Biblid: 1821-4487 (2020) 24; 1; p 13-17
UDK: 620.91
DOI: 10.5937/jpea24-25510

Original Scientific Paper
Originalni naučni rad

METHODS FOR ASSESSING THE ECONOMIC VIABILITY OF BIOGAS PLANT INVESTMENTS

METODE ZA OCENU EKONOMSKE OPRAVDANOSTI INVESTICIJA ZA POSTROJENJA ZA BIOGAS

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ABSTRACT

The development of the global economy and booming population growth have resulted in the increased consumption of energy and the growing need for alternative energy sources. This paper presents the use of yield methods for assessing the economic justification of investments in biogas plants, as well as a review of the economic results of biomass energy production, with the aim of determining the present value of future benefits from the electrical and heat energy generated in such plants for fruit drying and processing purposes. The purpose of this paper is to determine the economic viability of investments in renewable energy sources such as biogas plants that can be used effectively in the production and storage of dried fruit. The yield-method results obtained indicate that the production of electrical and heat energy from waste biomass in biogas plants can produce positive financial results.
Keywords: *yield value, biogas, biomass, energy.*

REZIME

Razvoj svetske ekonomije i porast populacije rezultirali su povećanom potrošnjom energije i potrebom za iznalaženjem alternativnih izvora energije. Usled toga, ali i težnje da se smanji zagađenje životne okoline i ublaže klimatske promene, sve veći značaj dobijaju biogasna postrojenja koja su značajan izvor obnovljive energije, pre svega električne i toplotne.

Sušenje i dorada svežeg voća zahteva upotrebu značajne količine energije. Nastojanje da se zaštiti životna sredina od zagađenja, ali i da se upotrebom alternativnih izvora energije ostvare ekonomski pozitivni efekti odnosno smanje troškovi i poveća rezultat u proizvodnji sušenog voća, podstiče upotrebu alternatinvih izvora energije.

U radu je analizirana primena prinosne metode za ocenu ekonomske opravdanosti investicija u postrojenja za biogas uz osvrt na ekonomske rezultate proizvodnje električne i toplotne energije od biomase, a sa ciljem da se utvrdi sadašnja vrednost budućih koristi upotrebe električne i toplotne energije od biogasa u postupku sušenja i dorade voća.

Cilj ovog rada jeste utvrđivanje ekonomske opravdanosti ulaganja u obnovljive izvore energije, odnosno biogasna postrojenja koji mogu da se koriste i u postupcima skladištenja i sušenja voća. Toplotna energija praktično predstavlja sporedni proizvod kod biogasnih postrojenja koji značajno utiče na isplativost ulaganja. Ukoliko se toplotna energija kao sporedni proizvod ne iskoristi, tada ne postoji mogućnost za njeno vrednovanje, što posledično dovodi do nižih prihoda od upotrebe ovih postrojenja.

Ocena ekonomske opravdanosti investicija u postrojenja za biogas primenom prinosne metode pokazuje da se proizvodnjom električne i toplotne energije iz otpadne biomase mogu ostvariti pozitivni finansijski rezultati.
Ključne reči*: prinosna vrednost, biogas, biomasa, energija.*

INTRODUCTION

The growing population in the world and the global increase of economic activities lead to an increasing need for the production and consumption of energy. Fossil fuels such as oil, coal and natural gas (made from fossils of plants and animals) are non-renewable sources of energy which are continuously depleting. However, environmental pollution issues have been receiving increased attention as they pose significant challenges to the global economic growth. Natural resources and the environment itself are becoming the limiting factors for human economic activities. Over the past few decades, the concern about the environment has been growing not only globally, but also on the national and local levels (*Rodić et al., 2011*).

Serbia has a relatively high growth rate of energy consumption (6-7 % annually) and primary energy reserves six times lower than the world average. The use and management of energy sources in Serbia must be very rational, exploiting all available sources such as waste fuel (*Zekić et al., 2010*). Therefore, alternative renewable energy sources have been gaining prominence in the country over the past decades. The renewable energy comprises the energy of the sun, water, wind, geothermal fluids and biomass. The basic characteristic of renewable energy sources is their natural origin and the fact that they are (completely or partially) naturally replenished. Their overall energy potential is enormous. As a renewable energy source, biomass can be used for the production of biofuels, electrical energy and heat energy. In contrast to the production of energy from fossil fuels, the production of energy from biomass is considered an environmentally friendly concept of energy production as it only releases carbon dioxide in the process of photosynthesis. Communal, industrial and other types of wastewater, byproducts from animal breeding and plant biomass from field farming can be used as raw materials for biogas production. The production and use of biogas energy contributes to environmental protection and global population health. It also represents a superior type of energy production because the electrical energy thus generated can be transported to other locations. Moreover, heat energy is a byproduct of biogas production, which is best used where it is created.

The production of energy from renewable sources is more expensive than the fossil fuel energy produced using conventional technologies. Therefore, state support measures are of paramount importance to the renewable-source energy production (*Tica et al., 2012*). The economic results of producing electrical and heat energy from biomass in biogas plants should be studied with the aim of providing the energy thus generated to larger amounts of users (*Tica et al., 2013*).

The drying and processing of fresh fruit are characterized by significant electrical and heat requirements. Both environmental and economic aspects of dried fruit production emphasize the increased use of alternative energy sources such as biomass. The share of methane in biogas approximates to 60 %, and the heat power of biogas is 21.500 kJ/Nm^3 or 5.97 kWh/m^3 (*Đulbić, 1986*). Many areas in Serbia and particularly Vojvodina are considered favorable for agricultural production with tremendous potential for biomass energy production.

MATERIAL AND METHOD

This paper presents a calculation of the economic results of electrical and heat energy production from biomass in a biogas plant. The yield method was employed for assessing the economic results so as to determine the profitability of such energy production. The discounted cash flow, i.e. the cash flow after debt service, was used for the yield value appraisal (*Tica, 1993, 1997; Tica, 2009; Marko et al., 1998; Leko et al., 1997; Ryan, 2007; Milić, 2010*). The cash flow considered included all inflows and outflows of funds during a period of five years. Residual values were assessed on the basis of the net cash flow after the end of the projection period using the Gordon model.

The yield method of assessment implies that the value of fixed assets is based on the present values of cash flow in the projected period and the present residual values (*Tica et al., 2009*). Cash flow is a sum of the company's business results, which, relative to construction objects, appear as incomes from rent and amortization. Moreover, cash flow also consists of potential funds generated from the use of the construction object during the calculation period. The calculation of the net cash flow after debt service is shown in Table 1.

Table 1. Net cash flow after the debt service calculation

No.	Category	Calculation
1	Revenue	
2	Operating expenses	
3	Gross profit <amortization-interest-tax>	1 – 2
4	Amortization	
5	Operating profit	3 – 4
6	Interest expenses	
7	Profit before tax	5 – 6
8	Taxes	
9	Net profit	7 – 8
10	Amortization	
11	Gross cash flow	9 + 10
12	Increase of long-term debt	
13	Increase of working capital	
14	Fixed assets investment	
15	Long-term debt repayment	
16	Net cash flow	11 + 12 - 13 - 14 – 15

According to *Tica et al. (2009)*, the present value of expected future cash flows is determined using a discount rate which expresses the time value of money. The initial step of cash flow discounting is the multiplication of the cash flow values projected for a specific period of time and the discount factors determined for that period. Discount factors represent a reciprocal value of the compound interest calculation, where discount rates are used instead of interests.

Discount rates present risk-free rates which are calculated as follows:

$$D = \frac{1}{(1+d)^n}$$

where

- D – discount factor for a specific year,
- d – discount rate
- n – the year discount factor is applied to (values from 1 to + ∞).

Discount rates represent the cost of capital which reflects the risk level of investments (*Serdar Raković, 2016*). As a measure of the time value of money, discount rates are used to calculate the present value of expected future cash flows on the basis of the risk-free rates, risks of investment in a certain country or region, and project-related risks.

According to *Tica et al. (2009)*, the yield value represents a sum of the discounted cash flow values in the projected period and the residual values. As the projection period includes only a limited number of years, future cash flow values are calculated for the period following the projection period. The values of the future cash flow, i.e. the economic benefits not included in the projection period, are referred to as the residual values, which are calculated using the Gordon model:

$$\text{RV} = \frac{(\text{DNNTr x } (1 + \text{SRr}))}{(\text{DS} - \text{SRr})}$$

where

RV – residual value,

- DNNTr – discounted cash flow in the residual period (the first year after the projection period),
- DS – discount rate,
- SRr – growth rate in the residual period.

The data on the investments in and operating expenses of biogas plants for electrical and heat energy production in the Autonomous Province of Vojvodina were used for calculation purposes in this study. Operating expenses were computed using analytical calculations for each production line within a company or family household. The basic scheme for a production line was calculated using the following equation: p – t = d (where p is the planned or market production value, t denotes the total production expenses, whereas d marks the financial result (namely profit or loss)). The results obtained for the biogas plant considered indicate that the mass of waste produced will amount to 20,000 tons annually, of which 15,000 tons will be the waste from the industrial processing of agricultural products and approximately 5,000 tons of silage mass.

The efficiency of production is one of the most significant indicators of business success. It reflects not only the soundness of the use of all production factors, but also the measure of production value and revenues against production costs. The reference value of this indicator is minimum 1.

The efficiency indicator (E) represents the ratio between total revenues and total expenses, i.e. production values and production expenses:

$$E = \frac{\text{Total revenues}}{\text{Total expenses}}$$

The profitability of production represents a tendency to achieve higher incomes on totally engaged assets and is most often calculated using the return on assets ratio (ROA):

$$ROA = \frac{\text{Profit before tax}}{\text{Total assets}}$$

Higher ROA values indicate greater asset profitability.

RESULTS AND DISCUSSION

Any organic substances such as carbon, nitrogen, phosphorus, potassium, magnesium and etc. can be used as raw materials in biogas production. Accordingly, the most convenient inputs for biogas production are communal and industrial wastewater and plant biomass. Agriculture is the economic sector with the greatest potential for producing inputs for biogas plants such as manure and crop biomass. Biogas is a result of the anaerobic fermentation of manure (without the presence of oxygen), i.e. the activation of bacterial cultures found in compost. In the first phase, the activity of saprophytic bacteria causes carbon substances to convert into volatile acids and water. Subsequently, acids are transformed into methane and carbon dioxide. In this process, organic substances of solid waste are lowered by 50-70 %, resulting in boiled manure (containing nitrogen, potassium and phosphorus) as a byproduct of biogas production (*Mulić, 1995*). In the present study, waste crop biomass is used as the basic raw material in biogas production.

The primary objective of this paper was to analyze and assess the yield value of investments in a biogas plant for the production of heat and electrical energy from biomass, with a total projected capacity of 740 kW of electrical energy and 888 kW of heat energy. The estimated value of investments amounted to €3,767,310, which is comparable to the usual investment value for this type of plants. A total of €3,150,000 was required for investments in the biogas plant and equipment, whereas a total of €617,310 was allocated for investments in the property and facility of the plant. All the data used in this study were obtained from the technical and technological documentation, which was the basis for the plant construction and operation.

A predicted interest rate of 6 % was also capitalized and added to the investment value.

The planned electrical and heat energy production was projected not to exceed the technical capacity of the plant, enabling a projected increase in the economic results of 2 % annually. In order to achieve such an increase, the material costs and other operating expenses had to be adjusted, whereas other expense categories remained unchanged. The projection of revenues and expenses is shown in Table 2.

The economic results obtained indicate that the production of heat and electrical energy from waste biomass can be cost-effective and profitable. The calculation of total revenues and expenses suggests that a biogas plant with a capacity of 740 kW can generate a profit before tax of €217,063 annually, supported by state-guaranteed purchase prices for the electrical energy from renewable sources. Moreover, the revenues from biomass heat energy production, which can be used for fruit drying and processing, were included in the calculation of the total revenues. The planned revenues from the delivered electrical energy accounted for 82 % of the total revenues, whereas the planned revenues from the heat energy produced accounted for 18 % of the total revenues.

A discount rate of 13.95 % was estimated for the biogas plant considered, of which a 4.5 % share was jointly claimed by the risk-free rate and the risk rate of investment in the Republic of Serbia, whereas the risk rate of investment in the biogas plant considered accounted for 9.45 % of the discount rate established.

Table 3. Calculation of the risks of investment in the biogas plant considered

Risk element	Risk level
Organization, management and personnel quality	1.20
Company size	2.00
Financial position	2.00
Production-placement potential	2.25
Prediction ability	2.00
TOTAL RISK RATE (%)	**9.45**

Table 2. Income statement (€)

ACCOUNT NAME	1st year amount	2nd year amount	3rd year amount	4th year amount	5th year amount
REVENUES AND EXPENSES FROM CONTINUING OPERATIONS	1,081,299	1,102,925	1,124,984	1,147,484	1,170,433
1. Sales revenues	1,081,299	1,102,925	1,124,984	1,147,484	1,170,433
OPERATING EXPENSES	864,237	874,895	885,766	896,855	908,165
1. Cost of material	313,158	319,421	325,809	332,326	338,972
2. Personnel expenses	35,935	35,935	35,935	35,935	35,935
3. Amortization	295,400	295,400	295,400	295,400	295,400
4. Other operating expenses	219,744	224,139	228,621	233,194	237,858
GROSS PROFIT	217,063	228,031	239,218	250,629	262,268
OPERATING PROFIT	217,063	228,031	239,218	250,629	262,268
PROFIT BEFORE TAX	217,063	228,031	239,218	250,629	262,268
TAX	27,675	19,383	20,334	21,303	22,293
NET PROFIT	189,387	208,648	218,884	229,326	239,975

Table 4. Projected cash flow (€)

Account name	**Year**				
	1	**2**	**3**	**4**	**5**
Total revenue	1,081,299	1,102,925	1,124,984	1,147,484	1,170,433
Operating expenses	568,837	579,495	590,366	601,455	612,765
Gross profit <amortization-interest-tax>	512,463	523,431	534,618	546,029	557,668
Amortization	295,400	295,400	295,400	295,400	295,400
Operating profit	217,063	228,031	239,218	250,629	262,268
Interest expenses	0	0	0	0	0
Profit before tax	217,063	228,031	239,218	250,629	262,268
Taxes	27,675	19,383	20,334	21,303	22,293
Net profit	189,387	208,648	218,884	229,326	239,975
Amortization	295,400	295,400	295,400	295,400	295,400
Gross cash flow	484,787	504,048	514,284	524,726	535,375
Additions to accounts payable	44,408	888	906	924	943
Additions to other short-term liabilities	27,611	0	0	0	0
Reductions in receivables			0	0	0
Reductions in cash		0	0	0	0
Reduction in inventories		0	0	0	0
Total inflow	72,020	888	906	924	943
Reductions in accounts payable		0	0	0	0
Additions to other short-term liabilities	9,011	180	184	187	191
Additions to receivables	90,108	1,802	1,838	1,875	1,912
Additions to inventories	50,848	722	737	752	767
Investments	295,400	295,400	295,400	295,400	295,400
Reductions in other short-term liabilities		0	0	0	0
Long-term loan repayment	0	0	0	0	0
Total outflow	445,367	298,105	298,159	298,214	298,270
Net cash flow	111,439	206,831	217,031	227,435	238,048
Discount factor	0.87758	0.77014	0.67586	0.59312	0.52051
Net present value	97,797	159,290	146,683	134,897	123,906
Total net present value					**662,572**

Prior to the cash flow projection, a calculation of the current assets and liabilities was performed to provide a basis for the planned projections relative to balance sheets and income statements. The cash flow projection performed is presented in Table 4. The residual value calculation was based on the Gordon model.

Table 5. Calculation of the residual values

Category	**Value (€)**
Net cash flow in the previous year	238,048
Growth rate in the residual year	0.02
Net cash flow in the residual year	242,809
Discount factor	0.5205091
Present value of net cash flow	126,384
Capitalization rate (discount factor-0,02)	0.120
Residual value	**1,057,607**

The total present value of the discounted cash flow was €662,572 in the five-year period considered, whereas the present residual value was €1,057,607. The yield value of the biogas plant considered is expected to be €1,720,179, with an estimated discount rate of 13.95 %.

Calculation of the efficiency and profitability of the project

The efficiency ratio is calculated as follows:

$$E = \frac{\text{Total revenues}}{\text{Total operating expenditure}} = \frac{1,081,299}{864,237} = 1.25$$

An E value of 1.25 indicates a high level of efficiency, i.e. 1.25 units of revenue per each monetary unit of expense.

The profitability ratio is calculated as follows:

$$ROA = \frac{\text{Profit before taxes}}{\text{Total assets}} = \frac{217,063}{3,767,310} \text{ x } 100 = 5.76\ \%$$

Owing to higher initial investments, an efficiency ratio of 5.76 % was found to be unacceptably low, indicating that this investment cannot be financed by loans at the current interest rates offered by commercial banks in Serbia.

The financial results obtained do not include all the outcomes of biomass electrical and heat energy production such as quality fertilizers thus produced and environmental protection benefits (*Tešić et al., 2005*). This study confirmed that biogas production is characterized by a great number of environmental benefits, which is consistent with the results reported elsewhere in the literature. Therefore, the total results of this production can only be assessed from wide-scale social and economic perspectives, including government support measures and incentives for the production of electrical and heat energy from renewable energy sources (*Zekić et al., 2007*).

CONCLUSION

Previous research has shown that renewable energy sources have great energy potential. However, the production of energy from renewable energy sources is more expensive than the fossil fuel energy produced by conventional means. Therefore, state support measures are of paramount importance to the renewable-source energy production.

The results obtained in this study indicate that the production of electrical and heat energy from waste crop biomass in a biogas plant can generate positive financial results. The planned revenues from the delivered electrical energy claimed a share of 82 % of the total revenues, whereas the planned revenues from the heat energy produced accounted for 18 % of the total revenues. On the basis of the projected revenues and expenses, a high level of efficiency was determined (1.25). However, these results are insufficient to ensure the economic viability of this type of investment, even though the calculation includes the revenues from the heat energy produced (which can be used for fruit drying and processing). The large investment funds required resulted in a low project profitability of 5.76 %, suggesting that this investment cannot be financed by loans at the current interest rates offered by commercial banks in Serbia.

Although the production of energy from crop biomass using biogas does not ensure the economically viable energy production, it significantly contributes to environmental protection and the conservation of natural resources. Governments should support the renewable energy production through price and tax policies which would ensure the economic viability of such production. Therefore, significant tax relief measures and favorable state-guaranteed purchase prices for the renewable energy production have been established in Serbia.

ACKNOWLEDGMENT: This paper is a result of the research within the project TR31058, 2011-2020, supported by the Ministry of Education, Science and Technology of the Republic of Serbia.

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Received: 19.02.2020. Accepted: 27.04.2020.