SzJ	1	606	–
MOR	0,3	735	–
Rizlingszilváni			716
J	0,5	814	–
D	0,8	654	–
Zengő	0,6	619	619
Tramini	1,2	1158	1158
Irsai Olivér	1,2	952	952

Source: own calculation

Table 3. Wine varieties in the scope of this study in Szentantalfa.

Varieties	Area in Szentantalfa [ha]	Averaged vine yield [kg/ha]	Total vine yield in Szentantalfa [t]
Italian Riesling	229,07	635,77	145,63
Müller-Thurgau	48,88	715,54	34,97
Zengő	5,18	619	3,21
Tramini	4,92	1158	5,70
Irsai Olivér	2,38	952	2,26
40 other varieties	198,31	832,16	165,03
Összesen:	488,74	–	357

Source: own calculation

Results

Quantification of vine yields

As we mentioned at the „materials and methods" we randomly selected 8 different sample regions. From each region we pruned 10 plants and collected the vine in a separate container. Considering the volume of the obtained vine its weight was rather small, on average we obtained 3.5 kg vine after pruning 10 plants with 0.09 tons/m^3 density without drying. (For comparison we measured the density of a raw vine truss resulting in 0.26 tons/m^3.) We assumed that after 40 days the collected raw vine will reach its airdry state totaling in 15% of water content. Following the studies from Pecznik (2001) and Pintér (2012) we determined the heating value to be 14.8 GJ/tons at 15% water content. According to our measurements the water content of the raw vine was 35%.

For the Italian Riesling and Müller-Thurgau varieties we investigated two plantations and averaged the yields as it is shown in Table 2. We projected the average values to the Szentantalfa township's wine region according to Table 3.

Similarly to other wine regions, the Szentantalfa township accommodates many wine varieties (Fig. 1). This variability is further increased by the differences in actual farming practices. The lack of homogeneity made it difficult to build a model.

The energy production plants utilizing vine will need to be ready to accept vine as fuel. Multiple Hungarian power plants have such capability, but due to large transportation distances only local vine burgning is of interest.

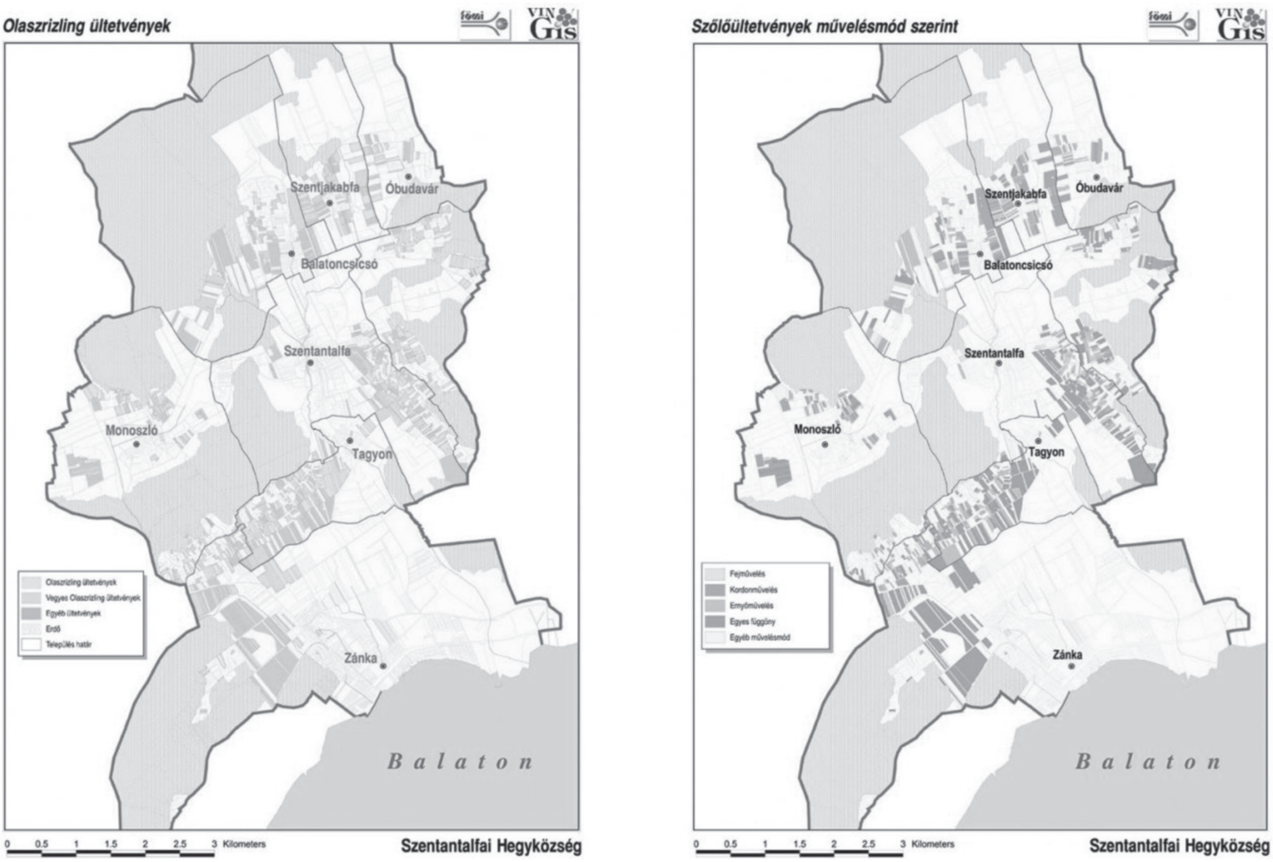
With the decreasing energy cost in 2013 the determination of a major power plant investment's rate of return is complicated, the time of return without significant government support increases and thus the investment incentive decreases.

According to the registry of the Balatonfüred–Csopak wine region there are 45 varieties of wine over 488.74 ha land in the Szentantalfa Township. From this selection – following the Pareto-theory – we chose five for our study that occupy 60% of the total area. For calculating the 2012 vine yield of the remaining 40 wine varieties over 198.32 ha we used a weighted average based on the 5 major varieties and their occupied area resulting in 832.16 kg/ha yield.

After summing the yields we concluded that that Szentantalfa Township produced 357 Tons of vine in the particularly dry year of 2012 that is far below the expected yield that was reported (Marosvölgyi 2002) for average weather conditions to be 1.2 tons/ha.

These values we report for the Balatonfüred–Csopak wine region are not outstanding as our observations in other wine regions showed similar, low values.

Figure 1. Distribution of wine farms in Szentantalfa (left: Italian Riesling, right: distribution of different farming methods)



Source: (Vingis, 2013.) http://www.vingis.hu/index.php/terkepek

Since the year 2012 is regarded as an extremely dry year we consider the 357 tons/year vine yield as the minimum value for the Szentantalfa Township. Considering 357 tons/year vine yield a power plant designed ofr utilizing this amount, will always receive sufficient supply as long as farmers are willing to sell the harvested vine for energy production.

Energetics Calculations

Our following analysis assesses the potential for a power plant based on the vine yield obtainable from the 488.74 ha agricultural area of the Szentantalfa township. We considered the possibility of two types of power plants: on one hand a facility with electricity and heat production and on the other hand heat production only facility as we mentioned at the "Materials and methods".

In both cases we determined the operating uptime considering planned and emergency shutdowns, in other words we accounted for maintenance a potential faults. Based on the data shown in table 4 we concluded that the 488.74 ha farmed area in the Szentantalfa township can operate a furnace that produces 180 kW in the calendar year or a smaller, half-year uptime facility producing 360 kW.

Thus the available vine can provide heating for 123 units considering 50 m^2 average size (excluding losses in the heat transportation system). In other words this replaces the use of

Table 4. Facility related data

	„A" type	„B" type
	Full year operation	Operation in heating season only
Available vine [t]	357	
Total energy content [TJ]	5,28	
Yearly uptime (without faults) [h/yr]	8000	4000
Power [MW]	0,18	0,36

Source: own calculation

155 290 m^3 natural gas (considering 34 MJ/m^3 heating capacity), which means 275.64 tons of CO_2 being not emitted. It is important to not that the specific natural gas consumption is heavily influenced by the heat efficiency of the actual building, thus allowing to use the same amount of energy to heat a larger space.

Our research shows that the yearly production of vine in a township is measurable and theoretically it is possible to design a power or heating plant for each of them.

The authors interviewed four farmers from the Szentantalfa region and concluded that their goal is to remove vine. Therefore as long as the commercialization or the value of produced energy of vine covers the cost of its removal the competitiveness of the farmers improves since a cost item disappears from the main products' production tree thus effectively lowering the specific production cost.

Besides studying vine burning we conducted an economic investigation of baling of vine for transportation purposes. (Burning plants can accept bales and vine chips. In this study we consider only bales.) Utilization of bales is costly, requires significant human and machine labor. We investigated the efficiency of baling through "workhours-counting"method. We determined that a vine-baling machine driven by a medium size (P=37kW) tractor completes baling 1.2 ha area in five hours. During this process 104 bales were produced from which the hourly efficiency can be determined to be 21 bales/hour with which we normalized the hourly operating cost.

According to our model the cost components of baling can be divided into four categories:
– operation cost of the power tool
– driving machine amortization (net value: 3 100 000 HUF, useful lifetime: 10 years, linear amortization, 750h/yr. operation)
– maintenance cost
– rope cost (80 HUF/bale, 21bale/h → 1680 HUF/h)

With items' cost in the above order we obtained the following result:

$$3500\ HUF/h + \left(\frac{3\,100\,000}{10 \times 450\ h}\right) + 40\ HUF/h + 1680\ HUF/h = 5633\ HUF/h$$

thus the cost of production for 21 bales is 5633 HUF that equals 268 HUF/bale. At the time of this study one bale can be commercialized at 250 HUF/bale for domestic and the represented energy value amounts to 157 HUF/bale can be obtained in a power plant, thus both cases bales can be produced with loss. It is important to note that after the 268 HUF/bale production the bales are still on the field in a random arrangement, therefore the above cost doesn't contain collection and transportation expenses.

We conducted further "workhours-counting" to study half-mechanized bale collection. During the work process a tractor with a trailer was transporting the bales and two workers loaded 35 bales (cylindrical bale dimensions: 40 cm in diameter and 60 cm in height) in one cycle that typically took 40 minutes (0.67 h). To calculate the hourly cost we considered the costs of the tractor + trailer + two workers.

For 35 bales this yields 3500 HUF/w.h + (2 × 713 HUF/h) = 4926 HUF/h × 0,67 h = 3300 HUF, therefor the collection cost for one bale is 94 HUF and the total cost of one bale increased to 268 HUF + 94 HUF = 362 HUF. At this stage the bales are collected in one place on the side of the field, but the commercialization of vine can be still only done with a loss.

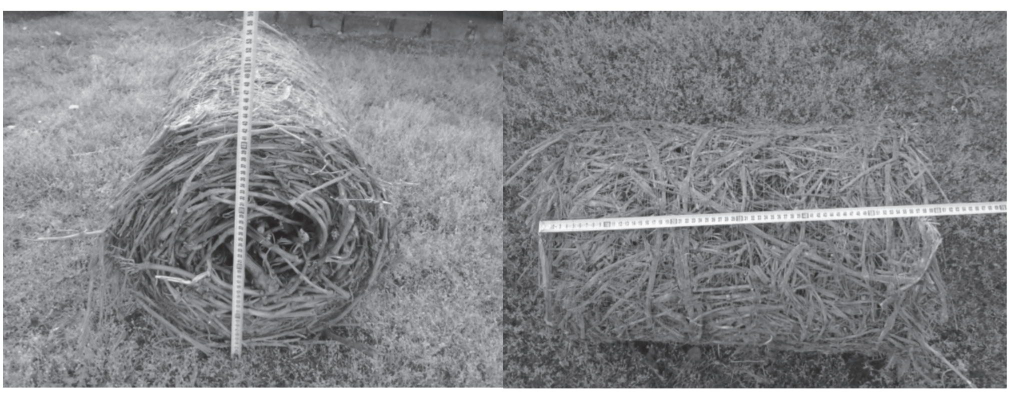
However, one shouldn't neglect the fact that currently vine is a byproduct in the region under study and thus it's removal represents only costs. In this study we attempted to determine the cost for vine removal.

Using the "workhours-counting" method we determined that one tractor is capable of removing vine from 0.5 ha in one hour, thus a 3500 HUF/h cost tractor will remove vine in two hours which will cost 7000 HUF. Currently, in the subjected are vine is considered to be waste, therefore the farmers have to pay the removal costs, regardless.

Since 87 bales can be produced on one hectare and the farmers have to pay the removal cost anyway, we lower the production cost of one bale by 7000 HUF/87 bales = 80 HUF/bale. Because of this cost reduction the actual production cost of one bale becomes 362 HUF – 80 HUF = 282 HUF, thus – with these considerations – the farmer can actually realize profit.

Because of the measured costs can be changed we calculated a sensitivity analyses for the whole process. The 2. figure show us the result of the analyses. 10% increase of the costs will give the cost of a bale at 311 HUF. According to our calculation for the 100 % on the "x" axis pass the 282 HUF/bale cost on the "y" axis. We calculated the effect of cost changing of difference components for the cost of a bale. If the removal cost of the vine is increase the cost of a bale decrease. The removal cost is a "have to" element of the cost, the farmer has to remove the vine independent from baling and selling it.

Figure 2. Vine bales in Szentantalfa



Source: own work

Table 5. Summarise of the calculation

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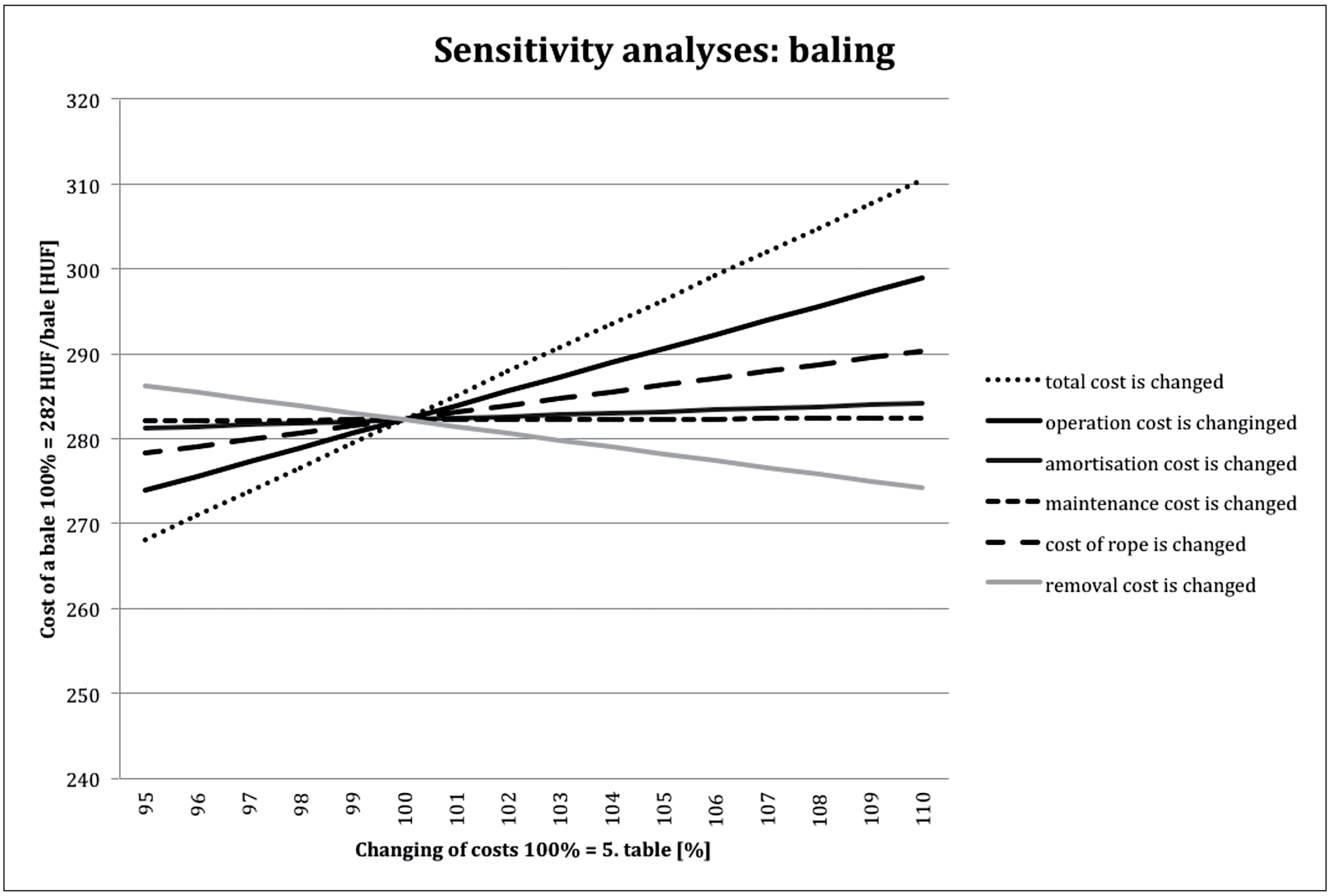
+ production cost of baling				+ collection	– removal
operation	amortization	maintenance	rope		The farmer have to do the removal anyway!
3500 HUF/h	413,33 HUF/h	40 HUF/h	1680 HUF/h		
∑ 5633 HUF/h					
+268 HUF/bale				+ 94 HUF/bale	– 80 HUF/bale
= 282 Ft/bale					

Source: own calculation

Graph 1. Sensitivity analyses of baling costs



Source: own calculation

Discussions

Recommendations and conclusions based on this study

In summary, we showed that vine can significantly contribute to local energy production. The Szentantalfa township of the Balatonfüred-Csopak wine region is capable of producing 0.36 MW energy in power plants operating for the heating season.

Investigating from an economy standpoint we concluded that vine utilization for energy production considering the current market in the Szentantalfa township is only feasible for „home use". Without subsidization energy production at the community level using vine is not realistic.

With market interest in vine truss and if the unit price reaches 282 HUF/truss a small company would be profitable. This naturally requires a power plant network that is capable of utilizing vine as fuel. A number of currently operating power plants in Hungary have this capability, but due to transportation costs, only the nearest areas can be counted on.

With decreasing energy costs in Hungary in 2013 it is difficult to determine the rate of return of a heating or power plant investment, the return time increases without significant government support and so does the willingness of private companies to invest.

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