

**University doctoral (PhD) dissertation abstract**

**THE ROLE AND THE WAYS OF USAGE OF VINE BRANCHES  
IN LOCAL BIOMASS UTILIZATION**

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# **1. THE BACKGROUND AND THE OBJECTIVES OF THE RESEARCH, THE INTRODUCTION OF THE RESEARCH HYPOTHESES**

Every scenario analysis of the European Commission shows that in 2050 most of the energy supply technologies in the European Union will derive from renewable energy sources. The second major prerequisite of a more sustainable and more secure energy system is the higher share of renewable energy after 2020. Every carbon dioxide discharge scenario suggests that the proportion of renewable energy sources in total gross energy consumption will rise by about 30 percent by 2030.

As things stand, Hungary can only meet this target by increasing the utilization of biomass among renewable energy sources. The other alternatives are too rudimentary to be relied on, they are only complementary to the current 90 percent share of biomass. However, it is an unfortunate fact that instead of recognizing and using the available stock, we promote the emergence of a new industry by the production of biomass. Meanwhile, a significant amount of biomass of plant origin can be obtained as by-products of agricultural activities, the utilization of which is currently not significant.

In the different regions of the country different crops are grown in greater proportion according to the diverse regional and economic conditions. In the micro-region of Gyöngyös, at the southern foot of the Mátra mountains, the typical agricultural activity is vine growing. During this activity the largest waste of energy is when the farmers burn the resulting vine branches unused after pruning. There are some initial efforts to utilize them, but they are not very widespread. However, the utilization of them for local energetic purposes, and their conversion into final products would result in additional revenue for the users and would also significantly reduce the fossil energy needs of the community.

On one hand, my goal is to draw attention to the wasteful behavior of agriculture, in this case of viticulture, while on the other hand to promote the domestic utilization of a typically unused resource by presenting a possible utilization in energy recovery that I have experienced, and by exploring other viable solutions as well.

During my research, I take the arguments and counter-arguments of the different areas of expertise on the subject into account, and present the practical experiences of other vine producing countries as well, in order to give a full picture of the problems.

It is my aim to find the optimal way of utilizing vine branches as an energy source, for which aim I carry out work organizational and economic investigations based on a questionnaire survey and a specific case study, and I also analyze the technological and environmental aspects of the energetic utilization of vine branches. To achieve this, the following hypotheses were set up:

H<sub>1</sub>: **Local farmers** are major contributors to the spread of the energetic utilization of vine branches. Their **knowledge about** renewable energy sources, and specifically about the possibilities of **the utilization of vine branches is decisive** in the success of the implementation.

H<sub>2</sub>: **The lack of the technical conditions of vine branch utilization** may be a reason why there were unsuccessful attempts about utilization in larger amounts in different parts of the country.

H<sub>3</sub>: The effectiveness of the use of high moisture by-products is not appropriate as they increase transport costs and reduce heating value.

**The moisture content of vine branches** thus fundamentally **determines economical transport distance and also the plant size that is worth installing.**

H<sub>4</sub>: **Vine branches** could play a significant role in local energy supply at the vine growing regions of the country. **The total amount** of energy recovered **might exceed the total amount of energy from renewable resources with non-biomass origin used in Hungary presently.**

H<sub>5</sub>: Taking **social aspects** into account in energetics essentially **inhibits the utilization of vine branches with energetic purposes.**

## **2. DATABASE AND METHODS**

The research topic is mainly based on primary data. Secondary data were collected to prove the soundness of the topic.

The analysis of domestic and international professional literature supported the importance of the utilization of by-products, and with their help I arrived at the judgment that vine branches are also included in this category. Lacking national experience about the utilization of vine branches I took an international outlook with the help of research results from Italy, Spain and Portugal.

I made experiments to specify the work organizational and economic needs of the collection of vine branches. I conducted a survey to determine the degree of the awareness and the acceptance of vine branch utilization. In the framework of a specific case study I carried out investment profitability calculations on the utilization of vine branches.

I made a national vine branch yield estimation with the help of data of the National Council of Wine Communities, based on my own experiments. I determined the position of vine branches among renewable energy sources assuming the utilization of the total potential volume according to the static tables of Eurostat.

### **2.1 Questionnaire survey**

I assumed that due to the lack of information of farmers the exploitation of vine branches is not yet widespread, so I examined farmers' knowledge about the utilization of vine branches. It was my goal to ensure the maximum possible amount of the raw material base in the future and to give an estimation of it, so I also examined the degree of the acceptance of vine branch utilization by a questionnaire survey. The questionnaires were filled out by the members of the Mátra wine region wine community. A total of 200 questionnaires were filled out in proportion to the members. The results of the survey are representative at the local level, the respondents were selected from the members of all of the wine communities of the Mátra wine region. As a result of the daily contact and the information forums organized for them, the knowledge of farmers is nearly identical, so the sample fully reflects the statistical population.

My questions can be divided into three topics, concerning the data of farms, the utilization of vine branches, and personal data of the farmers. Based on the responses I received I calculated expected frequencies.

In order to achieve that the questionnaires are fully evaluable, I myself visited all the respondents. Thus, at the same time I had the opportunity to make 200 personal interviews. The selection of respondents was carried out by random method, among the local vine growers.

## **2.2 Quantity determination**

Potential estimation is essential before planning the utilization of vine branches. There is a variety of factors that affect the amount of vine branches obtained per acre, the knowledge of which helped selecting the variety collection at parcel number 0171/12 on the outskirts of Nagyréde, where the quantity of vine branches per vine was determined for six varieties.

The first step of the calculation of the potential was the measurement of the resulting byproducts for the different varieties. To make the calculation more precise I specified the data for the vines, for which the corner points of the parcel and the starting and end points of the vine rows had to be recorded by a high-precision DGPS equipment, in the Unified National Projection system. For the estimation of the regional amount I calculated with the average of the obtained results.

## **2.3 The elaboration of the technology of vine branch collection**

I did not have previous information about practical examples of vine branch utilization even at the level of wine communities in Hungary. In several cases, I got information about initial attempts, but utilization did not get widespread, the cause of which is mainly the problems of organizing the collection of vine branches. Accordingly, in my dissertation, I put great emphasis on elaborating an appropriate vine-branch collection technology. To do this, I determined how the utilization of vine branches can be carried out, what processes it consists of, what conditions (e.g. machinery) are necessary, and moreover the costs of all these issues had to be considered.

I studied three collection technologies, baling, chopping in the rows and chopping in depots. To gather information about the technology of baling, I made interviews with two agricultural service suppliers and some machine distributors. I had the opportunity to carry out experiments with chopping methods for several years, which was supported by the machine park of Poplar Private Forestry Ltd and Károly Róbert College. I took detailed notes during the experiments and the interviews, which allowed the documented determination of costs.

I marked out collection nodes for chopping in depots. The first step of this was the analysis of the statistical data and the map stock of wine communities, and then with field surveys I checked for discrepancies, I examined the grape fields of wine communities, agricultural and non-agricultural roads, uncultivated areas and some other factors, such as hindrances.

My next task was to carry out route network optimization. The routes were digitized based on existing maps and GPS measurements taken during the field surveys, on which a geoinformatic database was built using the "ArcGIS" software. The software also allowed the determination of the geometric center of the area.

After collecting the vine branches I conducted interviews with the 13 service suppliers who performed the cultivation of the vineyards and at a wine community meeting I managed to meet the vine growers as well. The purpose of the interviews was to gather feedback whether the activity was useful for them, and whether they intend to participate in the collection of vine branches in the future.

## **2.4 The determination of the energy value of vine branches**

When designing the utilization of vine branches the cardinal question of economic calculations is to determine the amount of biomass that is necessary to elicit 1 m<sup>3</sup> of natural gas. To determine this amount the examination of the following factors is necessary:

- - The determination of heating value;
- - The loss resulting from the efficiency coefficient of boilers;
- - Regulatory and ash losses.

## **2.5 The examination of investment efficiency**

In my dissertation I studied the role of vine branches in heating public institutions at the local government of Gyöngyöstarján, which can be a typical example of good practice for utilizing vine branches for heating public institutions. I performed an analysis of investment efficiency for Gyöngyöstarján on a 15-year period with the cost data of an investment realized in Nagyréde in 2012/2013. The basic data I used came from different sources: the costs of the investment derived from the data of the local government of Nagyréde, while the expected costs of the operation and the savings derived from the results of my own experiments and calculations.

During the analysis I also took the time value of money into consideration. To calculate the present value of future cash flows I used discounting which took the mode of financing into account. For the analysis of investment efficiency I applied the net present value, the internal rate of return, the profitability index, and the discounted payback period indicators.

Changes in the most important economic factors and basic data, for example the appearance of the costs of the raw material (vine branches), changes in the price of natural gas or the increase in the cost of biomass (vine branch chops) production, may result in the significant modification of the indicators of return on investment, so I performed a sensitivity analysis to determine how much the certain factors can change in a way that the investment costs pay off and constitutes a source of income.

### **3. THE MOST IMPORTANT FINDINGS OF THE RESEARCH**

I carried out all the experiments and the technological developments that were necessary for my research in the administrative area of Gyöngyös.

#### **3.1 The examination of the awareness and the acceptance of vine branch utilization in the Mátra wine region**

Presently the vine growers in the Mátra wine region typically burn the resulting vine branches at the end of the vineyard, although they do so to a lesser extent than it is the national practice (51.5%). However, 96 percent of farmers have heard some kind of utilization of the vine branches. In most cases this utilization is in connection with home heating (67.5%), which can be traced back to the fact that farmers typically belong to the older generation, in this case 54.5 percent of the respondents were over the age of 50. Some of the interviewees themselves, or their parents once took home the vine branches bound in sheaves from the vineyard and used them for heating or cooking.

Due to various media coverages (TV, radio, printed media) 58.5 percent of the respondents have heard that vine branches are burned in power plants, and 40 percent were informed about their utilization in public institutions. Only 23.5 percent of them have heard about the utilization possibility of heating glass or foil houses. One respondent has marked another mode of utilization, the heating of the workshop, and he also seeks to utilize vine branches this way. Thanks to the awareness of farmers it is expected that the spread of utilization will not be hampered by refraining from new things that is characteristic at the introduction of new technologies. If there was a plant that processes vine branches nearby, 84 percent of the respondents would offer their vine branches to the plant for free. 4.5 percent of the respondents think about their own utilization, that is the reason why they would not transfer the vine branches, they have no objection to the idea. Some of them would only offer the vine branches, if they were sure that they would not have additional costs, and they also consider it important that the vine branches are taken away from the vineyard as soon as possible, since otherwise they would not be able to start spring works in time on their plantations.

Most of the farmers belong to the older age group, they are typically well-informed and open to new things. Eventually, they do not refuse utilization. Many of them think that the organization of the task and the additional costs of implementation pose problems. However,

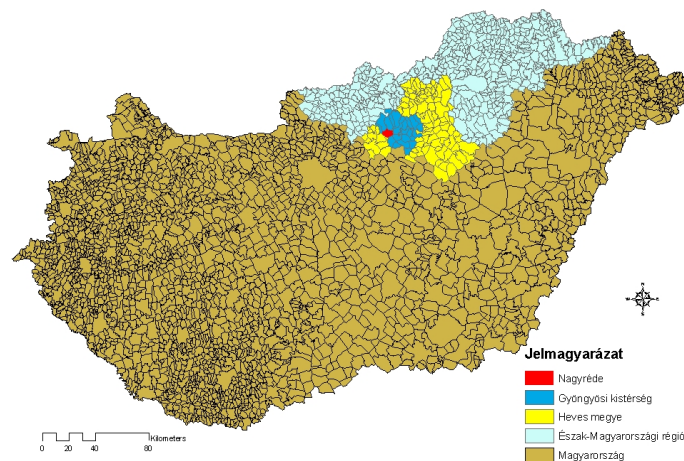
it is clear that most of them have small vineyards, and it is not them who cultivate their plantations.

When designing the collection of vine branches the fragmented areas and the fact that the vine growers can not perform the gathering of the vine branches on their own must be taken into account. When designing the collection technology the cooperation of farmers who have agricultural machinery (about 10%) is needed to achieve the highest possible degree of utilization.

### 3.2 Vine branch yield estimation in the administrative area of Gyöngyös

The selected plot of the yield experiment belongs to the area of Nagyréde wine community in the Mátra wine region. According to the classification by Somogy-Péchi Nagyréde is situated in a valley surrounded by hills at the southern edge of Mátraalja, in the Mátra Bükk landscape. Within the landscape it belongs to the administrative area of Gyöngyös, while administratively to Heves County. The location of the village in the country is shown in Figure 1. As a sample area I selected the variety collection of Gonda Winery, the area of which is 7.9 acres.

**Figure 1: The location of Nagyréde in Hungary**



Forrás: own composition based on TSTAR, 2004

Based on the laboratory results the average moisture content of the examined vine branches was 10 percent when weighed. Based on this results it became possible to calculate the solids content of the resulting vine branch varieties (Table 1) and after a further measurement that of the vines (Table 2).

**Table 1: The amount of vine branches generated in the study area by variety**

Variety	Total by-product (kg)	Solids content of the by-product (kg)	By-product (kg/acre)	Solids content of the by-product (kg/acre)
<b>Blauburger</b>	140	126	1400	1260
<b>Cabernet franc</b>	5120	4608	3200	2880
<b>Blue Frankish</b>	3770	3393	1508	1357
<b>Blauer Portugieser</b>	810	729	1157	1041
<b>Welschriesling</b>	120	108	1200	1080
<b>Pinot gris</b>	2370	2133	1823	1641

Source: own result

**Table 2: The amount of vine branches generated in the study area by vine**

Variety	Number of vines (pieces)	By-product (kg/vine)	Solids content of the by-product (kg/vine)
<b>Blauburger</b>	289	0.48	0.44
<b>Cabernet franc</b>	5154	0.99	0.89
<b>Blue Frankish</b>	7320	0.52	0.46
<b>Blauer Portugieser</b>	1688	0.48	0.43
<b>Welschriesling</b>	254	0.47	0.43
<b>Pinot gris</b>	4369	0.54	0.49

Source: own result

The variety Cabernet Franc produced an outstanding value of 0.89 kg branch yield per vine, the reason of which was ice dam in the previous year. The ice beat the fresh shoots, so more new sprouts were left during the green works to ensure that year's and the next's harvest. It was detectable at the measurement of the branches as well.

The impact of the damage on the branch yield represents the fluctuations of the yield caused by the turbulent thunderstorms not affecting the total area of the region in summer. Based on the investigations 1.5 tons of vine branches is expected per hectare, which is about 0.5 kg per vine.

According to my estimation more than nine tons of vine branches is produced in the administrative area of Gyöngyös annually. It is expected that an annual amount of 150 TJ heating value can be obtained in the administrative area of Gyöngyös by utilizing vine branches with 10 percent moisture content.

### **3.3 The practical development of the technology of vine branch collection logistics**

In practice, I experienced that the farmers do not have any interest in not burning the branches. The legal regulations are not observed, and the control of agricultural areas can not be realized all the time and everywhere. Another important factor is that after the branches are pulled out of the rows the area has to be cultivated urgently. If the field path is narrow, then in case the branches are pulled out of the rows, the machines can not work because of the stacks.

With the full support of Poplar Private Forestry Ltd I started to work out the technology of vine branch collection logistics in 2008.

With the help of my experiments related to the elaboration of the logistics of vine branch collection on the level of wine communities I found out that the most serious task is the organization of vine branch utilization. Transportation decides whether it is economical, that is why I think that there are two models applicable for utilizing the branches in a chopped form.

The biomass was produced by high-performance blade (40/100 m<sup>3</sup>/h, 35-65 mm output) and hammer (360 kW engine power, 220 m<sup>3</sup>/h, 660 mm output) shredding machines, for which the company also had other server machines and tools.

The college has its own vineyards and biomass heating plant. To collect the resulting cuttings an ORSI BTK PEGASUS walking shredder (40mm input, 25-80 HP is required for its operation) which can be connected to a tractor was acquired, with which I carried out additional experiments.

According to one of the models the vine branches are pulled out of the rows after pruning, they are pushed together and dumped, and finally processed with a heavy-duty shredder. For its implementation it is essential to join, group and mobilize local resources, which is only possible in case of self-conscious, well-organized communities.

At municipalities where farmers cultivate the vines themselves, it would be a solution to wait until all the vine branches are pulled out of the lines and become transportable.

By placing flyers at public places, using loudspeakers and organizing informational forums it is soluble to inform stakeholders.

Another alternative is if the branches are pulled out of all the plantations of a vineyard on a given day. In this way, machine utilization is the most efficient and the field paths are immediately free for transportation. It can be realized if the mechanical work is performed by a few major service suppliers on the area of the wine community. This can easily be arranged through personal contact.

The other option is the application of a low-power walking shredder, which blows the chops into its own tank and can be emptied at the end of the row.

As a further result of my dissertation I compared the implementation costs of each technology for the year 2012 based on my own data.

Based on the results of the investigation I determined the cost of vine branch production in case a shredder is used. I also took account of the costs of the baler of Török Ltd. in Nagyréde, which are shown in Table 3. For the first two technologies, the shipping costs are shown separately, where I calculated with a 10 km transport distance, as I examined utilization within the limits of the municipality. For the third technology the calculated value of the economically viable transport distance to a power plant is 45 kms (PINTÉR, 2012).

**Table 3: The cost of vine branch production based on my own data from 2012**

Technology	Production costs (HUF/acre)	Production costs (HUF/ton)	Production costs (HUF/GJ)
<b>Baling</b>			
Baling	12500	8335	521
Picking up the bales and loading	4520	3014	188
Truck with a carrying capacity of 10-15 ton used mostly on paved roads within 10 kms	935	623	39
<b>Total</b>	<b>17955</b>	<b>11972</b>	<b>748</b>
<b>Walking shredder</b>			
Walking shredder	13600	9067	567
Truck with a carrying capacity of 10-15 ton used mostly on paved roads within 10 kms	935	623	39
<b>Total</b>	<b>14535</b>	<b>9690</b>	<b>606</b>
<b>High performance shredder</b>			
Pulling out	6245	4163	260
Crushing	283	189	12
Loading	1743	1162	73
Chopping	15130	10087	630
Transportation	2856	1904	119
Other costs	790	527	33
<b>Total</b>	<b>27047</b>	<b>18032</b>	<b>1127</b>

Source: own calculation

My calculations are based on the average value of my own measurements, which result in 1.5 tons of by-product per hectare, the heating value of which is 16 MJ/kg at a moisture content of 10 percent, resulting in a total expected heating value of 24 GJ per hectare. In order to ensure that my calculations are dynamically transposable even if certain conditions are changed (e.g. the amount of by-products), I determined the costs for a hectare, a ton and also for one amount of heating value.

### **3.4 The determination of the energy value of the vine-branch**

One of the most unfavorable characteristics of plant biomass forms is that they contain a significant amount of water at the time of their collection. Because of this unfavorable feature of the vine branch I applied natural drying when I was designing the logistics of the collection in order to reduce costs. The chopping lasted for one month, during which period the moisture content of the transported goods was measured on every occasion. It was an apparent result of the study that the moisture content of the vine branches got very low in quite a short time, by the end of May 2009, the moisture content measured at the time of transportation was around 10 percent. The moisture content which was close to 35 percent at the time of the pruning may reduce to 10 per cent in only 50 days under appropriate weather conditions.

The amount of vine branches required to substitute natural gas, taking into account the impact of some specific factors (1% ash loss, 10.1% boiler efficiency loss) with a 2 °C heat loss from overheating, can be estimated on the basis of Table 4.

**Table 4: The amount of vine branches required to substitute 1m<sup>3</sup> of natural gas**

Moisture content (%)	The heating value of the wet material (MJ/kg)	Heat loss (MJ/kg)	The amount of vine branches required to substitute 1m <sup>3</sup> of natural gas (kg)
0	18,0	4,26	2,49
1	17,8	4,21	2,52
2	17,6	4,16	2,55
3	17,4	4,11	2,58
4	17,2	4,07	2,61
5	17,0	4,02	2,64
6	16,8	3,97	2,67
7	16,6	3,92	2,71
8	16,4	3,87	2,74
9	16,2	3,82	2,77
<b>10</b>	<b>16,0</b>	<b>3,78</b>	<b>2,81</b>
11	15,8	3,73	2,85
12	15,6	3,68	2,88
13	15,4	3,63	2,92
14	15,2	3,58	2,96
15	15,0	3,53	3,00
16	14,8	3,49	3,04
17	14,6	3,44	3,09
18	14,4	3,39	3,13
19	14,2	3,34	3,18
20	14,0	3,29	3,22
21	13,7	3,24	3,27
22	13,5	3,20	3,32
23	13,3	3,15	3,37
24	13,1	3,10	3,42
25	12,9	3,05	3,48
26	12,7	3,00	3,53
27	12,5	2,95	3,59
28	12,3	2,91	3,65
29	12,1	2,86	3,71
30	11,9	2,81	3,78
31	11,7	2,76	3,84
32	11,5	2,71	3,91
33	11,3	2,66	3,98
34	11,1	2,62	4,06
35	10,9	2,57	4,13
36	10,7	2,52	4,21
37	10,5	2,47	4,30
38	10,3	2,42	4,38

Source: own calculation

### **3.5 The role of vine branches in the heating of the institutions of the local government in Gyöngyöstarján**

It is a good opportunity for the municipalities of Hungary where vine growing is present, but pruning clippings are not utilized, and the gas boilers of the institutions of the local governments are outdated, and they are not able to either replace the windows or insulate the buildings, to utilize the vine branches for heating purposes. Gyöngyöstarján is also such a settlement, where the natural gas needs of all the institutions of the local government is close to 64.000 m<sup>3</sup> annually, which is an expenditure of nearly 9 million HUF per year.

Based on my investigations presented above it can be stated that calculating with 1.5 tons of vine branches per hectare with 10 percent moisture content 24 GJ heating value is created, a which is equal to the heating value of 697.7 m<sup>3</sup> of natural gas. The residual ash and charcoal still contains unused energy, so only 691 m<sup>3</sup> of natural gas has to be substituted. I calculated with a 10.1 percent loss difference between the efficiency of the gas boiler and the biomass boiler. The 2 °C heat loss from overheating resulting from the heating technology means an additional 2000 kJ loss per kg. Thus, taking into account the various influencing factors, calculating with a 2 °C heat loss from overheating, 180 tons of vine branches with a moisture content of 10 percent is required for the heating of the institutions of the local government of beaded Gyöngyöstarján. According to the potential estimation 4.5 times of this amount of vine branches is generated in the vineyard areas of municipality each year.

Based on my experiments, the production costs of the vine branch chops is 9,690 HUF per ton, in case walking shredder technology is applied, which includes the crushing and transport costs (for 10 km transport distance) as well. The walking shredder picks up the branches in the rows of the vineyard, at which time the moisture content of the branches is 20 percent on the basis of my laboratory examinations. Due to the smoothness of viticultural work, the branches should not be left in the rows for drying, they must be dried in a container. Because of the extra moisture content, 10 percent more branches should be collected from the area. It is essential to establish a well-ventilated premise for storing the chops. Accordingly, the production costs of the vine branch chops necessary for the heating of the institutions of the local government in Gyöngyöstarján is 1.92 million HUF, which is 7.15 million HUF less than the annual cost of the natural gas consumption of the local government.

On the basis of my results the utilization of the vine branches is much more favorable than the use of natural gas. However, a significant amount of investment is required for its collection and utilization (the purchase of the machinery, the establishment of a vine branch container, the conversion of the heating system).

In the next step of my dissertation I examined the expected (most likely) cash flow, the investment costs necessary for installing a heating system based on biomass firing in the institutions of the local government in Gyöngyöstarján on the basis of regional investments in the previous year, designed for a 15 year useful life period.

In this case, assuming funding solely on the local government's own merits, I examined the profitability of the investment. To determine the interest rate I used the most favorable long-term commercial bank deposit announced by commercial banks, the rate of which is 4.4 percent at present.

By the use of biomass additional personal needs/costs occur. I assume that 3 people have to be employed for this purpose in the framework of the local government's public works program, the gross cost of which is 95,700 HUF/month.

Increase in the value of the costs and revenues can be caused by price changes on the one hand, and the increase in expenses on the other hand. In my study I did not calculate with materials cost because I assumed that the investment is operated with waste materials and by-products, which currently do not have a receipt price. For designing the production and the shipping costs of vine branch chops the basis of my calculation was the results of the experiment with the walking shredder. The maintenance and repair costs of boilers were also taken into account according to raw materials costs denoted by the manufacturer's recommendation (Halex 3 Ltd.). If they are continuously and properly carried out, it is not necessary to calculate with other major renovation costs during the 15 year life period of the investment.

To estimate the price changes of biomass production I calculated with a continuous price increase of 9 percent applied by Poplar Private Forestry Ltd. in the previous period. I assumed 10 percent annual increase in maintenance and repair costs. According to the database of the Central Statistical Office I calculated with a 5 percent increase in personnel costs per year.

To determine the annual amortization expenses, the individual factors were treated separately. For building type investments (storage, boiler house, flue drainage) I used an average 3 percent, while for production equipment (boilers, HM storage) I used a 10 percent linear depreciation rate.

During the 15-year life period of the investment heat energy savings are generated each year, the value of which is the price of natural gas savings reduced by the costs of the production of vine branch chops.

Under the test conditions, the investment is worth implementing, which is confirmed by the investment-economic indicators shown in Table 5.

**Table 5: Investment-economic indicators**

<b>Indicator</b>	<b>Value</b>
<b>Net present value (NPV)</b>	87,363,000 HUF
<b>Discounted payback period (DPP)</b>	5.46 years
<b>Profitability Index (PI)</b>	7.7
<b>Internal Rate of Return (IRR)</b>	25%

*Source:* own result

To evaluate the investment I calculated the net present value, which is an indicator that can be used on its own. Its value is more than 87 million HUF, which means that during the 15 years life period of the investment, it generates 87 million HUF more revenue than it would do if the local government put it in a bank. This sum should provide compensation for the possible additional risk in comparison to other investment opportunities. I calculated the payback period with the indicator discounted payback period, the value of which is 5.46 years, which means that the money invested pays off in less than six years. The profitability index of the investment is 7.7, which provides additional information when compared to other alternatives. The investment's internal rate of return is 25 percent, which is higher than the profitability of the available alternative uses of capital (4.4% deposit rate), so the investment is worth implementing based on this indicator too.

### *3.5.1 Risk analysis of the return of the investment*

I assumed that if the risk factors change, the return on investment is not guaranteed. In case the properly dry storage of the vine branches is not soluble, then it is possible that it will dry only to a 15 percent moisture content. In this case, 202 tons of vine branches with 20 percent moisture content has to be collected, the production costs of which is 1,954,000 HUF. According to my calculations the investment pays off within 6 years (DPP = 5.55 years) even in this case, and it generates 85 million HUF revenue by the end of the 15<sup>th</sup> year. It means that the additional need for vine branches does not significantly impair the potential return on investment.

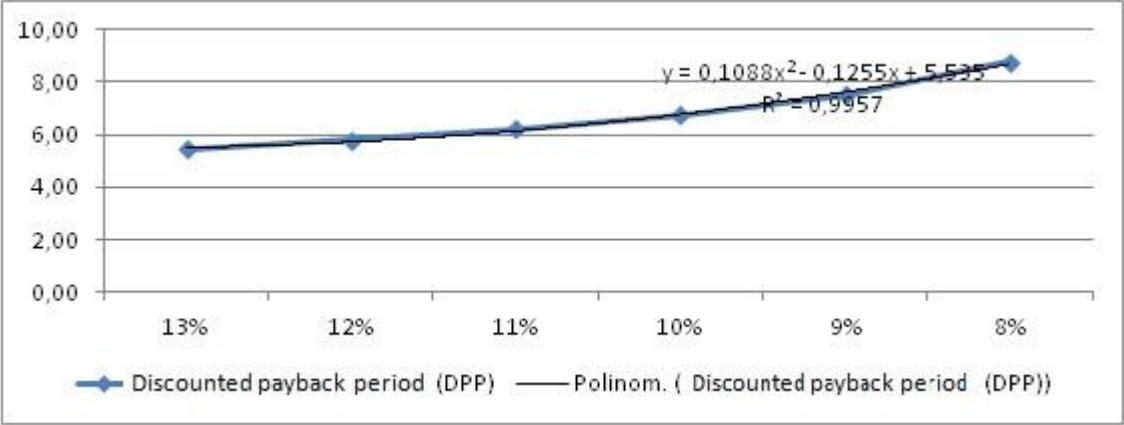
Another risk factor is the appearance of the price of the raw material, and its continuous growth (10%) in the future. I took into consideration the modifying impact of the price of raw material that is currently available for free on the examined indicators by applying a scale with 1,000 HUF increments. According to my calculations the investment is probable to pay off during the planned 15 year life period with a maximum raw material price of 20,000 HUF (DPP = 14.59 years), but based on the internal rate of return (IRR = 5%) the limit at which the investment is worth implementing is 17,000 HUF.

It is also possible that in the future the collection of vine branches from the area will not be done by walking shredders, but by the baling method. The technology choice can be justified, for example if the soil is plowed together in the area in order to improve its water management characteristics, which reduces the efficiency of the walking shredders. The use of the baling technology is 2,000 HUF/ton more expensive than the collection with walking shredders. I examined the effect of the additional cost of the baling technology on the return of the investment taking different raw material prices into account. In this case, the investment is probable to pay off during the planned 15 year life period with a maximum of 15,000 HUF per ton raw material price, but according to the internal rate of return (IRR = 5%), the limit at which the investment is worth implementing is 13,000 HUF.

Due to reduction of maintenance costs that has taken place in several steps recently, I assumed that, in contrast to the 15 year trend, the increase in the price of natural gas may be lower than the average in the future. The results of the related sensitivity analysis show that the most influential factor of the return on investment is the changes in the price of natural gas. If it is smaller than the 8 percent average annual increase, it will not be worth

implementing the investment (in case of 7% increase the value of IRR is 3%). The effect of the increase in natural gas prices during the return period is demonstrated by Figure 2.

**Figure 2: The expected payback period depending on the changes in the price of natural gas (years)**



Source: own result

The polynomial trend line fit for the data fits the data points with high precision ( $R^2=0,9957$ ) in the regression domain, which supports the result that if the price of natural gas rose by less than the expected value in the coming years, then the investment would pay off even later.

In the previously presented investment analysis I assumed funding solely on the local government’s own merits, without resorting any loans or grants. At the same time the mitigating effect of the public works programs implemented in recent years on the expenditure of local governments should not be ignored. The state takes over the personal expenses after the employment of the 3 people planned at the annual expenses of the investment, thus lightening the burden on local governments. Personal expenditure makes up to 59 per cent of the planned annual expenditure, therefore I made a new calculation (with the previously defined basic data) for the payback period of the investment.

The result of the examination shows that the State's takeover of personnel costs significantly improves the possibility of the return on investment, which is confirmed by the investment-economic indicators in Table 6.

**Table 6: Investment-economic indicators**

<b>Indicator</b>	<b>Value</b>
<b>Net present value (NPV)</b>	138,915,000 HUF
<b>Discounted payback period (DPP)</b>	2.67 year
<b>Profitability Index (PI)</b>	11.6
<b>Internal Rate of Return (IRR)</b>	44%

*Source:* own result

The net present value which was calculated to evaluate the investment is 139 million HUF, which means that the investment will pay for in case of the cash flows I assumed, and generates profit as well. The City Council is likely to have 139 million HUF more cash than if they had put the money in the bank. The payback period on the basis of the discounted payback period indicator is 2.67 years, which means that the money invested pays off in less than three years. The profitability index of the investment is 11.6 which is also more favorable than if the personnel expenditures were also included. The investment's internal rate of return is 44 percent, which is considerably higher than the profitability of the available alternative uses of capital.

## 4. NEW AND NOVEL RESULTS

The overall objective of my doctoral (PhD) dissertation is to raise the awareness of farmers and policy makers of the wasteful behavior of agriculture, and also to elaborate a method of vine branch utilization which would facilitate changes in that. To achieve this goal, I formulated five specific objectives and five hypotheses related to them. During the examination of these I got to the following conclusions:

1. As a result of the combination of a questionnaire survey with interviews conducted in the wine region of Matra it can be stated that farmers, despite the fact that most of them belong to the older age group, were typically well-informed and open to new things. However, I have shown that the region is fragmented, most of the farmers have small vineyards, and in many cases it is not them who work on the land. Lacking the necessary machinery they are not planning to utilize the vine branches in the near future. However, they do not refuse to utilize them. Based on the results it can be stated that, despite the H1 hypothesis, the problem is not the lack of information, but the additional costs of the organization and implementation of the tasks.
2. Based on my several year experience of vine branch collection in the wine region of Máttra it can be stated that contrary to my H2 hypothesis the reason for the lack of collection is not the immaturity of the technological background, but the difficulty of organizing the utilization of the collected vine branches. The results of my investigations reveal that the chopped vine branches can be collected by 2 different technologies from the field.

According to one of these technologies the vine branches are pulled out of the rows after pruning, they are pushed together and dumped, and finally processed with a heavy-duty shredder. The use of a high performance shredder is expedient for deliveries for industrial installations and power plants, as in case of municipal level use the appropriate level of utilization of the machines can not be solved.

The other option is to use a low-power walking shredder, which blows the chops into its own tank and at the end of the row it can be emptied on a trailer. Based on the observations I suggest the use of walking shredders for local governments. The major disadvantage of the technology is that the machine does not work at full efficiency on uneven ground surface, it does not pick up all the branches.

To realize the collection of the branches it is essential to join, group and mobilize local resources, which is only possible in case of self-conscious, well-organized communities.

3. I found out, when measuring the moisture content of the vine branches in several steps by taking samples from the different varieties during the transportation to the power plant, that moisture content can decrease to 10 per cent in the open air, which means that my H3 hypothesis is not true, moisture content does not deteriorate the efficiency of utilization. The residual ash and charcoal still contains unused energy, there can be some loss between the efficiency of gas boilers and biomass boilers, and there can also be some heat loss deriving from the heating technology at overheating. Taking these losses into account, 2.8 to 3 kg of vine-branches with 10-15 percent moisture content can substitute 1 m<sup>3</sup> of natural gas.

The investment in my examinations which facilitates the utilization of the chopped vine branches at the institutions of the local governments of Gyöngyöstarján may pay off in only 6 years, and during its operation it can save up to 86 million HUF surplus to the return of alternative costs over the planned 15 year operation period, by not having to pay for natural gas.

4. My experiments related to the amount of vine branches indicate that my H4 hypothesis is true: a significant amount of by-products (vine branches) deriving from vine growing is produced in Hungary every year. The energy value of it is 1.7 PJ (with 10% moisture content) calculating with 1.5 tons per hectare of by-products that is characteristic of the Mátra wine region. This amount of energy is close to the amount of solar and hydropower produced in Hungary annually (1.8 PJ), and half of that of geothermal power (4 PJ). 2.7 percent of the energy from biomass and wastes could be produced from vine branches.
5. Based on the analysis of investment efficiency my H5 hypothesis is not true: the risk analysis of the investment shows that taking social aspects into account may have contradictory effects, the price reduction of natural gas (the reduction of maintenance costs) has a negative effect, while the support for wage contributions (public works program) has a positive effect on the return of these investments.

## **5. THE THEORETICAL / PRACTICAL USEFULNESS OF THE RESULTS**

In practice, my new and novel results may be useful for agricultural stakeholders and also for policy makers. The results may help the domestic use of vine branches by the presentation of the method I have experienced, the determination of helping or inhibiting factors, and the exploration of other viable solutions. My research results may help policy makers on renewable energy to prove that the significant amount of state subsidies recently introduced, which were aimed to support the investment of local governments into the utilization of biomass, are sustainable in case the by-products are utilized, and thus the investments will pay off.

In my opinion, the exploration of further, perhaps presently unused by-products, the determination of their amount and the elaboration of ways of usage would be necessary in the future. I can see such opportunities related to woody by-products in the institutional and residential utilization of trimmings resulting in orchards and in forest management in the joint utilization of branches, chumps and logging waste in small power plants with a capacity of a few MWe.

For a further research area I would suggest the measurement of the affecting factors of vine branch utilization on rural development, such as its effect on employment, energy management and environment protection.

## **6. PUBLICATIONS RELATED TO THE SUBJECT MATTER OF THE THESIS**

### **Foreign language peer-reviewed articles in journals and periodicals**

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### **Hungarian language peer-reviewed conference papers**

**Gonda C. – Ambrus A. – Szűcs A. (2011):** Termőhely-Specifikus Térinformatikai e-szaktanácsadási rendszer. Agrárinformatika konferencia 2011, Innovatív információtechníák az agrárgazdaságban. ISBN 978-615-5094-05-7 Debreceni Egyetem – Debrecen, Konferencia Kiadvány pp. 227-233.

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