Evaluating possible solutions of building a small-scale heating and/or power plant based on biomass in the conditions of a private farmer in the Middle Slovakia

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"Master of Science"

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Affidavit

I, **Pavol Lunter,** hereby declare

1. that I am the sole author of the present Master Thesis, " Evaluating possible solutions of building a small-scale heating and/or power plant based on biomass in the conditions of a private farmer in the Middle Slovakia ",
   34 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and

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Abstract

Small-scale farms are nowadays a common part of the agriculture system in Slovakia. Projects based on the renewable energy sources could be a possibility for the farmers to develop their farms. The objective of this work is to propose a solution of such RES based project to a farmer operating in the specific condition of the Middle Slovakia. For these purpose three alternatives have been chosen. All three alternative solutions focus on the sources currently available in the farm. After stating the amounts of energy that can be produced with the specific technology an economic model of calculating the net present value was applied. Two from the assessed alternatives are not recommendable due to the negative net present value calculated over the project life time.

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Acronyms

CHP	Combined heat and power
DS	Dry substance
EU	European Union
EUR	Euro (currency)
NPV	Net present value
RES	Renewable energy sources
SKK	Slovak crown (currency)

Units

d/a	days per year
GJ	gigajoule
ha	hectare
kg/d	kilograms per day
kW	kilowatt
kWh	kilowatt hour
kWh/d	kilowatt hours per day
kWh/m^3	kilowatt hours per cubic meter
m^3/a	cubic meters per year
m^3/d	cubic meters per day
m^3/t	cubic meters per ton
MJ/kg	megajoule per kilogram
MW	megawatt
t	ton
t/a	tons per year

1. Introduction

Although having very diverse landscape, Slovakia is a traditional agricultural country. Specific type of agricultural production depends very much on microregional ambience. Thus we can find warm localities with favourable conditions for growing traditional central-european vegetables, wide corn fields, hilly regions with wineyards and orchards as well as regions in the mountains with tough conditions, where only low demanding crops or plants can be grown.

Agriculture in the past was characterised by large ammount of small scale farmers and simple type of agricultural products. During the communist period large cooperatives had been formed which destroyed the traditional relations between people and their own land. Everything belonged to anybody but in fact to nobody. After this period several cooperatives went bankruptcy, other have been transformed to business companies and a large ammount of farmers got back to small scale farming.

In the reality of common agricultural policy of European Union, many of the farmers as well as farming companies have to reassess the philosophy of their business. Some of the traditional agricultural products of specific regions become no more competitive, some product are completely out of market. And some agricultural production finds new markets – industry, energy, transportation.

1.1 Motivation

During his studies, author used some of his holidays to work on his uncle's farm. Since the local mountainous climate does not allow to grow nearly any cultivated plants, the farm is oriented on dairy production, based on haylage. After 17 years of growing production the farmer has to cope with changing conditions for his work due to various EU directives and regulations. Thus he started to think about various possible ways how to develop or direct his business. This is the right time to assess his business also through the RES optics.

1.2 Core objective

The main aim of this work is to select, describe and evaluate possible alternatives of producing the renewable energy in the conditions of a real farm. The renewable energy production should supplement the agricultural production or offer another possible business opportunity to the farmer. This work should give the first impuls for the farmer to start considerations. The evaluation of the alternatives will be focused on their own economy. But it can serve as a basis for evaluating the economy of the farmer's business after implementing a new RES based project.

1.3 Structure of work

The topic of the work is handled in six chapters. First chapter introduces the topic and the motivation. In the second chapter the legal environment of the renewable energy sector in Slovakia is given as well as the introduction of the specific farmer's situation and resources. The third chapter is about the choosing of alternatives and their basic description. In the fourth chapter there is the technical description of the alternatives and heat and power production characteristics are described. Fifth chapter is the summary of energy production and economical evaluation of the alternatives. Sixth chapter concludes the results and gives recommendations for further possible steps.

2. Actual situation

2.1 Description of the legal situation in RES

Slovak legislation system consists in general from laws issued by national parliament and regulations and ordinances issued by government, ministries and other responsible offices and units. In the energy sector the responsible ministry is the Ministry of Economy. The regulation issues are handled by the Regulatory Office for Network Industries. Other important offices are Slovak Innovation and Energy Agency and Slovak Energy Inspection. The Act handles also the duties of power and gas grids operators.

Main law dealing with the energy issues is the Act Nr. 656/2004 on Energy. This Act defines the rules for energy sector and gives the general rules for business in the sector. It also states roles of responsible offices and sets the energetic interests of the state. Act on Energy is dealing with the branches electricity and gas industry. The topic of renewable sources is handled as it comes to power and gas production from RES. The Act is showing basic interest of state in promoting the RES, but this promotion is rather limited. For example, RES projects are excluded from the obligation of applying for a license, but only projects with installed output up to 5 MW. Other example: distributors of electricity are obliged to purchase the power produced from RES. This obligation is however limited to ammounts that are equal to losses of energy in the grid. Moreover this kind of preferred purchase is valid also for power produced from domestic coal or in combined heat and power plant.

Other act influencing the operation of biogas plant is the Act Nr. 657/2004 on Thermal Energy. Under some conditions it states the obligation of purchase of heat produced from RES. There is no special statemne regarding the biogas plant in this Act. However biogas plants are usually designed with the heat supply, so this act regulates the possibility of feeding the heat from biogas plant to public or private heating grids.

Important document dealing with feed-in tariffs for several energy sources is the Regulation Nr. 2/2007 of the Regulatory Office for Network Industries. This Regulation states the exact feed-in tariffs for specific types of RES. The feed-in tariffs are stated for the year 2008 and the mechanism for increasing the tariffs for the following years is defined. Usually a new regulation is issued every year, so that it reflects the actual priorities in RES. For the biogas the actual Regulation is stating following feed-in tariffs:

- for power produced using the biogas from sewage water treatment plants and landfill gas in the height of 2,630 SKK/MWh (ca 79.70 EUR/MWh);
- for power produced using the biogas from anaerobic fermentation technology in plants with installed power up to 1.0 MW in the height of 4,310 SKK/MWh (ca 130.61 EUR/MWh);
- for power produced using the biogas from fermentation technology in plants with installed power over 1.0 MW in the height of 3,900 SKK/MWh (ca 118.18 EUR/MWh) [6].

2.2 Description of resources of the specific farmer

The considered farm is located in the middle Slovakia. The village of Telgárt is the east-most community of the Brezno district, which belongs to the self-governing region of Banská Bystrica. In the village there are living 1,531 people.

The local climate is influenced by several factors. First of them is the the altitude, which is 881 m a.s.l. (village centre). The village is lying on the slope of the Nízke Tatry mountains. Quite high altitude is combined with the specifics of the location in the valley of the river Hron. The local climate is rather cold and coarse. Last summer periods have been increasingly wet.

The farmer has 100 ha of meadows available for hay production and further 70 ha of pasture. The local climate allows that 70% of the meadows are mowed twice a season. The farmer is using bale methods for producing hay and haylage.

After the grass is mowed and dried to certain content of water, it is pressed to bales in form of cylinders with a diameter and height of 1.2 m. The number of animals can be expressed in the form of adult units which means a 650 kg heavy animal. The farmer has 40 such adult units.

3. Choosing and description of alternatives

3.1 Choosing of alternatives

Renewable energy sources are in their essence „local“ sources. Using of the renewable energy source has to respect the local conditions of the specific place. Otherwise the project can become non-renewable although using renewable sources. On the other hand, commercial projects using RES also have to show certain economy. This means every project has to be thoroughly assessed for fulfilling the given legal and business conditions as well as for economical viability. These preconditions influence also the choosing of appropriate alternatives for evaluation.

Generally, the aim is to offer solution, which uses very much the current know-how and available equipment of the farmer. From this reason we excluded renewable sources like wind, water or solar and focused further on the usage of available biomass. The available biomass and its reasonable usage is given by the local conditions of the farm such as climate, landscape, possible usage of the energy.
Taking into account the above mentioned criteria and commercially available technologies, following three alternatives have been chosen for further evaluation: biogas power plant, biomas combined heat and power plant and communal heating plant.

3.2 Description of alternatives

3.2.1 Biogas power plant

One of the actual problems the farmer is coping is handling the manure. Current EU regulations do not allow to distribute the fresh manure to the fields. The manure has to be stored in a certain manner and ripened before further usage. To be able to follow these regulations, the farmer has to invest some money into the manure storages or other systems of manure handling. Biogas power plant means in this case solving of two problems at the same time. Building the plant infrastructure offers the possibility to

handle the manure until it becomes a fertilizer that can be distributed to the fields without restrictions. On the other hand the biogas plant allows the farm to use the renewable energy stored in the biogas, which is in this case a by-product of handling the manure. The biogas power plant will be designed with respect to current farm conditions as it comes to number of animals and available ammounts of the biomass. Excess heat can be used for heating the farm houses and guest house.

3.2.2 Biomass CHP

Second possible alternative is the biomass fired combined heat and power plant. The hay can be fired in a special type boiler, produced steam can be fed into a steam turbine. Exhaust heat can be used for the purposes of heating the farm houses and guest house. Awaited excess heat can be utilized either for final drying of the hay or for drying of the wood for the nearby local sawmill. This type of project would however expect that the number of farm animals will be reduced. This would secure that the actual field area covers the hay consumption of the CHP plant. The number of the animals should be stabilized to ammount, which would on the other hand secure enough manure to be used for natural fertilizing of the fields. For the purposes of this work, we will not consider the influence of decreasing the number of animals on farm economy. In current situation the plant economy depends on the state subvention which is somehow a function of the number of animals.

3.2.3 Communal heating plant

In the village where the farm is located, several buildings are administrated by the community such as local authority's office, primary school, special school or community centre and workshops. Since there is no natural gas grid available in the village, community houses are heated by local coal boilers. The third alternative solution for the farmer will be the taking over (outsourcing) of the heat supply for the community. The fuel for the heat supply system will be hay produced by the farmer. Since the heated buildings are distributed in the village, only three of them would be taken into account to be connected to a heating grid: authority's office, school and workshops. A new boiler will be installed on the available community's facilities as well as a pipework connecting the three mentioned buildings. In this case no power production is considered, thus there is no need to install rather complicated steam boiler with respective auxiliaries.

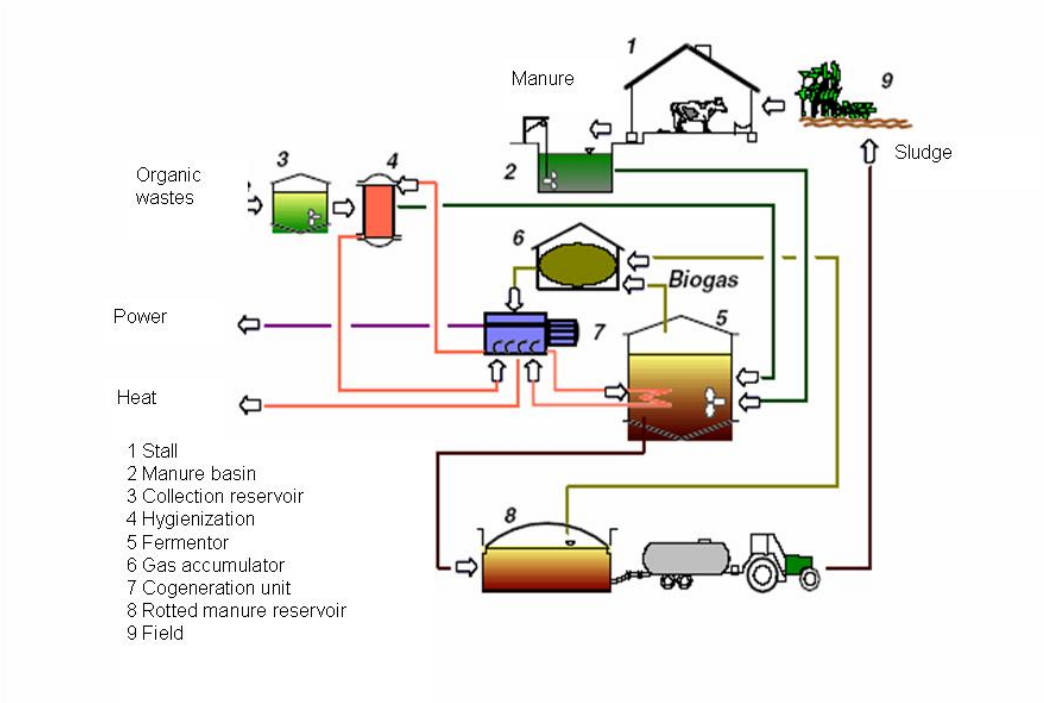
4. Technical specification

4.1 Technology specification

4.1.1 Biogas Plant

The design of the proposed biogas plant is matching the actual situation of the farm. The purpose is to process the existing ammount of the manure and rests from the haylage production. From he point of view biogas technology it is a co-fermentation of the cattle manure in solid and liquid state with the rests of the haylage production. From this reason a wet fermentation process has been chosen. The process diagram of the plant is similar to that one shown in the Figure 4.1 with one exception. In the case where organic wastes like animal fats are used in the biogas production process, the hygienization step (point 4 in the figure) is needed. This means that the input material is beeing preheated to elevated temperatures to destroy microbs potentially hazardous for health. In the case of our example there is no need of such hygienization step in the biogas plant.

For the purposes of this work a cogeneration unit Micro T25 AP BIO from the Czech producer Tedom was chosen. The basic data is given in the Table 4.1.



Source: Handreichung Biogasgewinnung und -nutzung, Fachagentur Nachwachsende Rohstoffe e.v., 2005

Figure 4.1: Basic process diagram of a farming biogas plant

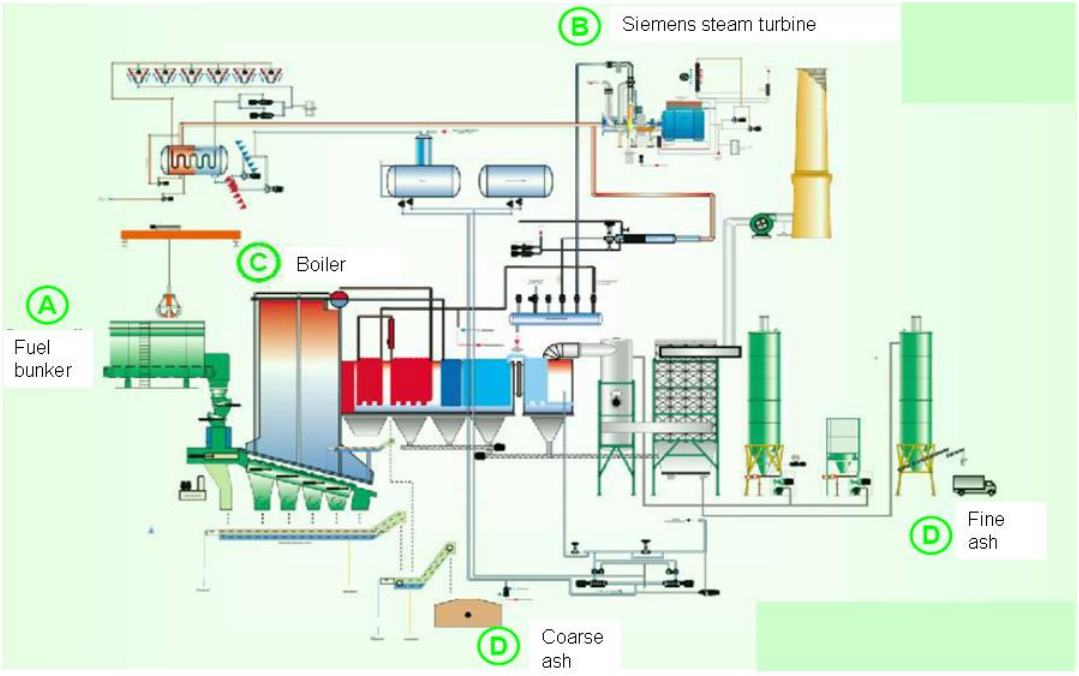
Table 4.1: Basic data of the cogeneration unit Micro T25 AP BIO		
Nominal power	23	kW
Max. heating output	41.5	kW
Fuel input	75.5	kW
Electrical efficiency	30.5	%
Thermal efficiency	54.9	%
Total efficiency (fuel usage)	85.4	%

4.1.2 Biomass CHP

The design of the biomass CHP plant comes out from the precondition that the hay produced in the farm is used for the purposes for power and heat generation. Only

a part of the hay is used to feed the cattle which is further kept to secure the sufficient manure production. The combined heat and power plant is based on a biomass boiler capable of burning hay. In the case of burning hay one of the most important problem is the low ash melting temperature. Since the melting ash could precipitate on the heat exchanging surfaces thus decreasing the heating transfer some solution should be used in the boiler construction to prevent this. Similar solution is used in the incinerator system Reject Power from Siemens. Flue gas is cooled below the ash melting temperature before entering the heat exchange section. This results in lower fuel energy usage although the parameters of produced steam are still enough to use the steam for power generation in a steam turbine. Basic process diagram of a biomass combined heat and power plant is given in the Figure 4.2.

The plant uses a Siemens pre-designed back-pressure steam turbine SST-060 with nominal output of 50 kW. The turbine is an overhung design, one wheel machine with gearbox and oil system integrated in the base frame. The turbine is capable of quick starts and is weel known and appreciated for the high reliability and low maintenance costs. For the purposes of this work we do not take into account the usage of a steam condenser. The steam from the turbine back-pressure is led directly to the heat consumer which can be for example a wood dryer for the nearby sawmill. In case of burning the hay also the flue gas cleaning system should be adapted to the fuel burned.



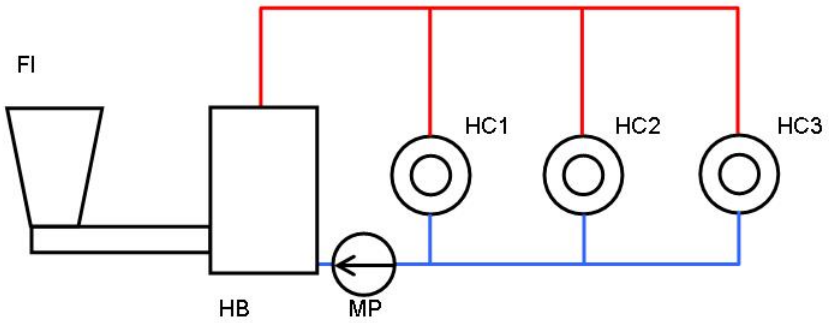
Source: Siemens

Figure 4.2: Basic process diagram of a biomass fired CHP plant

4.1.3 Communal heating plant

From the point of view technology the heating plant represents the most simple solution among all proposed alternatives. The technology part consists of a boiler which has to be designed for the hay fuel, piping, pumps and respective heat exchange units in the heated objects. This means that the design of the boiler should be capable of the low ash melting temperature like it was in the biomass CHP alternative. This should not be a big problem since the output medium is warm water which is not as demanding for the boiler design as the steam. Basic process diagram of this alternative is given in the Figure 4.3.

Since the heated objects are not far from each other (up to 100 m), small piping grid is considered. This solution does not require complicated solution. For the piping pre-insulated pipes are considered.



FI	Fuel Input
HB	Hay Boiler
MP	Main Circulating Pump
HC1,2,3	Heat Consumer 1,2,3

Figure 4.3: Basic process diagram of a heating plant

4.2 Heat and power production

For each alternative the ammount of input and produced usable energy has to be stated. These energy flows are important for the purposes of economic evaluation of the proposed alternatives. Since each alternative represents other type of energy production, different characteristics are important in every specific case.

4.2.1 Biogas Plant

The biogas production is very much depending on the raw material availability and quality. The type and ammounts of raw materials for the biogas plant are given by the conditions of the farm. These details as well as the respective gas production are listed in the Table 4.2.

Table 4.2: Raw materials and gas production of a biogas plant				
Raw material	Ammount		Gas production	
	[t/a]	[kg/d]	[m^3/d]	[m^3/a]
Solid cattle manure	496.4	1,360.0	62.4	22,785
Liquid cattle manure	306.6	840.0	21.9	8,003
Haylage	249.6	683.8	123.8	45,174
SUM				75,962

Since there were no characteristic measurements of the real raw materials available, for the purposes of this work coefficients needed for gas production calculation have been used from the literature. The coefficients needed for calculation of the biogas production are listed in the Table 4.3.

Table 4.3: Coefficients for calculation of biogas production			
	Dry Substance	Organic DS	Biogas production
Solid cattle manure	25.00%	72.00%	255 m^3/t of ODS
Liquid cattle manure	9.50%	78.50%	350 m^3/t of ODS
Haylage	37.50%	82.50%	585 m^3/t of ODS

Source: Handreichung Biogasgewinnung und -nutzung, Fachagentur Nachwachsende Rohstoffe e.v., 2005

Based on the calculated ammount of biogas production and expected operation period, respective cogeneration unit has been chosen (see Table 4.4 and Table 4.1).

Table 4.4: Dimensioning of the cogeneration unit	
Expected operating time	335 d/a
Gas calorific value	6 kWh/m^3
Total energy in biogas per year	455,772 kWh
Daily energy in biogas (operating day)	1,360.5 kWh/d
Electrical efficiency	30.5%
Heat efficiency	54.9%
Design engine output (20% reserve)	23 kW

4.2.2 Biomass CHP

In the CHP plant based on biomass fuel there are two main characteristics of the fuel important for calculating the energy output: dry matter and calorific value. The calorific value strongly depends on the dry matter content of the material. Dry matter content itself also influences the fuel handling and burning process. In this work we do not handle specific problems of burning the biomass, especially hay. From this reason we assume the dry matter content of 20%. Respective calorific value and energy content of the available fuel are listed in the Table 4.5.

Table 4.5: Energy content of available hay	
Available field area	100 ha
Hay production, 1st mow	300 t
Hay production, 2nd mow	200 t
Available energy crop (80% of hay production)	400 t
Hay calorific value	14 MJ/kg
Yearly energy content	5,600 GJ

For the known ammount of energy in the hay and expected operation time, respective boiler with steam turbine is proposed (Table 4.6).

Table 4.6: CHP plant design	
Expected operating time	335 d/a
Boiler heat output	205 kW
Electrical efficiency	25%
Design turbine output	50 kW

4.2.3 Communal heating plant

The design of the heating plant is made opposite to previous cases. In this case the base for the design was the heat demand of the communal buildings to be heated. This heat gives then the ammount of hay to be burned in specified boiler. Since there were no exact values of the heat demand of the three communal buildings as well as needed boiler output, values from similar project have been used for the purpose of this work

(Table 4.7). As we will see later, the results of the economic analysis will not be influenced very much with small changes in the plant output.

Table 4.7: Heat demand definition	
Expected operating time	335 d/a
Boiler heat output	150 kW
Yearly heat demand	1,680 GJ
Boiler efficiency	89%
Yearly heat demand in fuel	1,887 GJ

While the heat demand of the heating plant is given, respective ammount of needed fuel is calculated. In this case we set the same fuel characteristics as in the CHP plant alternative. (Table 4.8)

Table 4.8: Fuel production for heating plant	
Available field area	100 ha
Hay production, 1st mow	300 t
Hay production, 2nd mow	200 t
Total hay production	500 t
Hay calorific value	14 MJ/kg
Ammount of hay for covering the boiler output	135 t

5. Economic evaluation of alternatives

The aim of this work is to propose possible technical solution of a RES based project for the farmer as well as its economic evaluation. For the economic evaluation the method of Net Present Value was chosen. This method uses the evaluation of the project cash flows from the point of view of their present value. To be able to calculate the cash flows and the respective net present value of the project it is important to state the related costs and earnings. There are also other common presumptions, that have to be stated at the beginning. Here they are:

- The projects are supported with grants in the height of 50% of the investment.
- The operation time of the technology is 335 days per year.
- The profit tax rate is 19%.
- The discount rate is 5%.
- The credit in the height of 30% of investment with the interest rate of 8% for 10 years is assumed.
- The life time of the project is 20 years.

5.1 Summary of inputs

a.1.1 Production summary

In the chapter 4.2 for each alternative the respective plant design was proposed. From this design and fuel input the energy output can be calculated. The summary of energy production for sale is shown in the Table 5.1. Power for sale and heat for sale are at the end the inputs for calculation of earnings of the project. For simplicity we assume that the whole ammount of energy intended for sale is sold indeed.

Table 5.1 Energy production and balances				
		Biogas plant	Biomass CHP	Heating plant
Raw materials production				
Solid cattle manure	t/a	496.4	0	0
Liquid cattle manure	t/a	306.6	0	0
Haylage	t/a	249.6	0	0
Biogas	m^3/a	75,962	0	0
Hay	t/a	0	400	135
Total energy in fuel				
Biogas	GJ/a	1640.8	0	0
Hay	GJ/a	0	5600.0	1887.0
Electric power				
Power production	MWh/a	136.37	346.11	0
Power own consumption[I.]	MWh/a	10.91	69.22	20.77
Power for sale	MWh/a	125.46	276.89	0
Heat				
Heat production	GJ/a	900.8	3360.0	1680.0
Heat own consumption[II.]	GJ/a	300.3	134.0	33.6
Heat for sale	GJ/a	600.5	3226.0	1646.4

Notes:

I. Biogas plant 8%; Biomass CHP 20%

II. Biogas plant 33,3%; Biomass CHP 4%, Heating plant 2%

For the calculation of the incomes from energy sales following prices are calculated:

- Feed in tariff for power from biogas plant is 130.61 EUR/MWh.
- Feed in tariff for power from biomass CHP plant is 95.45 EUR/MWh.
- Heat price is stated at the level of 9.09 EUR/GJ same for all alternatives.
- The growth rate of feed-in tariffs is 1.5% and for heat price is 1.0%.

a.1.2 Associated costs

There are two basic types of costs connected with the investment project. First type are the investment costs and second are the running or operating costs. Investement costs are represented with one number in our work The running costs can be divided into further groups. First group of costs is connected with the fuel preparation. Second group are costs of other materials, represented in our work by the costs of water. Third group are costs of services connected to the operation of the plant like maintenance, transport, and personal costs. Last group from running costs are costs connected with financing and accounting of the project like payments of loans and depreciations. For costs that are assumed to change (grow) within the project life time also the grow rate has to be stated. The summary of costs is given in the table 5.2.

Table 5.2 Summary of costs (per year)[a)]

		Biogas plant	Biomass CHP	Heating plant
Investment cost				
Investment	EUR	100,000	295,455	45,500
Running costs				
Fuel[b)h)]	EUR	4,379.06	21,820.00	7,364.25
Water[c)i)]	EUR	451.00	164.00	2,545.00
Maintenance[h)]	EUR	2,454.66	750.00	1,000.00
Transport[h)]	EUR	750.00	750.00	750.00
Personal[d)e)h)]	EUR	7,500.00	10,000.00	7,500.00
Insurance[f)]	EUR	750.00	2,215.91	341.25
Depreciation[g)]	EUR	8,333.33	24,621.25	3,791.67

Remarks:

a) Exchange rate 33 SKK/EUR was used.

b) In case of biogas the fuel costs are composed from costs of separate raw materials (solid and liquid cattle manure, haylage).

c) In case of heating plant the water costs include the power own consumption.

d) In personal costs only the costs of operating personal are calculated.

e) In case of CHP where more sensitive technology is used, personal costs are calculated for 1.3 persons.

f) Insurance rate is 0.75% of the investment price.

g) Depreciation is given by the accounting rules as 1/12 of the investment costs per year. For simplicity all the components are depreciated with the same rate.

h) The costs growth rate is 1.5%.

i) The water costs growth rate is 1.0%.

5.2 NPV calculation

For the calculation of NPV the respective discounted cash flows have to be calculated. For simplicity we assume that the project starts in the year zero with the full production. The NPV is calculated for the life time plus one year.

The NPV calculation for biogas plant is in the Table 5.3, for biomass CHP in Table 5.4 and for herating plant in Table 5.5.

Table 5.3 Net present value calculation of the biogas plant

Running costs																					
Item	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Solid manure	t/a	496,40	496,40	496,40	496,40	496,40	496,40	496,40	496,40	496,40	496,40	496,40	496,40	496,40	496,40	496,40	496,40	496,40	496,40	496,40	496,40	496,40
Specific costs solid manure	EUR/t	5,15	5,23	5,31	5,39	5,47	5,55	5,63	5,72	5,80	5,89	5,98	6,07	6,16	6,25	6,34	6,44	6,54	6,63	6,73	6,83	6,94
Costs solid manure	EUR	2 556,46	2 594,81	2 633,73	2 673,23	2 713,33	2 754,03	2 795,34	2 837,27	2 879,83	2 923,03	2 966,88	3 011,38	3 056,55	3 102,40	3 148,93	3 196,17	3 244,11	3 292,77	3 342,16	3 392,30	3 443,18
Liquid manure	t/a	306,60	306,60	306,60	306,60	306,60	306,60	306,60	306,60	306,60	306,60	306,60	306,60	306,60	306,60	306,60	306,60	306,60	306,60	306,60	306,60	306,60
Specific costs liquid manure	EUR/t	1,06	1,08	1,09	1,11	1,13	1,14	1,16	1,18	1,19	1,21	1,23	1,25	1,27	1,29	1,31	1,33	1,35	1,37	1,39	1,41	1,43
Costs liquid manure	EUR	325,00	329,87	334,82	339,84	344,94	350,11	355,36	360,70	366,11	371,60	377,17	382,83	388,57	394,40	400,32	406,32	412,42	418,60	424,88	431,25	437,72
Haylage	t/a	249,60	249,60	249,60	249,60	249,60	249,60	249,60	249,60	249,60	249,60	249,60	249,60	249,60	249,60	249,60	249,60	249,60	249,60	249,60	249,60	249,60
Specific costs haylage	EUR/t	6,00	6,09	6,18	6,27	6,37	6,46	6,56	6,66	6,76	6,86	6,96	7,07	7,17	7,28	7,39	7,50	7,61	7,73	7,84	7,96	8,08
Costs haylage	EUR	1 497,60	1 520,06	1 542,86	1 566,01	1 589,50	1 613,34	1 637,54	1 662,10	1 687,04	1 712,34	1 738,03	1 764,10	1 790,56	1 817,42	1 844,68	1 872,35	1 900,43	1 928,94	1 957,87	1 987,24	2 017,05
Sum fuel costs	EUR	4 379,06	4 444,74	4 511,41	4 579,08	4 647,77	4 717,49	4 788,25	4 860,07	4 932,97	5 006,97	5 082,07	5 158,30	5 235,68	5 314,21	5 393,93	5 474,84	5 556,96	5 640,31	5 724,92	5 810,79	5 897,95
Costs of water	EUR	451,00	455,51	460,07	464,67	469,31	474,01	478,75	483,53	488,37	493,25	498,18	503,17	508,20	513,28	518,41	523,60	528,83	534,12	539,46	544,86	550,31
Costs of maintenance	EUR	2 454,66	2 491,48	2 528,85	2 566,78	2 605,29	2 644,37	2 684,03	2 724,29	2 765,16	2 806,63	2 848,73	2 891,46	2 934,84	2 978,86	3 023,54	3 068,89	3 114,93	3 161,65	3 209,08	3 257,21	3 306,07
Transport costs	EUR	750,00	761,25	772,67	784,26	796,02	807,96	820,08	832,38	844,87	857,54	870,41	883,46	896,71	910,16	923,82	937,67	951,74	966,02	980,51	995,21	1 010,14
Personal costs	EUR	7 500,00	7 612,50	7 726,69	7 842,59	7 960,23	8 079,63	8 200,82	8 323,84	8 448,69	8 575,42	8 704,06	8 834,62	8 967,14	9 101,64	9 238,17	9 376,74	9 517,39	9 660,15	9 805,05	9 952,13	10 101,41
Insurance costs	EUR	750,00	750,00	750,00	750,00	750,00	750,00	750,00	750,00	750,00	750,00	750,00	750,00	750,00	750,00	750,00	750,00	750,00	750,00	750,00	750,00	750,00
Depreciation	EUR	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Sum of running costs	**EUR**	**24 618,05**	**24 848,82**	**25 083,02**	**25 320,71**	**25 561,95**	**25 806,78**	**26 055,27**	**26 307,45**	**26 563,40**	**26 823,16**	**27 086,79**	**27 354,35**	**19 292,56**	**19 568,16**	**19 847,87**	**20 131,74**	**20 419,85**	**20 712,25**	**21 009,02**	**21 310,21**	**21 615,88**
Running incomes																						
Item	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Power for sale	MWh/a	125,46	125,46	125,46	125,46	125,46	125,46	125,46	125,46	125,46	125,46	125,46	125,46	125,46	125,46	125,46	125,46	125,46	125,46	125,46	125,46	125,46
Heat for sale	GJ/a	600,50	600,50	600,50	600,50	600,50	600,50	600,50	600,50	600,50	600,50	600,50	600,50	600,50	600,50	600,50	600,50	600,50	600,50	600,50	600,50	600,50
Power sale price	EUR/MWh	130,61	132,57	134,56	136,58	138,62	140,70	142,81	144,96	147,13	149,34	151,58	153,85	156,16	158,50	160,88	163,29	165,74	168,23	170,75	173,31	175,91
Heat sale price	EUR/GJ	9,09	9,18	9,27	9,37	9,46	9,55	9,65	9,75	9,84	9,94	10,04	10,14	10,24	10,35	10,45	10,55	10,66	10,77	10,87	10,98	11,09
Income power sales	EUR	16 386,33	16 632,13	16 881,61	17 134,83	17 391,85	17 652,73	17 917,52	18 186,29	18 459,08	18 735,97	19 017,01	19 302,26	19 591,79	19 885,67	20 183,96	20 486,72	20 794,02	21 105,93	21 422,52	21 743,85	22 070,01
Income heat sales	EUR	5 458,55	5 513,13	5 568,26	5 623,94	5 680,18	5 736,99	5 794,36	5 852,30	5 910,82	5 969,93	6 029,63	6 089,93	6 150,83	6 212,33	6 274,46	6 337,20	6 400,57	6 464,58	6 529,22	6 594,52	6 660,46
Sum of incomes	**EUR**	**21 844,88**	**22 145,26**	**22 449,87**	**22 758,78**	**23 072,04**	**23 389,72**	**23 711,88**	**24 038,58**	**24 369,90**	**24 705,90**	**25 046,64**	**25 392,19**	**25 742,62**	**26 098,00**	**26 458,41**	**26 823,92**	**27 194,59**	**27 570,51**	**27 951,74**	**28 338,37**	**28 730,47**
Net present value																						
Item	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Investment	EUR	100 000,00																				
Running incomes	EUR	21 844,88	22 145,26	22 449,87	22 758,78	23 072,04	23 389,72	23 711,88	24 038,58	24 369,90	24 705,90	25 046,64	25 392,19	25 742,62	26 098,00	26 458,41	26 823,92	27 194,59	27 570,51	27 951,74	28 338,37	28 730,47
Running costs	EUR	24 618,05	24 848,82	25 083,02	25 320,71	25 561,95	25 806,78	26 055,27	26 307,45	26 563,40	26 823,16	27 086,79	27 354,35	19 292,56	19 568,16	19 847,87	20 131,74	20 419,85	20 712,25	21 009,02	21 310,21	21 615,88
Earnings	EUR	-2 773,17	-2 703,56	-2 633,15	-2 561,94	-2 489,91	-2 417,07	-2 343,39	-2 268,87	-2 193,49	-2 117,26	-2 040,15	-1 962,16	6 450,06	6 529,84	6 610,55	6 692,17	6 774,74	6 858,25	6 942,72	7 028,17	7 114,59
Tax	EUR	0	0	0	0	0	0	0	0	0	0	0	0	1225,5108	1240,6704	1256,0039	1271,5132	1287,2005	1303,0678	1319,1174	1335,3514	1351,772
Earnings after tax	EUR	-2 773,17	-2 703,56	-2 633,15	-2 561,94	-2 489,91	-2 417,07	-2 343,39	-2 268,87	-2 193,49	-2 117,26	-2 040,15	-1 962,16	5 224,55	5 289,17	5 354,54	5 420,66	5 487,54	5 555,18	5 623,61	5 692,81	5 762,82
Depreciation	EUR	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Cash flow	EUR	-94 439,84	5 629,77	5 700,18	5 771,39	5 843,42	5 916,27	5 989,95	6 064,47	6 139,84	6 216,07	6 293,18	6 371,17	5 224,55	5 289,17	5 354,54	5 420,66	5 487,54	5 555,18	5 623,61	5 692,81	5 762,82
Cash flow cummulative	EUR	-94 439,84	-88 810,07	-83 109,88	-77 338,49	-71 495,07	-65 578,80	-59 588,86	-53 524,39	-47 384,55	-41 168,48	-34 875,30	-28 504,12	-23 279,58	-17 990,40	-12 635,86	-7 215,20	-1 727,66	3 827,52	9 451,13	15 143,94	20 906,76
NPV	EUR	-94 439,84	5 361,69	5 170,23	4 985,55	4 807,40	4 635,55	4 469,79	4 309,90	4 155,68	4 006,94	3 863,47	3 725,09	2 808,22	2 804,86	2 704,41	2 607,43	2 513,90	2 423,71	2 336,72	2 252,84	2 171,95
NPV cummulative	**EUR**	**-94 439,84**	**-89 078,15**	**-83 907,92**	**-78 922,37**	**-74 114,97**	**-69 479,42**	**-65 009,64**	**-60 699,73**	**-56 544,05**	**-52 537,11**	**-48 673,64**	**-44 948,55**	**-42 039,33**	**-39 234,36**	**-36 529,96**	**-33 922,53**	**-31 408,62**	**-28 984,91**	**-26 648,19**	**-24 395,35**	**-22 223,40**

Table 5.4 Net present value calculation of the biomass CHP plant

Running costs																						
Item	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Hay	t/a	400,00	400,00	400,00	400,00	400,00	400,00	400,00	400,00	400,00	400,00	400,00	400,00	400,00	400,00	400,00	400,00	400,00	400,00	400,00	400,00	400,00
Specific costs hay	EUR/t	54,55	55,37	56,20	57,04	57,90	58,77	59,65	60,54	61,45	62,37	63,31	64,26	65,22	66,20	67,19	68,20	69,22	70,26	71,32	72,39	73,47
Sum fuel costs	EUR	21 820,00	22 147,30	22 479,51	22 816,70	23 158,95	23 508,34	23 858,93	24 216,82	24 580,07	24 948,77	25 323,00	25 702,85	26 088,39	26 479,71	26 876,91	27 280,06	27 689,26	28 104,60	28 526,17	28 954,07	29 388,38
Costs of water	EUR	164,00	165,64	167,30	168,97	170,66	172,37	174,09	175,83	177,59	179,36	181,16	182,97	184,80	186,65	188,51	190,40	192,30	194,23	196,17	198,13	200,11
Costs of maintenance	EUR	750,00	761,25	772,67	784,26	796,02	807,96	820,08	832,38	844,87	857,54	870,41	883,46	896,71	910,16	923,82	937,67	951,74	966,02	980,51	995,21	1 010,14
Transport costs	EUR	750,00	761,25	772,67	784,26	796,02	807,96	820,08	832,38	844,87	857,54	870,41	883,46	896,71	910,16	923,82	937,67	951,74	966,02	980,51	995,21	1 010,14
Personal costs	EUR	10 000,00	10 150,00	10 302,25	10 456,78	10 613,64	10 772,84	10 934,43	11 098,45	11 264,93	11 433,90	11 605,41	11 779,49	11 956,18	12 135,52	12 317,56	12 502,32	12 689,86	12 880,20	13 073,41	13 269,51	13 468,55
Insurance costs	EUR	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91	2 215,91
Depreciation	EUR	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Sum of running costs	**EUR**	**60 321,16**	**60 822,60**	**61 331,56**	**61 848,14**	**62 372,46**	**62 904,63**	**63 444,78**	**63 993,03**	**64 549,48**	**65 114,28**	**65 687,54**	**66 269,39**	**42 238,71**	**42 838,13**	**43 446,53**	**44 064,04**	**44 690,81**	**45 326,98**	**45 972,67**	**46 628,04**	**47 293,23**
Running incomes																						
Item	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Power for sale	MWh/a	276,09	276,09	276,09	276,09	276,09	276,09	276,09	276,09	276,09	276,09	276,09	276,09	276,09	276,09	276,09	276,09	276,09	276,09	276,09	276,09	276,09
Heat for sale	GJ/a	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00
Power sale price	EUR/MWh	95,45	96,09	96,34	99,01	101,31	102,03	104,37	105,94	107,53	109,14	110,78	112,44	114,13	115,84	117,58	119,34	121,13	122,95	124,79	126,66	128,56
Heat sale price	EUR/GJ	9,09	9,18	9,27	9,37	9,46	9,55	9,65	9,75	9,84	9,94	10,04	10,14	10,24	10,35	10,45	10,55	10,66	10,77	10,87	10,98	11,09
Income power sales	EUR	26 430,41	26 826,87	27 229,27	27 637,71	28 052,27	28 473,06	28 900,15	29 333,66	29 773,66	30 220,26	30 673,57	31 133,67	31 600,69	32 074,69	32 555,81	33 044,14	33 539,81	34 042,90	34 553,55	35 071,85	35 597,93
Income heat sales	EUR	29 324,34	29 617,58	29 913,76	30 212,90	30 515,03	30 820,18	31 128,38	31 439,66	31 754,06	32 071,60	32 392,31	32 716,24	33 043,40	33 373,83	33 707,57	34 044,65	34 385,09	34 728,95	35 076,24	35 427,00	35 781,27
Sum of incomes	**EUR**	**55 754,75**	**56 444,45**	**57 143,03**	**57 850,60**	**58 567,30**	**59 293,23**	**60 028,53**	**60 773,32**	**61 527,72**	**62 291,86**	**63 065,88**	**63 849,91**	**64 644,08**	**65 448,52**	**66 263,38**	**67 088,79**	**67 924,90**	**68 771,85**	**69 629,78**	**70 498,85**	**71 379,20**
Net present value																						
Item	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Investment	EUR	285 455,00																				
Running incomes	EUR	55 754,75	56 444,45	57 143,03	57 850,60	58 567,30	59 293,23	60 028,53	60 773,32	61 527,72	62 291,86	63 065,88	63 849,91	64 644,08	65 448,52	66 263,38	67 088,79	67 924,90	68 771,85	69 629,78	70 498,85	71 379,20
Running costs	EUR	60 321,16	60 822,60	61 331,56	61 848,14	62 372,46	62 904,63	63 444,78	63 993,03	64 549,48	65 114,28	65 687,54	66 269,39	42 238,71	42 838,13	43 446,53	44 064,04	44 690,81	45 326,98	45 972,67	46 628,04	47 293,23
Earnings	EUR	-4 566,41	-4 378,15	-4 188,53	-3 997,53	-3 805,16	-3 611,40	-3 416,25	-3 219,71	-3 021,77	-2 822,42	-2 621,66	-2 419,48	22 405,37	22 610,39	22 816,85	23 024,75	23 234,09	23 444,87	23 657,11	23 870,81	24 085,96
Tax	EUR	0	0	0	0	0	0	0	0	0	0	0	0	4257,02	4295,975	4335,2021	4374,7024	4414,4760	4454,5261	4494,8514	4535,4534	4576,3331
Earnings after tax	EUR	-4 566,41	-4 378,15	-4 188,53	-3 997,53	-3 805,16	-3 611,40	-3 416,25	-3 219,71	-3 021,77	-2 822,42	-2 621,66	-2 419,48	18 148,35	18 314,42	18 481,65	18 650,05	18 819,61	18 990,35	19 162,26	19 335,35	19 509,63
Depreciation	EUR	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Cash flow	EUR	-275 400,16	20 243,10	20 432,72	20 623,72	20 816,09	21 009,85	21 205,00	21 401,54	21 599,48	21 798,83	21 999,59	22 201,77	18 148,35	18 314,42	18 481,65	18 650,05	18 819,61	18 990,35	19 162,26	19 335,35	19 509,63
Cash flow cummulative	EUR	-275 400,16	-255 157,07	-234 724,35	-214 100,63	-193 284,53	-172 274,68	-151 069,68	-129 669,14	-108 069,66	-86 269,82	-64 270,23	-42 068,46	-23 920,11	-5 605,69	12 875,96	31 526,00	50 345,62	69 335,96	88 498,23	107 833,58	127 343,21
NPV	EUR	-275 400,16	18 279,14	18 533,08	17 815,54	17 125,45	16 461,77	15 823,50	15 209,68	14 619,38	14 051,72	13 505,84	12 980,91	10 105,68	8 712,53	8 334,48	8 870,89	8 621,48	8 285,43	7 862,32	7 651,66	7 352,87
NPV cummulative	**EUR**	**-275 400,16**	**-256 121,02**	**-237 587,94**	**-219 772,40**	**-202 646,95**	**-186 185,18**	**-170 361,68**	**-155 152,01**	**-140 532,63**	**-126 480,90**	**-112 975,06**	**-99 994,15**	**-89 888,47**	**-80 175,94**	**-70 841,45**	**-61 870,46**	**-53 248,98**	**-44 963,55**	**-37 001,24**	**-29 349,58**	**-21 996,61**

Table 5.5 Net present value calculation of the heating plant

Running costs																						
Item	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Hay	t/a	135,00	135,00	135,00	135,00	135,00	135,00	135,00	135,00	135,00	135,00	135,00	135,00	135,00	135,00	135,00	135,00	135,00	135,00	135,00	135,00	135,00
Specific costs hay	EUR/t	54,55	55,37	56,20	57,04	57,90	58,77	59,65	60,54	61,45	62,37	63,31	64,26	65,22	66,20	67,19	68,20	69,22	70,26	71,32	72,39	73,47
Sum fuel costs	EUR	7 364,25	7 474,71	7 586,83	7 700,64	7 816,15	7 933,39	8 052,39	8 173,18	8 295,77	8 420,21	8 546,51	8 674,71	8 804,83	8 936,90	9 070,96	9 207,02	9 345,13	9 485,30	9 627,58	9 772,00	9 918,58
Costs of water	EUR	2 545,00	2 570,45	2 596,15	2 622,12	2 648,34	2 674,82	2 701,57	2 728,58	2 755,87	2 783,43	2 811,26	2 839,38	2 867,77	2 896,45	2 925,41	2 954,67	2 984,21	3 014,05	3 044,20	3 074,64	3 105,38
Costs of maintenance	EUR	1 000,00	1 015,00	1 030,23	1 045,68	1 061,36	1 077,28	1 093,44	1 109,84	1 126,49	1 143,39	1 160,54	1 177,95	1 195,62	1 213,55	1 231,76	1 250,23	1 268,99	1 288,02	1 307,34	1 326,95	1 346,86
Transport costs	EUR	750,00	761,25	772,67	784,26	796,02	807,96	820,08	832,38	844,87	857,54	870,41	883,46	896,71	910,18	923,82	937,67	951,74	966,02	980,51	995,21	1 010,14
Personal costs	EUR	7 500,00	7 612,50	7 726,69	7 842,59	7 960,23	8 079,63	8 200,82	8 323,84	8 448,69	8 575,42	8 704,06	8 834,62	8 967,14	9 101,64	9 238,17	9 376,74	9 517,39	9 660,15	9 805,05	9 952,13	10 101,41
Insurance costs	EUR	341,25	341,25	341,25	341,25	341,25	341,25	341,25	341,25	341,25	341,25	341,25	341,25	341,25	341,25	341,25	341,25	341,25	341,25	341,25	341,25	341,25
Depreciation	EUR	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Sum of running costs	**EUR**	**23 292,17**	**23 566,83**	**23 845,49**	**24 128,19**	**24 415,01**	**24 706,00**	**25 001,23**	**25 300,74**	**25 604,62**	**25 912,91**	**26 225,70**	**26 543,03**	**23 073,32**	**23 399,96**	**23 731,36**	**24 067,58**	**24 408,71**	**24 754,80**	**25 105,93**	**25 462,18**	**25 823,62**
Running incomes																						
Item	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Heat for sale	GJ/a	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00	3 226,00
Heat sale price	EUR/GJ	8,08	8,18	8,27	8,37	8,46	8,55	8,65	8,75	8,84	8,94	10,04	10,14	10,24	10,35	10,45	10,55	10,66	10,77	10,87	10,98	11,08
Income heat sales	EUR	29 324,34	29 617,58	29 913,76	30 212,90	30 515,03	30 820,18	31 128,38	31 439,66	31 754,06	32 071,60	32 392,31	32 716,24	33 043,40	33 373,83	33 707,57	34 044,65	34 385,09	34 728,95	35 076,24	35 427,00	35 781,27
Sum of incomes	**EUR**	**29 324,34**	**29 617,58**	**29 913,76**	**30 212,90**	**30 515,03**	**30 820,18**	**31 128,38**	**31 439,66**	**31 754,06**	**32 071,60**	**32 392,31**	**32 716,24**	**33 043,40**	**33 373,83**	**33 707,57**	**34 044,65**	**34 385,09**	**34 728,95**	**35 076,24**	**35 427,00**	**35 781,27**
Net present value																						
Item	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Investment	EUR	45 500,00																				
Running incomes	EUR	29 324,34	29 617,58	29 913,76	30 212,90	30 515,03	30 820,18	31 128,38	31 439,66	31 754,06	32 071,60	32 392,31	32 716,24	33 043,40	33 373,83	33 707,57	34 044,65	34 385,09	34 728,95	35 076,24	35 427,00	35 781,27
Running costs	EUR	23 292,17	23 566,83	23 845,49	24 128,19	24 415,01	24 706,00	25 001,23	25 300,74	25 604,62	25 912,91	26 225,70	26 543,03	23 073,32	23 399,96	23 731,36	24 067,58	24 408,71	24 754,80	25 105,93	25 462,18	25 823,62
Earnings	EUR	6 032,17	6 050,75	6 068,27	6 084,70	6 100,01	6 114,17	6 127,15	6 138,92	6 149,44	6 158,69	6 166,62	6 173,21	9 970,08	9 973,87	9 976,21	9 977,06	9 976,39	9 974,15	9 970,31	9 964,82	9 957,65
Tax	EUR	1146,11293	1149,84307	1152,97175	1156,09341	1159,00238	1161,69288	1164,159	1166,39473	1168,39394	1170,15038	1171,65769	1172,90936	1894,31547	1895,03591	1895,48049	1895,64221	1895,51392	1895,08836	1894,3581	1893,31559	1891,95315
Earnings after tax	EUR	4 886,06	4 901,11	4 915,30	4 928,61	4 941,01	4 952,48	4 962,99	4 972,52	4 981,05	4 988,54	4 994,96	5 000,30	8 075,77	8 078,84	8 080,73	8 081,42	8 080,88	8 079,06	8 075,95	8 071,50	8 065,70
Depreciation	EUR	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Cash flow	EUR	-36 822,27	8 692,78	8 706,97	8 720,28	8 732,68	8 744,15	8 754,66	8 764,19	8 772,71	8 780,20	8 786,63	8 791,96	8 075,77	8 078,84	8 080,73	8 081,42	8 080,88	8 079,06	8 075,95	8 071,50	8 065,70
Cash flow cummulative	EUR	-36 822,27	-28 129,50	-19 422,53	-10 702,25	-1 969,58	6 774,57	15 529,23	24 293,42	33 066,14	41 846,34	50 632,97	59 424,93	67 500,70	75 579,53	83 660,27	91 741,68	99 822,56	107 901,63	115 977,57	124 049,08	132 114,77
NPV	EUR	-36 822,27	8 278,83	7 897,49	7 532,90	7 184,39	6 851,27	6 532,08	6 226,55	5 937,72	5 659,80	5 394,23	5 140,49	4 498,89	4 284,39	4 081,32	3 887,30	3 701,94	3 524,87	3 355,72	3 194,17	3 039,88
NPV cummulative	**EUR**	**-36 822,27**	**-28 543,44**	**-20 645,96**	**-13 113,06**	**-5 928,67**	**922,60**	**7 455,46**	**13 684,01**	**19 621,73**	**25 281,53**	**30 675,75**	**35 816,23**	**40 313,12**	**44 597,50**	**48 678,82**	**52 566,12**	**56 268,07**	**59 792,93**	**63 148,66**	**66 342,82**	**69 382,70**

5.3 Cash flow calculation

Financial cash flow of the project is beeing calculated to prove also the financial viability of the specific alternative. Financial cash flow calculation can also show the need of some operational loan if appropriate. Respective financial cash flow calculations are in the tables 5.6, 5.7 and 5.8.

Table 5.6 Financial cash flow calculation of the biogas plant

Financial cash flow																						
Item	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Investment	EUR	100 000,00																				
Own sources	EUR	20 000,00																				
Credits	EUR	30 000,00																				
Grants	EUR	50 000,00																				
Credit principal	EUR	3 000,00	3 000,00	3 000,00	3 000,00	3 000,00	3 000,00	3 000,00	3 000,00	3 000,00	3 000,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Running incomes	EUR	21 844,88	22 145,28	22 449,87	22 758,78	23 072,04	23 389,72	23 711,88	24 038,58	24 369,90	24 705,90	25 046,64	25 392,19	25 742,62	26 098,00	26 458,41	26 823,92	27 194,59	27 570,51	27 951,74	28 338,37	28 730,47
Running costs	EUR	24 618,05	24 848,82	25 083,02	25 320,71	25 561,95	25 806,78	26 055,27	26 307,45	26 563,40	26 823,16	27 086,79	27 354,35	19 292,56	19 568,16	19 847,87	20 131,74	20 419,85	20 712,25	21 009,02	21 310,21	21 615,88
Credit interest	EUR	2 400,00	2 160,00	1 920,00	1 680,00	1 440,00	1 200,00	960,00	720,00	480,00	240,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Earnings	EUR	-5 173,17	-4 863,56	-4 553,15	-4 241,94	-3 929,91	-3 617,07	-3 303,39	-2 988,87	-2 673,49	-2 357,26	-2 040,15	-1 962,16	6 450,06	6 529,84	6 610,55	6 692,17	6 774,74	6 858,25	6 942,72	7 028,17	7 114,59
Tax	EUR	0	0	0	0	0	0	0	0	0	0	0	0	1225,51	1240,87	1256,00	1271,51	1287,20	1303,07	1319,12	1335,35	1351,77
Earnings after tax	EUR	-5 173,17	-4 863,56	-4 553,15	-4 241,94	-3 929,91	-3 617,07	-3 303,39	-2 988,87	-2 673,49	-2 357,26	-2 040,15	-1 962,16	5 224,55	5 288,17	5 354,54	5 420,66	5 487,54	5 555,18	5 623,61	5 692,81	5 762,82
Depreciation	EUR	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	8 333,33	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Cash flow	EUR	760,16	1 309,77	1 860,18	2 411,39	2 963,42	3 516,27	4 069,95	4 624,47	5 179,84	5 736,07	6 293,18	6 371,17	5 224,55	5 288,17	5 354,54	5 420,66	5 487,54	5 555,18	5 623,61	5 692,81	5 762,82
Cash flow cummulative	EUR	760,16	2 069,93	3 930,12	6 341,51	9 304,93	12 821,20	16 891,14	21 515,61	26 695,45	32 431,52	38 724,70	45 095,88	50 320,42	55 609,60	60 964,14	66 384,80	71 872,34	77 427,52	83 051,13	88 743,94	94 506,76
NPV	EUR	760,16	1 247,40	1 687,24	2 083,05	2 438,01	2 755,09	3 037,06	3 286,52	3 505,92	3 697,52	3 863,47	3 725,09	2 809,22	2 804,96	2 704,41	2 607,43	2 513,90	2 423,71	2 336,72	2 252,84	2 171,95
NPV cummulative	EUR	760,16	2 007,56	3 694,80	5 777,86	8 215,87	10 970,96	14 008,01	17 294,53	20 800,45	24 497,98	28 361,45	32 086,54	34 995,76	37 800,72	40 505,13	43 112,56	45 626,47	48 050,18	50 386,90	52 639,74	54 811,69

Table 5.7 Financial cash flow calculation of the biomass CHP plant

Financial cash flow																						
Item	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Investment	EUR	295 455,00																				
Own sources	EUR	59 091,00																				
Credits	EUR	88 637,00																				
Grants	EUR	147 727,00																				
Credit principal	EUR	8 863,65	8 863,65	8 863,65	8 863,65	8 863,65	8 863,65	8 863,65	8 863,65	8 863,65	8 863,65	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Running incomes	EUR	55 754,75	56 444,45	57 143,03	57 850,80	58 567,30	59 293,23	60 028,53	60 773,32	61 527,72	62 291,88	63 065,88	63 849,91	64 644,08	65 448,52	66 263,38	67 088,79	67 924,90	68 771,85	69 629,78	70 498,85	71 379,20
Running costs	EUR	60 321,16	60 822,60	61 331,56	61 848,14	62 372,46	62 904,63	63 444,78	63 993,03	64 549,48	65 114,28	65 687,54	66 269,39	42 238,71	42 838,13	43 446,53	44 064,04	44 690,81	45 326,98	45 972,67	46 628,04	47 293,23
Credit interest	EUR	7 090,92	6 381,83	5 672,74	4 963,64	4 254,55	3 545,46	2 836,37	2 127,28	1 418,18	709,09	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Earnings	EUR	-11 657,33	-10 759,98	-9 861,26	-8 961,18	-8 059,71	-7 156,86	-6 252,62	-5 346,98	-4 439,95	-3 531,51	-2 621,66	-2 419,48	22 405,37	22 610,38	22 816,85	23 024,75	23 234,09	23 444,87	23 657,11	23 870,81	24 085,96
Tax	EUR	0	0	0	0	0	0	0	0	0	0	0	0	4257,02	4295,97	4335,20	4374,70	4414,48	4454,53	4494,85	4535,45	4576,33
Earnings after tax	EUR	-11 657,33	-10 759,98	-9 861,26	-8 961,18	-8 059,71	-7 156,86	-6 252,62	-5 346,98	-4 439,95	-3 531,51	-2 621,66	-2 419,48	18 148,35	18 314,42	18 481,65	18 650,05	18 819,61	18 990,35	19 162,26	19 335,35	19 509,63
Depreciation	EUR	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	24 621,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Cash flow	EUR	5 873,00	7 479,44	8 087,25	10 686,43	12 306,89	13 918,93	15 532,26	17 146,89	18 763,12	20 380,65	21 999,59	22 201,77	18 148,35	18 314,42	18 481,65	18 650,05	18 819,61	18 990,35	19 162,26	19 335,35	19 509,63
Cash flow cummulative	EUR	5 873,00	13 352,44	22 439,69	33 136,12	45 443,11	59 362,04	74 894,30	92 041,29	110 804,41	131 185,06	153 184,65	175 386,42	193 534,77	211 849,19	230 330,84	248 980,89	267 800,50	286 790,84	305 953,11	325 288,46	344 798,09
NPV	EUR	5 873,00	7 123,28	8 242,40	9 238,88	10 124,88	10 905,85	11 590,41	12 186,05	12 698,62	13 137,55	13 505,84	12 980,91	10 105,68	9 712,53	9 334,48	8 970,99	8 621,48	8 285,43	7 962,32	7 651,66	7 352,87
NPV cummulative	EUR	5 873,00	12 996,27	21 238,68	30 476,66	40 603,65	51 509,49	63 099,91	75 285,95	87 985,57	101 123,12	114 628,96	127 609,87	137 715,55	147 428,08	156 762,57	165 733,56	174 355,04	182 640,47	190 602,79	198 254,44	205 607,31

Table 5.8 Financial cash flow calculation of the communal heating plant

Financial cash flow																						
Item	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Investment	EUR	45 500,00																				
Own sources	EUR	9 100,00																				
Credits	EUR	13 650,00																				
Grants	EUR	22 750,00																				
Credit principal	EUR	1 365,00	1 365,00	1 365,00	1 365,00	1 365,00	1 365,00	1 365,00	1 365,00	1 365,00	1 365,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Running incomes	EUR	29 324,34	29 617,58	29 913,76	30 212,90	30 515,03	30 820,18	31 128,38	31 439,66	31 754,06	32 071,60	32 392,31	32 716,24	33 043,40	33 373,83	33 707,57	34 044,65	34 385,09	34 728,95	35 076,24	35 427,00	35 781,27
Running costs	EUR	23 292,17	23 566,83	23 845,49	24 128,19	24 415,01	24 706,00	25 001,23	25 300,74	25 604,62	25 912,91	26 225,70	26 543,03	23 073,32	23 399,96	23 731,36	24 067,58	24 408,71	24 754,80	25 105,93	25 462,18	25 823,62
Credit interest	EUR	1 092,00	982,80	873,60	764,40	655,20	546,00	436,80	327,60	218,40	109,20	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Earnings	EUR	4 940,17	5 067,95	5 194,67	5 320,30	5 444,81	5 568,17	5 690,35	5 811,32	5 931,04	6 049,49	6 166,62	6 173,21	9 970,08	9 973,87	9 976,21	9 977,06	9 976,39	9 974,15	9 970,31	9 964,82	9 957,65
Tax	EUR	938,63	962,91	986,99	1010,86	1034,51	1057,95	1081,17	1104,15	1126,90	1149,40	1171,66	1172,91	1894,32	1895,04	1895,48	1895,64	1895,51	1895,09	1894,36	1893,32	1891,95
Earnings after tax	EUR	4 001,54	4 105,04	4 207,68	4 309,44	4 410,30	4 510,22	4 609,19	4 707,17	4 804,14	4 900,08	4 994,96	5 000,30	8 075,77	8 078,84	8 080,73	8 081,42	8 080,88	8 079,06	8 075,95	8 071,50	8 065,70
Depreciation	EUR	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	3 791,67	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Cash flow	EUR	6 701,21	6 913,91	7 125,75	7 336,71	7 546,76	7 755,89	7 964,05	8 171,24	8 377,41	8 582,55	8 786,63	8 791,96	8 075,77	8 078,84	8 080,73	8 081,42	8 080,88	8 079,06	8 075,95	8 071,50	8 065,70
Cash flow cummulative	EUR	6 701,21	13 615,12	20 740,87	28 077,58	35 624,34	43 380,23	51 344,28	59 515,52	67 892,93	76 475,48	85 262,11	94 054,07	102 129,84	110 208,67	118 289,41	126 370,83	134 451,70	142 530,77	150 606,71	158 678,22	166 743,91
NPV	EUR	6 701,21	6 584,67	6 463,27	6 337,73	6 208,74	6 076,94	5 942,90	5 807,14	5 670,16	5 532,39	5 394,23	5 140,48	4 498,89	4 284,38	4 081,32	3 887,30	3 701,94	3 524,87	3 355,72	3 194,17	3 039,88
NPV cummulative	EUR	6 701,21	13 285,88	19 749,15	26 086,88	32 295,62	38 372,56	44 315,46	50 122,60	55 792,76	61 325,15	66 719,38	71 859,86	76 358,75	80 641,13	84 722,45	88 609,75	92 311,69	95 836,56	99 192,28	102 386,45	105 426,32

6. Evaluation of results, recommendations

6.1 Biogas plant

From the technical point of view the alternative with the biogas plant represents quite sophisticated technology. Nevertheless the biogas technology have been developed and are still popular mainly in the farming environment. Biogas plant can be seen as an upgrade of the manure handling system with power and heat production as added value. In this case there will be no changes in the farm characteristics – the number of the animals, the farming areas and the field products stay the same. There is no need to invest into new agricultural machines. Only one fact could be risky for this alternative. In the same time as the biogas plant also some other project has to be implemented which would be able to use all the heat produced in the biogas plant, e.g. a drying chamber.

When it comes to economic evaluation, the situation is a little bit other. From the calculations made in chapter 5.2 we can see that the cash flows are positive since the 2 year of project life time. But when it comes to cumulative net present value we see that the it is negative during the project life time. From the economic point of view this is generally agreed sign that the project should not be realized since it lowers the value of the farm company.

6.2 Biomass CHP plant

Situation in the farms would change rapidly with the implementation of the biomass combined heat and power plant. First of all the exact number of the animals has to be stated which would cover the hay production with respective manure production. We expect that the number of animals would be decreased rapidly comparing to the actual situation. This means also the change in using the actual size of the stall buildings and related infrastructure. Due to changing climate it is also rather hard to produce big ammounts of quality hay since the seasons become more wet from year to year. In this case also similar problem with the produced heat consumption arises but even bigger – the amount of heat produced is nearly four times higher than in the biogas alternative. On the other hand the

technology of the steam plant itself is quite sensitive and to full performance it would expect skilled operator.

The economic evaluation shows also positive cash flows from the project's second year. But the cummulative net present value is also negative. This shows that also this project should not be implemented.

6.3 Heating plant

Alternative with the usage of hay for the solely heat production leads to moderate changes of the situation in the farm. Nowadays about 40 tons of hay is surplus. For the purposes of heating the communal buildings the ammount of hay would be 135 tons. This would mean the reduction of the current number of animals. Partial problem would be the implementation of the technology and spaces for fuel handling since the three buildings to be heated within this project are situated in the village centre.

From the economic evaluation we can see that this project shows not only positive cash flows but also positive NPV even in the sixth year of project life time. Positive net present value can be seen as a signal for positive decision to implement the project.

6.4 General conclusion

From the proposed alternatives only the heating plant have shown a clear positive result. To make this project really viable for the farmer further checks has to be performed. Among all of them the influence of the project implementation to current farm business has to be checked. Other important issue is the affection of the community to this solution since the community would be the only customer of this project. The involvement of the community could also positively influence the investment phase from the point of view receiving needed permissions. Even a higher grant support can be expected together with the community.

Other way to interpret the results of this work is that if a biogas or a biomass CHP plant should be implemented, the unit output has to be increased. Several authors write that these

kind of projects only show positive economic results from a certain size. And when it comes to higher outputs, the combination of these alternatives with heating of communal buildings seems to be the way.

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