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Original scientific paper

ENERGETIC AND ECONOMIC ANALYSIS FOR UTILIZATION OF BIOGAS FROM PIG FARMS IN NORTH MACEDONIA

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A b s t r a c t: Today, when the world is facing an increasing need for energy, and therefore, the exploitation of natural resources is increasing, the problem of environmental pollution and global warming grows. The question of finding and using alternative and clean energy sources, imposes itself. The problem of environmental pollution and the need for renewable energy sources have increased the interest in allocating more funds for scientific research work for the use of biodegradable waste, so that in many countries more and more plants are being built that use biomass for biogas production. Biogas is a very interesting and important source of energy. All organic matter originating from mowing the lawn, cutting branches, farm waste, plant biomass from agricultural production, can be used as raw material for biogas production. Macedonia has large quantities of this type of waste, so there is a good precondition for economical use of them and to get electricity and heat from them. The paper focus is on assessment of the economic viability for utilization of biogas in pigs farms in Macedonia through integration of cogeneration power plant. The economic analysis is performed with method of benefit to cost ratio. Also sensitivity analysis is performed as a function of levelized cost of energy in regard of 7 critical factors: capital cost (amount of capital investment cost), interest rates (*D* is equal to 0%, 5%, 10 % and 15%), capacity factor (plant size), fuel cost (cost of procurement, preparation and transport of the substrate), cost of capital, debt ratio and net plant efficiency. The results indicate that the payback period could be in less than 9 years.

Key words: biogas; renewable energy sources; biogas plants; combined heat power plants

ЕНЕРГЕТСКА И ЕКОНОМСКА АНАЛИЗА ЗА ИСКОРИСТУВАЊЕ БИОГАС ОД ФАРМИ ЗА СВИЊИ ВО СЕВЕРНА МАКЕДОНИЈА

А п с т р а к т: Денес, кога светот се соочува со зголемена потреба од енергија, со што се зголемува и експлоатацијата на природните ресурси, расте проблемот со загадувањето на животната средина и глобалното затоплување. Се наметнува потребата од изнаоѓање и користење на алтернативни и чисти извори на енергија. Проблемот со загадувањето на животната средина и потребата од обновливи извори на енергија го зголемија интересот за издвојување повеќе средства за научноистражувачка работа за искористување на биоразградливиот отпад, така што во многу земји се градат сè повеќе постројки кои користат биомаса за производство на биогас. Биогасот е многу интересен и важен извор на енергија. Целата органска материја која потекнува од косење трева, сечење гранки, отпад од фарми, растителна биомаса од земјоделско производство, може да се користи како суровина за производство на биогас. Македонија располага со големи количества на овој вид отпад, така што има добар предуслов за негово економично искористување во производството на струја и топлинска енергија. Фокусот на трудот е процена на економската исплатливост на производство и искористување на биогасот од свињарските фарми во Македонија преку интегрирање на когенеративна постројка. Економската анализа се врши со методот на сооднос корист/трошок. Исто така, анализата на сензитивноста се врши како функција на нивелираните трошоци на енергија во однос на 7 критични фактори: капитални трошоци (износ на трошоците за капитални инвестиции), каматни стапки (*D* е еднаква на 0%, 5%, 10% и 15%), фактор на капацитет (големина на постројката), трошок за гориво (трошок за набавка, подготовка и транспорт на подлогата), трошок на капитал, коефициент на долг и нето ефикасност на постројката. Резултатите покажуваат дека периодот на враќање може да биде покус од 9 години.

Клучни зборови: биогас; обновливи извори на енергија; постројки за биогас; комбинирани постројки за топлинска и електрична енергија

1. INTRODUCTION

The rapid development of society that emerges as a consequence of the technical and technological revolution that is always ongoing, is based on the ability to meet the growing needs for energy. Due to the mismatch of energy needs and opportunities for its provision, energy crises occur, and as a consequence is the increased interest in better and more rational use of existing and new renewable energy sources. Encouraging the use of renewable energy sources is a strategic goal of the EU, as it is in line with the Sustainable Development Strategy and enables the achievement of the goals of the Kyoto Protocol in terms of reducing greenhouse gas emissions and protecting the environment [1]. Renewable or alternative energy sources are already in use, but some are in development and their application is yet to be developed. Along with the energy crises, there is another crisis in the world, the global environmental crisis, which is created as a result of waste disposal problems, because uncontrolled and irresponsible waste disposal endangers human health and the environment. Through the processes of anaerobic fermentation of biodegradable waste, biogas is obtained which mostly contains methane as an energy resource, then carbon dioxide, and less hydrogen, oxygen, ammonia and others. Various technologies for the use of biomass as a renewable energy source for obtaining electricity and heat, as well as fuels for vehicles have already been widely established in the world. Hundreds of larger and smaller installations for production of biogas have been made in the European Union which are suppling biogas for power plants, steam boilers, vehicles and more. The process of decomposition is called anaerobic digestion and occurs naturally in many environments with limited oxygen presence: for example, in ponds and swamps, in rice fields, but also in the stomachs of ruminants. This natural process can be used in biogas plants where organic material is placed. The basic part of the plant is a closed chamber or hermetically sealed container (or often called a reactor – digester) in which the reaction of digestion takes place. The end product of decomposition is a combustible gas called biogas and organic residue in a mineral-containing digester that is suitable for use as a liquid or solid biofertilizer. Biogas is mostly composed of methane which contains the energy of combustion. Biogas, depending on the conditions at the time of creation, contains from 45% to 85% methane and 15% to 45% carbon dioxide. Biogas also contains small amounts of hydrogen sulphite, ammonia, and nitrogen. Biogas often also contains water vapor [2].

Biomass means biodegradable materials obtained from agriculture, animal husbandry and related industries and activities, as well as biodegradable part of industrial and municipal waste. Biomass is an organic material derived from living organisms; plants, animals, humans and microorganisms, which contain stored energy from the Sun, where they bind solar energy through the process of photosynthesis. Biomass by its characteristics is a very quality fuel with the fact that for its use activities should be undertaken for: collection, transport, storage, treatment and the like. Anaerobic decomposition processes can vary according to the content of the substrate and the number of reactors or stages of the process in which the process is performed. In a single-stage process, different phases of anaerobic decomposition are performed in one digester, while in a multi-stage process, two or more digesters are performed in which the phases of anaerobic decomposition are separated from each other. Due to the flow of the substrate through the reaction system, there are a number of different designs of anaerobic decomposition digesters, and a choice can be made between three basic types of digesters: boiler, flow boiler and tubular digester. Complete mixing processes in the field of agricultural biogas production, mainly reactors with complete mixing of cylindrical, vertical shape are used. Fermenters consist of a tank with a concrete bottom and walls made of steel or reinforced concrete. The reservoir may be completely or partially buried in the ground or may be built entirely above ground. A gas-tight cover is upgraded on the tank, which can be performed in different ways depending on the requirements and the construction. Membrane roofs and concrete roofs are most commonly used. The complete mixing is realized with the help of mixers placed in the reactor, i.e. on the reactor.

In the implementation of the anaerobic decomposition process, the basic criteria related to the selection of the digester are the composition of the reaction medium (substrate), the kinetics of decomposition of the substrate and the growth of biomass, as well as the shape of the biocatalyst. The time required to digest the material in the reactor before being removed from it is called the storage time. Storage time varies, depending on the properties of the substrate and how much methane can be extracted from it. Storage time is sometimes expressed as hydraulic retention time (HRT), which usually varies between 10 and 80 days [3]. If a temperature of 10 to 20 ºC is maintained in the digester, the reactions are called psychrophilic, and the material should be processed for 90 days. If a temperature of 37 ºC is maintained in the digester, the reactions are called mesophilic and the material should be processed for 30 days, and if a temperature of about 55 ºC is maintained, the reactions are called thermophilic, and the reaction ends in 10 days [4]. The largest producers of raw material for biogas plants are: animal farms, slaughterhouses, restaurants, hospitals and all other entities that produce organic waste. These types of waste represent huge amounts of raw material for anaerobic fermentation installations and production of biogas as energy and compost as quality fertilizer. Biomass of animal origin – animal manure, is a useful energy source only for livestock breeding. Among the most compatible substrates for biogas production is fertilizer, solid or liquid, because it is most often used by a farm and is free. Energy plants are also often used as the basis for the operation of a biogas plant for higher biogas yields. The rest of the fermentation is a by-product of biogas production and is commonly used as fertilizer. Energy plants mean purposefully cultivated agricultural biomass, which usually reinforces the substrate.

As can be concluded from examples in previous plants and from the waste yields themselves, waste characteristics and waste quantities, the composition of the substrate is generally defined from the available resources, i.e. each substrate composition is defined as a single plant. There is no exact rule as to what the substrate must be, but the composition of the substrate depends on the yield of biogas from a certain amount of substrate, and thus the profit.

2. EXAMPLE OF BIOGAS PLANT WITH CHP

Slurry coming from a pig farm may have a rough screening before entering the anaerobic digester with 30 days of hydraulic retention time (20–50 days recommended). The proposed anaerobic digests would have a depth of 3.0 meters. The anaerobic digester has a mixing system to improve the efficiency of the digester, to optimize the production of biogas and to avoid (as much as possible) sedimentation and accumulation of solids in the digester. The efficiency of biochemical removal of oxygen demand in anaerobic lagoons is 50–85% [5]. Schematic plan of the whole plant should be defined before the calculations, as shown in Figure 1.

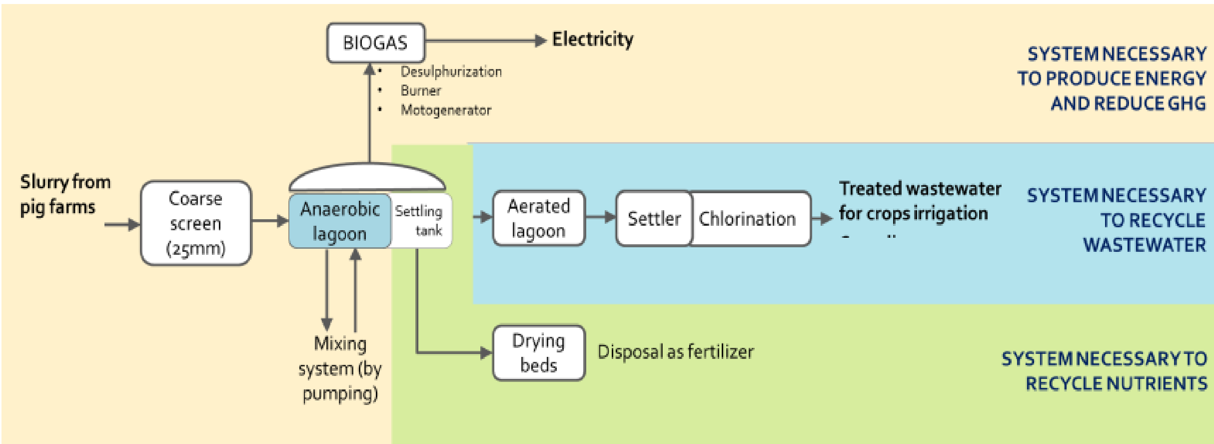

Fig. 1. Plant schematic plan [5]

The composition of the substrate would look like this:

– 27.5 tons of liquid pig waste (46%),

– 16.5 tons of solid pig waste (28%),

– 15 tons of corn silage (26%).

In the considered case it can be concluded that the most compatible mode of operation in mesophilic mode. From the above data it can be seen that the psychrophilic regime does not give a sufficient yield of biogas over time and it takes a very long time to retain the substrate which is not compatible for us given the large amount we have to process. The thermophilic operating mode of the digester is not recommended for animal waste. Therefore, as in most examples so far, it has been decided to use the mesophilic operating mode, because it offers consumption of a medium (reasonable) amount of heat energy and a reasonable retention time. on the substrate. Cogeneration using internal combustion engines is commonly used in biogas plants. Electricity efficiency is high, and investments are lower. A gas turbine and an internal combustion engine can also be used as a cogeneration device in a combined heat and power plant. To determine which unit to choose, the characteristic dimensions of a combined plant such as heat generated, and electricity must be considered also and daily biogas production. So, biogas produced in the anaerobic digestor and the one released in the solid deposition digestor department can be collected and transported by pipes to a treatment system. The corresponding amount of biogas from pig farm waste would be 1646 m^3/d approximately, with 58% methane shown in the following calculations:

$$\text{Methane produc.} = 3180\,\frac{\text{kg}}{\text{d}}\cdot 300\frac{\text{Nm}^3\text{CH}_4}{\text{kg}} = 954\,\frac{\text{Nm}^3\text{CH}_4}{\text{d}} \tag{2.1}$$

$$\text{Biogas production} = 954\,\frac{\text{Nm}^3\text{CH}_4}{\text{d}}\cdot\frac{1}{0.58}\,\frac{\text{Nm}^3\text{biogas}}{\text{d}} \tag{2.2}$$

Biogas should be burned (released) when the biogas pressure exceeds a certain level, and the combustion engine does not work due to maintenance or if there is an additional tank to be stored. The production of electricity from biogas exceeds the consumed electricity on the farm, the remaining electricity will be sold in the national grid, to the national electricity company. The purchase price for electricity produced from biogas in Macedonia now is 180 euros/MWh [6]. Pig production does not have constant heat requirements, so biogas is not recommended to be used exclusively for combustion in a boiler for heat production. The production of fuel for vehicles is not evaluated in this study and is relevant only if the entire fleet of vehicles is supplied with gas. The only reasonable use of biogas is the production of electricity, and as a by-product is the thermal energy. Thus, the biogas produced in the anaerobic digester and the one released in the digester storage compartment of the solids can be collected and transported by pipes to a treatment system. In this example it is defined to be used as a cogeneration device by an internal combustion engine, due to the smaller initial investment and due to the larger selection of powers available for sale. The sizing of the plant will be based on the production of electricity, it will be based on the maximum utilization of biogas and main production of electricity, and as a by-product will appear thermal energy. A small part of the electricity (12%) will be used for the needs of the farm while the remaining part will be sold to the electricity distribution company and will be given to the electricity network. Part of the thermal energy (47%) will be used for heating the substrate and the fermenter and technical water, and in the winter for heating the premises of the farm itself. Before economical calculations we must define schematic representation of a CHP cogeneration plant, as shown in Figure 2.

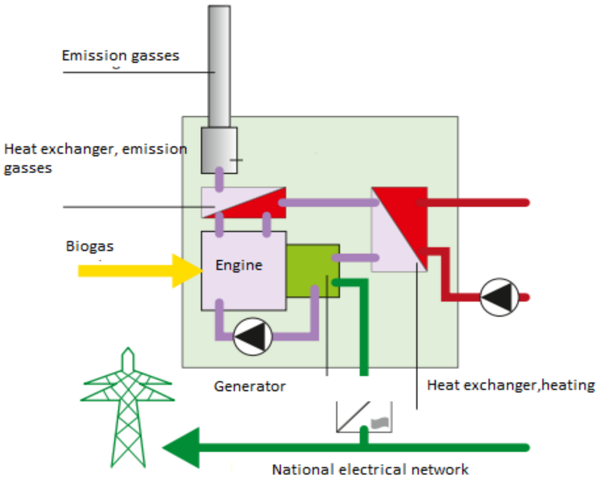

Fig. 2. CHP schematic plan [10]

Modern internal combustion engines have a degree of utilization of over 40%, but even then, a large amount of heat is available. Cogeneration is achieved by using the heat energy of the coolant and combustion products. The heat energy obtained from the coolant is at a low temperature, so it can only be used to heat water up to about 90 °C. Hot water can be used to heat fermenters or nearby work or residential premises. Suitable heat exchangers are required to achieve cogeneration, utilization of coolant heat energy and combustion products. The electrical efficiency of a cogeneration plant is calculated as the product of the efficiency of the engine and the efficiency of the generator. To dimension a plant, it is necessary to make an energy balance that graphically shows the distribution of energy.

The generator – engine technical data in the analysis is for the MTU 6R500 GS [7]. This genset has consumption at full power of 70 m^3/h and the available biogas in the plant is 68 m^3/h. The idea is to have genset that can consume the whole amount of produced biogas. A cogeneration plant is installed with an assumed electrical efficiency of 42%. In terms of annual load hours, the starting point is 8000 hours. The capacity of the gas tank is sufficient so that the produced gas can be used in its entirety and does not have to be burned through a torch. The lower thermal power of methane is 9.97 kWh/m^3 [8]. Every producer of CHP plants must supply energy balance of theirs generator – engine set, as shown in Figure 3.

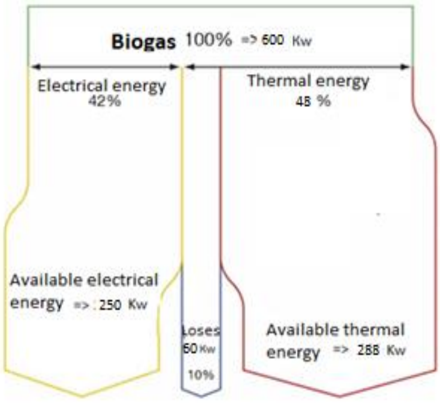

Fig. 3. Example – energy balance and efficiency of a CHP [7]

For the considered digestor it is assumed mesophilic temperature mode of working, with 37 °C degrees in the digester. From the existing biogas plants it can be derived value of about 50 kWh of thermal energy, required per ton of substrate to heat the substrate and maintain the temperature in the digester or a maximum level of up to 20 percent of the produced heat energy [9]. Additional 5.4 kwh/ton substrate, electrical energy for mixers, pumps and equipment in the biogas plant [10]. The daily net amounts of produced energy are:

Electricity = 6000 kwh – 319 kwh – 356 kwh = 5325 kwh

(= daily electricity production – daily consumer for the operation of the equipment of the plant – daily average consumer for the needs of the farm itself = residual electricity)

Thermal energy = 6912 kwh – 2950 kwh – 667 kwh = 3295 kwh

(= daily heat production – daily consumption of heat for digester and substrate – average daily consumption of heat for space heating and technical water = residual heat)

The average consumption of electricity for the needs of the farm can be taken as a constant value, while the average consumption of heat varies depending on outside temperatures, in winter we have increased consumption while in summer we have reduced consumption. The remaining electricity will be sold to the electricity distribution company. From the genset we have three options for heat recovery with temperatures of 180, 90 and 40 °C. All heat requirements are satisfied like heating digester and administration offices and farm. From this we have left 3295 kwh daily of heat energy. Lot of this energy can be sold to outside company or we can heat one small neighbourhood. There it is a lot of option to do with the extra heat energy.

3. ECONOMIC ASSESMENT – CASE STUDY

The purpose of this analysis is to determine whether the combined plant is technically properly selected and whether it will offer significant potential economic benefit to the company in order for the company to decide whether to fund a more comprehensive study. It is analyzed the existing electrical and thermal needs of the company, collected data related to the operation of the company and the permanent equipment and data on the produced waste. To perform an economic analysis of a system with this level of data, the use of assumptions and averages is required. Therefore, this preliminary analysis should be considered as an indicator only for technical and economic potential. This analysis primarily refers to the marginal production costs, plant maintenance costs and credit costs for CHP plant or the various options considered. The specific investments, both in relation to the whole plant and in relation to the cogeneration unit, are in principle higher compared to the larger plants. It is also relatively noticeable that the workload of a smaller plant is generally higher, especially if larger amounts of solids are to be used as a liquid fertilizer additive. All costs are calculated by already existing examples, as kw/$. Investment prices are defeined by existing plant examples, usually they are called as CAPEX. Investment prices for our project are defined and shown in Table 1.

T a b l e 1

Prices by sector (CAPEX)

Investition	Anaerobic	Sludge	Aerobic	Sumary
Description	USD	USD	USD	USD
Electromechanical gear	154 225	69 614	88 476	312 306
Constructions work	192 300	73 500	94 455	360 255
Electrical installations	125 952	43 256	47 288	216 496
Pipelines and mechanical installations		140 000	100 125	240 225
Engineering project	56 411	84 616	28 205	169 235
Start up	39 215		78 430	117 645
Summary	794 279	92 386	161848	1 416 162

For complete economic analysis we must show and operational costs or OPEX costs. OPEX cost are defined by producers of the equipment used and by already existing examples of plants. In the OPEX cost are included all operational costs which can be fixed and variable costs per year, as shown in Table 2.

Table 2

OPEX costs, fixed and variable costs by sectors

Operational costs	Anaerobic	Sludge	Aerobic	Summary
Fixed costs	USD/year	USD/year	USD/year	USD/year
Working costs	14 331	7 850	11 230	33 411
Depreciation	29 352	5 033	10 000	44 385
Interest rate and insurance	12 121	12 121	12 121	36 363
Summary fixed costs	55 804	25 004	33 351	116 159
Variable costs	USD/year	USD/year	USD/year	USD/year
Sludge	0	83 240	0	83 240
Maintenance	15 000	9 252	7 925	32 177
Chemical reagents/ Biogas treatment	7 406	0	1 763	9 169
Summary variable costs	22 406	92 492	9 688	134 586
Summary OPEX	78 210	117 496	43 039	238 745

The project would have some cost savings due to energy production and the use of part of that energy for own needs. Calulation of the saving are one of the key faktor to calculate the payback period, savings for our project are shown in Table 3.

Table 3

Savings

Moto-generator	kW	221
Working hours	h/yr.	8 000
Production electricity	kWh/yr.	1 775 000
Price for electricity	$/kWh	0.21
Savings electricity for pig's farm	USD/yr.	372 750
Consumption diesel fuel for heating	Lit./yr.	20 000
Price diesel fuel	USD/lit.	2
Savings for diesel fuel	USD/yr.	40 000
Summary savings	USD/yr.	392 750

Finally, the surplus electricity from the anaerobic system with a motor generator in a farm of 10,000 pigs is approximately 221 kW. Another cost savings included in the savings is diesel fuel used for combustion in the boiler and to obtain heat energy and for combustion in a generator in cases where there is no electricity. To estimate this cost savings, it is necessary to know the historical consumption of diesel, the number of hours per year that farms need to operate a diesel generator due to lack of electricity.

Payback period

Payback period is one of the key factors to decide if we want to invest or not. In payback period we do not consider the inflation rates or interest rates associated with bank loans.

In Table 4 is shown summary of the payback period for our project.

In Figure 4 it is shown graph of the payback period, with years horizontally and USD vertically.

Table 4

Summary – payback period

CAPEX	USD	1 416 162
OPEX	USD/yr.	238 745
Savings	USD/yr.	392 750
Payback period	Year	9.19

Net present value

The NPV (net present value) of the project is calculated by subtracting the present value of the savings from the present value of the investment and the cost. With this calculation we can define the value of the plant in future, as shown in Figure 5. NPV values are calculated by next formula:

$$\mathrm{NPV} = \sum_{n=0}^{N} \frac{Fn}{(1+d)^n} + \frac{F_1}{(1+d)^1} + \frac{F_2}{(1+d)^2} + \cdots + \frac{F_N}{(1+d)^n} \tag{3.1}$$

where is:

NPV – Net present value

Fn – Net cash flows in year *n*

d – Intrest rate

n – Year

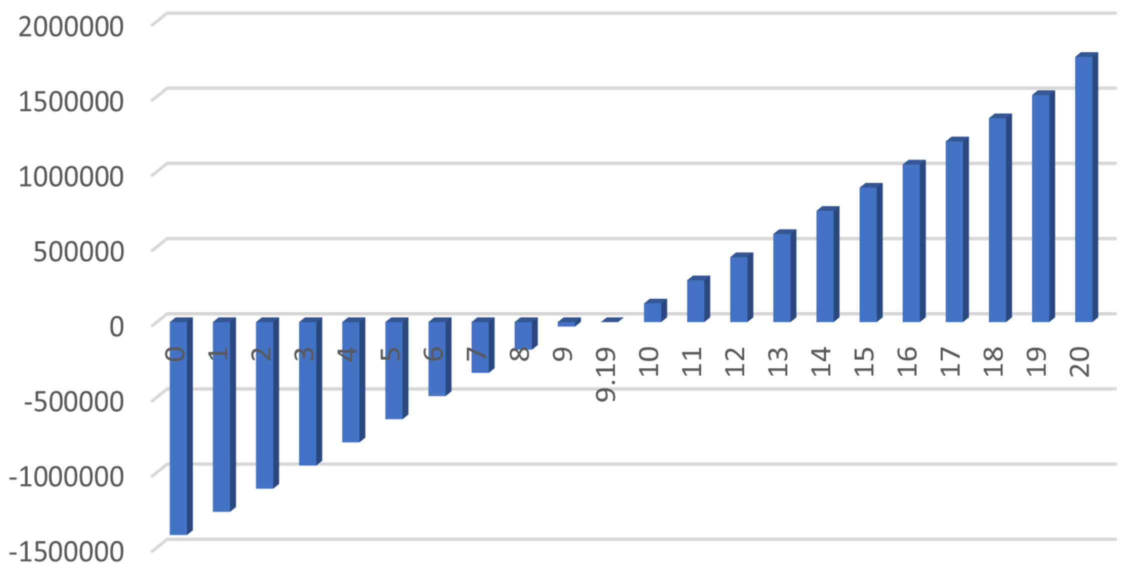

Fig. 4. Payback period graph

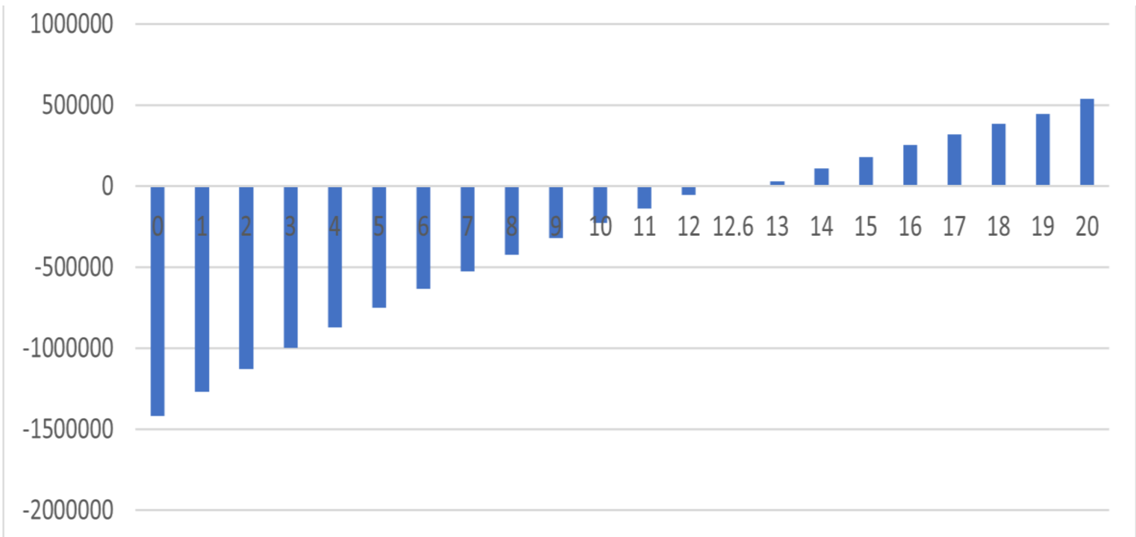

Fig. 5. Cash flow – net present value (NPV)

The net present value (NPV) of the project is the net savings from its life cycle. It is the absolute monetary value of the project. A positive NPV (net present value) indicates how much money a project will earn over its lifetime. NPV shows the total potential earnings of the project. The NPV considers the effect of interest rates on future net savings. NPV is a major decision-making tool for project owners. If NPV > 0, the project is profitable (economically feasible).

Benefit/cost ratio

The relative value, BCR (ratio of savings and investments) of the project is calculated by dividing the present value of the savings / the present value of the investments. If benefit / cost ratio is bigger than 1.0, then the project is profitable.

$$\mathrm{BCR} = PV_{\mathrm{AS}} / PV_{\mathrm{I}}, \qquad (3.2)$$

where is:

PV_{AS} – benefits present value

PV_{I} – costs present value

Example:

BCR = 2 443 030 / 2 112 511 = 1.13

Internal rate of return

Internal rate of return (IRR) is a hypothetical discount rate at which BCR = 1.0 or NPV = 0. IRR requires a recurring, computer-friendly calculation. If the IRR ≥ discount rate used in the analysis, the investment is worthwhile (economically feasible). High IRR earns more profit per dollar invested. IRR is a major decision-making tool for lenders, usually the first question they ask. Each investor can arbitrarily set their own acceptable IRR.

In our example IRR = 11%, this value is calculated using the equation in excel.

Levelized cost of electricity

Levelized cost of electricity (LCOE) is the value that must be obtained for each unit of energy produced to ensure that all costs and reasonable profits are incurred. The profit is provided by discounted (decreasing) future income at a reduced rate equal to the rate of return that can be obtained for other investments with comparable risk, i.e. the possible cost of capital. The specific production price of energy is calculated with an excel calculation, and it is 0.076 $/kWh.

Levelized cost of heat energy (LCOE)

The LCOE method is also applied to thermal energy which can also be called LCOH. The calculation is performed according to the next formula (3.3). The specific production price of energy is calculated with an excel calculation, which is 0.058 $/kWh (Table 5).

$$\sum_{t=1}^{t=N} \frac{\mathrm{LCOE}*Q_t}{(1+d\prime)^t} = \sum_{t=0}^{t=N} \frac{C_t}{(1+d)^t} \qquad (3.3)$$

T a b l e 5

Current $ level annual cost (LAC)

Cost of money	0.0500
Net current value (year)	224464
Net current value	1 555 485
Capital recovery factor (current)	0.0802
Current $ level annual revenue requirements ($/y)	103016
Current $ LAC of Heat Energy ($/kWh)	**0.058**

Sensitivity analysis

Sensitivity analysis is a method for considering uncertainty that does not require probability estimates. Sensitivity of economic tests the performance to alternative numbers of key uncertainty factors. The sensitivity analysis always provides multiple answers in economic terms, and it shows decision points such as the economic viability of a renewable energy project, downside rates, time horizons and other critical factors.

In Figure 6 it is illustrated the sensitivity of fuel savings, i.e. the specific energy price achieved by the combined plant with 7 critical factors: capital cost (amount of capital investment cost), interest rates (D is equal to 0%, 5%, 10 % and 15%), capacity factor (plant size), fuel cost (cost of procurement, preparation and transport of the substrate), cost of capital, debt ratio and net plant efficiency.

In the considered case, the main impact of the escalation of the energy price is with a relative change in the net efficiency of the plant. A big change can also be seen in the relative change in the loan-to-equity ratio. In these two factors sharper changes can be noticed, compared with the other factors, which have milder reflections on the specific price of energy with their change.

This example graphically illustrates the situation often encounter in the economic viability of energy efficiency and renewable energy projects.

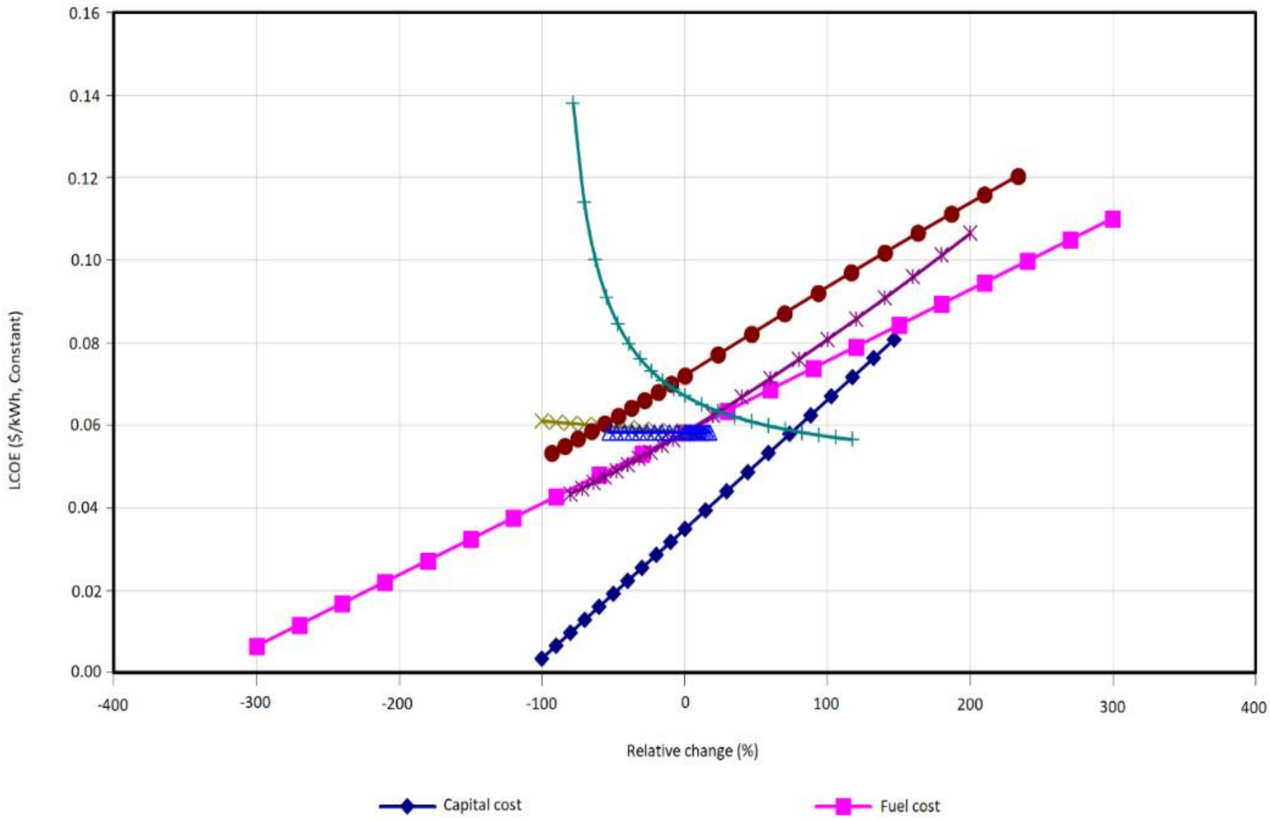

Fig. 6. Sensitivty analysis project

4. CONCLUSION

In the paper is analyzed techno-economic possibility for integration of anaerobic system and the biogas system in pig farms in Macedonia. The investment costs are assumed as 1.416.162 USD and the simple payback period for the considered financial conditions is less than 9 years.

According to the economic assessment results, it can be concluded that investment in cogeneration power plants in pig farms can be sustainable solution. With investing in biogas plant there are in general two main benefits: financial and ecological. Beside the financial and ecological benefits, the pig farms with CHP units has independent electricity and heat supply and as a byproduct-benefit are the fertilizers.

Summary variable and fixed costs are around 238.745 USD per year.

On annual basis compared with the existing system there are several main benefits: saved 20.000 liters light oil and production of 3295 MWh electricity.

The results from the NPV calculations, indicate that the whole project after the technical lifetime period of 20 years will be in economical positive with 540 770 USD with payback period of less than 9 years for the whole plant.

The LCOE method is applied in order to define the energy price for electricity and heat energy and compare with the market prices.

With the sensitivity analysis we could see all important factors or decision makers. One relative change to one factor can affect in direction of big cost of one amount energy. It should be noted, that each of the considered factors in the sensitivity analysis is important and need to be taken into account in the decision process. In the sensitivity analysis for the considered conditions, the electricity market price, the loan to equity ratio and cogeneration power plant efficiency have the main impact on the plant economic feasibility. The world trends which are indicating potential price escalations in electricity and fossil fuels, will positively reflect on the economic viability of biogas power plants.

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