"Biogas as an alternative energy resource for Ukrainian companies: EU experience"

AUTHORS	Yuri Yevdokimov Olena Chygryn https://orcid.org/0000-0002-4007-3728 http://www.researcherid.com/rid/R-4090-2018 Tetyana Pimonenko https://orcid.org/0000-0001-6442-3684 http://www.researcherid.com/rid/K-1188-2018 Oleksii Lyulyov https://orcid.org/0000-0002-4865-7306 http://www.researcherid.com/rid/O-7046-2018

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Yuri Yevdokimov (Canada), Olena Chygryn (Ukraine), Tetyana Pimonenko (Ukraine), Oleksii Lyulyov (Ukraine)

Biogas as an alternative energy resource for Ukrainian companies: EU experience

Abstract

The paper deals with analysis of the preconditions of alternative energy market development in Ukraine. In this case study, the authors analyzed the EU experience. The results of analysis showed that the leader of the EU countries in renewable energy has already achieved the target (20%), which had been indicated. In addition, the findings showed that the share of renewable energy in gross final energy consumption has been increasing from year to year. The authors allocate that, according to the Ukrainian potential, biogas is the most perspective one among alternative resources. Moreover, results of analysis showed that Ukraine has the huge potential of agricultural sector. In this direction, the authors allocated the main types of the agricultural activities, which have the highest potential of biogas production: sugar factories, corn silage and poultry farms. The authors underlined that biogas spreading is restrained by the stereotypes that green investments are not attractive for investors. In order to analyze the economic efficiency of investments to the biogas installation, the authors calculated the profit from the biogas installation for poultry farm. The authors made two scenarios for calculation. The first – the whole volume of energy, which was generated from the biogas unit, will be sold with feed-in tariff. The second – the farm covers its own needs in electricity, the rest will be sold with feed-in tariff. The findings showed that the first scenario is more attractive. Moreover, the farm could receive higher profit if it installed the biogas in 2016, not in 2017. In addition, based on the EU experience and features of farm functioning, the authors approved that the biogas installation has not only the economic effect (profit and additional profit) for company, but also ecological and social effects for rural area, where this farm was located.

Keywords: biogas, biofuel, consumption, efficiency, investment, potential, renewable energy market.
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Introduction

The dependence from the gas and other fuel resources contributed to the development of alternative energy market. Moreover, world's energy crisis contributes to research, development and implementation of new types of energy sources. According to the expertise forecasting, in the nearest future, the traditional energy resources (crude, coal, etc.) will run out. It is, therefore, necessary to find and develop alternative sources of energy. This goal is compatible with the theory of sustainable development, which states that current generation must preserve the living and environmental conditions we have and make the conditions of the next generations at least as good as our own.

In addition, in the ongoing world situation, it is very important to enhance and spread the results of research at all levels: from government to company and civil society. Moreover, it is necessary to change and redirect the mind of companies' management from the "unlimited consumption" to "green consumption". It is noted, that the idea of "green consumption" has already spread in companies marketing strategies in the EU countries.

On the other hand, such activities need to attract the huge and powerful additional financial and economic resources. In addition, the stereotype that green investments are not attractive for investors retard the development and spread of the alternative energy resources among the companies. In this case, it is relevant to develop and implement approaches for promoting the alternative energy among companies through the allocation of the economic, social and ecological benefits from renewable energy for them.

1. Literature review

The huge number of investigations had already been done in this sphere. Moreover, the scientists around the world have been researching the necessity and perspectives of the development and implementation of different types of the alternative energy sources.

Thus, in their work, Angelis-Dimakis et al. (2011) have been researching the engineering systems of renewable energy for companies. In the paper of

Yuri Yevdokimov, Ph.D., Professor, Department of Economics, University of New Brunswick, Canada.
Olena Chygryn, Ph.D., Associate Professor, Economics, Entrepreneurship and Business Administration Department, Sumy State University, Ukraine.
Tetyana Pimonenko, Ph.D., Associate Professor, Economics, Entrepreneurship and Business Administration Department, Sumy State University, Ukraine.
Oleksii Lyulyov, Ph.D., Associate Professor, Economics, Entrepreneurship and Business Administration Department, Sumy State University, Ukraine.

Rafindadi (2017), the scientists investigated whether the impacts of renewable energy have consolidated the economic growth prospects of the country. They proved the correlation between renewable energy consumption in Germany and the country's economic growth. Thus, 1% increase in renewable energy consumption boosts German economic growth by 0.2194% (Rafindadi, 2017).

According to Callaway et al. (2018), development and spread of renewable energy lead to increasing the energy efficiency and decreasing the greenhouse gas.

In their paper, Burke and Stephens (2017) analyzed the energy democracy and allocated that alternative energy was a basis of the energy dependence. In addition, they highlighted the necessity of developing the instruments for advocacy of the alternative energy among society. The scientists Grant and Vasi, I. in their work analyzed the role of civil society in the advocacy policy under the current environmental problems.

In their works, the Ukrainian scientists Geletukh (2013), Prokopenko (2017) are researching the economics and environmental benefits of the different types of renewable energy. Besides, they highlighted the perspective of development of renewable energy market in Ukraine.

The experts from the 'Bioenergy Association of Ukraine' assumed that Ukraine had the huge potential for biogas development as an alternative resource. In this case, in the official reports, they estimated the Ukrainian biogas potential and allocated the advantages from the biogas development for Ukraine.

The scientists Buczkowski and Postawa assumed that biogas as an alternative energy leads to the reduced carbon dioxide footprint (Buczkowski, 2017).

In their papers, the scientists Buczkowski (2012), Iglinskin (2011), Krjaklina (2012) analyzed main features of biogas as the renewable energy resources for farms. They analyzed and calculated the efficiency of biogas installation from the technical point of view.

It is noted, that their paper, Cebula and Pimonenko (2015) tried to analyze the efficiency of biogas installation from the economic point of view. In addition, they made a conclusion, that biogas had social, economic and ecological benefits. They analyzed the Polish and Ukrainian potential on biogas development and accordingly they allocated the advantages of biogas development for Ukraine and Poland.

In their paper, Yasar et al. (2017) justified the socio-economic, health and agriculture benefits of rural household biogas plants. According to their investigation, the total monthly saving in terms of socio-economic and health benefits was 48 US dollars by the use of biogas plant of single household. There was 25% reduction in respiratory ailment and cardiovascular disease due to the reduction in air pollution by the use biogas plant (Yasar, 2017).

On the contrary, in their paper, Gasparatos et al. (2017) proved that development of renewable energy has the irreversible effect on biodiversity. That is why they underlined, that it was necessary to reorient the energy policy and synchronize it with biodiversity problems and new way of green economy.

In spite of the huge investigation on biogas like the alternative energy resource, no proper attention is paid to the efficiency of biogas development among farming companies according to the natural conditions and features in Ukraine from the different points of view.

2. Methods

This paper is based on the traditional methods of scientific knowledge: analysis and synthesis – in identifying trends of developed countries to decrease the dependence from traditional energy resources and spread alternative energy resources among companies; comparison and compilation – to analyze the experience of EU to develop alternative energy market and to achieve Sustainable Developments Goals 2030 on renewable energy; statistical and mathematical methods – due to the economic justification of efficiency of the biogas installation at the Ukrainian agriculture company; scientific support methods – to summarize and to formulate conclusions on social, economic and ecological benefits from biogas installation for farming companies. These approaches allow to allocate the challenges and opportunities for Ukraine to develop alternative energy, especially biogas, and to achieve the Sustainable Development Goals 2030 on renewable energy. In addition, it allows to take into account the best EU practice on spreading the alternative energy among farming companies.

The main purpose of this article is to analyze the potential of the alternative energy market, especially biogas sector, in Ukraine. Particular emphasis is placed on the economic, social and ecological efficiency of the biogas energy among Ukrainian farming companies.

3. Results

All economically developed countries have already started the process of developing the alternative and renewable energy resources. Thus, every country has already indicated the goal for the share of the alternative energy in gross final energy consumption – 20% by 2020 and 80-100% by 2050 (Fig. 1).

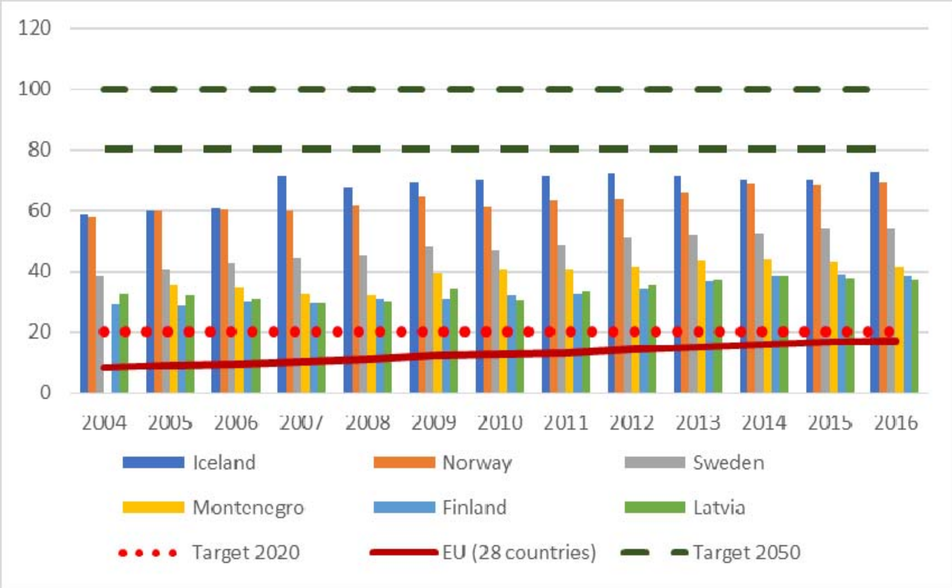

Fig. 1. Share of renewable energy in gross final energy consumption in EU

Source: Eurostat (2018).

The results of analysis showed that the Ukrainian achievements are not so impressive as in the EU countries. Thus, in 2017, the renewable energy in gross final energy consumption in Ukraine was approximately 7% (the goal for 2020 – 11%) (Ukrstat, 2017).

It should be underlined that some countries have already achieved the indicated share, some of them have the pessimistic attitude towards that. The findings showed that the leaders among EU countries are Iceland, Norway and Sweden. The outsiders among EU countries are Luxembourg, Netherlands and Malta (see Table 1). Unfortunately, Ukraine could be also characterized as an outsider. That is why it is necessary to develop and implement renewable energy resources in all sphere of activities.

Table 1. Dynamics of share of renewable energy in gross final energy consumption in the EU countries

	Countries	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	Iceland	58,9	60,1	60,8	71,4	67,4	69,6	70,3	71,5	72,4	71,6	70,4	70,2	72,6
2	Norway	58,1	59,8	60,2	60,1	61,7	64,8	61,1	63,7	64	65,9	68,6	68,4	69,4
3	Sweden	38,7	40,6	42,7	44,2	45,3	48,2	47,2	48,8	51,1	52	52,5	53,8	53,8
4	Montenegro	:	35,7	34,8	32,9	32,3	39,4	40,6	40,6	41,5	43,7	44,1	43,1	41,5
5	Finland	29,2	28,8	30	29,6	31,3	31,3	32,4	32,8	34,4	36,7	38,7	39,2	38,7
6	Latvia	32,8	32,3	31,1	29,6	29,8	34,3	30,4	33,5	35,7	37,1	38,7	37,6	37,2
	....													
21	Poland	6,9	6,9	6,9	6,9	7,7	8,7	9,3	10,3	10,9	11,4	11,5	11,7	11,3
22	Ireland	2,4	2,9	3,2	3,7	4,1	5,1	5,7	6,5	7,1	7,7	8,7	9,2	9,5
23	Cyprus	3,1	3,1	3,3	4	5,1	5,6	6	6	6,8	8,1	8,9	9,4	9,3
24	United Kingdom	1,1	1,3	1,5	1,8	2,7	3,3	3,7	4,2	4,6	5,7	7	8,5	9,3
25	Belgium	1,9	2,3	2,6	3,1	3,6	4,7	5,7	6,3	7,2	7,5	8	7,9	8,7
26	Malta	0,1	0,1	0,1	0,2	0,2	0,2	1	1,9	2,8	3,7	4,7	5	6
27	Netherlands	2	2,5	2,8	3,3	3,6	4,3	3,9	4,5	4,7	4,8	5,5	5,8	6
28	Luxembourg	0,9	1,4	1,5	2,7	2,8	2,9	2,9	2,9	3,1	3,5	4,5	5	5,4
	EU (28)	8,5	9	9,5	10,5	11,1	12,4	12,9	13,2	14,4	15,2	16,1	16,7	17

Source: Eurostat (2018).

The results of analysis showed that, from year to year, the share of renewable energy in gross final energy consumption among the European Union (EU) countries is increasing from year to year. Thus, in 2016, the share of renewable energy in gross final energy consumption was 17% (see Table 2), which is higher by 100% compared to 2004 (when the energy goals had been already accepted). In addition, the abrupt jump was twice in 2007 (by 11% compared to 2006) and 2009 (by 12% compared to 2008).

Table 2. Growth rate of share of renewable energy in gross final energy consumption in the EU countries

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
EU (28)	8.5	9	9.5	10.5	11.1	12.4	12.9	13.2	14.4	15.2	16.1	16.7	17
Compared to:													
previous year		6	6	11	6	12	4	2	9	6	6	4	2
basic year 2004		6	12	24	31	46	52	55	69	79	89	96	100

Source: Compiled by authors on the basis of Eurostat (2018).

Although, according to the Sustainable Development Goals 2030, access is ensured to affordable, reliable, sustainable and modern energy for all is the seventh Goals (Report, 2017). The findings showed that water, solar and wind energy were the most popular and make an increase.

The comparative analysis of the structure of electricity production from renewable sources in the EU and Ukraine showed that, in Germany, the electricity is mainly produced from wind energy, solar energy and biogas. In Poland, it is solid biomass, hydropower and wind energy. In Ukraine, it is hydropower and wind energy (Eurostat, Ukrstat, 2004–2017).

The results of analysis of the Ukrainian potential and Energy Road Map of the EU countries showed that Ukraine has a huge potential to develop the biogas as an alternative energy resource. Moreover, the experts made a forecast that in future, the structure of electricity production will be as follows: the share of wind farms can reach 45%, solar – 36%, and biomass and waste in the structure of heat energy production – up to 73% (Aliyeva, 2018).

Ukrainian government has already begun to make the first steps in developing the biogas like an alternative energy resource among Ukrainian companies. Thus, the Ukrainian government had already accepted the indicative goal of biomass in gross energy consumption by 2020 (Table 3).

Table 3. The Ukrainian indicative goals of biomass in gross energy consumption by 2020

Indicators	2009	2014	2015	2016	2017	2018	2019	2020
Production heating energy from the biomass, thousands of tons of oil equivalent	1,433	2,280	2,700	3,100	3,580	**4,050**	**4,525**	**5,000**
Electricity production from the biomass, thousands of tons of oil equivalent	40	40	250	380	520	**650**	**780**	**950**
including: – solid biomass – biogas	 28 12	 28 12	 175 75	 2,601 20	 360 160	 **455** **195**	 **540** **240**	 **660** **290**

Source: Compiled by the authors on the literature (National, 2018).

The results of the biogas production in the leader countries showed that biodiesel collection and utilization at solid waste disposal sites has already been included in leading countries practice. Particularly, the USA is using more than 150 large landfills for the purpose of generating heating and electricity for households. In 2013, the quantity of biogas installations in the USA is 244 units, which produced 4.3 billion m^3 per year (World Energy Resources, 2013).

For example, in Germany, the number of biogas installations is 4,000 units. Each year, 280 plants produce 3.7 ml tons of biogas. According to the forecast, more than 20,000 biogas plants will work by 2020 (Bioenergy, 2014).

According to the official Ukrainian database in 2016, more than 295.9 ml tons of waste were generated, only 0.35% were burned for the purpose of generating electricity (920.3 thousand tons of waste) and 0.01% for heating recycling (40 thousand tons of waste) (Ukrstat, 2018).

The other waste (84.63 ml tons) was utilized and landfilled (more than 152 ml tons of waste). The dynamics of waste in Ukraine is presented in Table 4.

Table 4. The dynamics of waste in Ukraine (2011–2016)

Year	Total, ml tons	Utilized, ml tons	Burnt, ml tons	With purpose, thousand tons		Landfilled, ml tons
				generating energy	heating recycling	
2011	447,6	153,7	0,8	800,6	-	-
2012	450,7	143,5	1,1	1082,9	-	-
2013	448,1	147,2	0,9	918,7	-	-
2014	354,8	109,1	0,9	873,6	71	203,8
2015	312,3	92,5	1,1	1086,3	48,4	152,3
2016	295,87	84,63	1,1	1000,3	45,0	140,2

Source: Compiled by the authors based on information from Ukrstat (2018).

Furthermore, Ukraine has the huge biomass potential to energy production. Thus, every year more than 50 ml ton of cereals are gathered by the agriculture companies. In addition, Ukraine has the huge volume of straw and plant waste which received from the agricultural crop production. According to the State Agency on Energy Efficiency and Energy Saving of Ukraine the annual energy potential of Ukrainian solid biomass is 18 equivalents to ml tons of oil. Furthermore, according to the official report (which presented in 2013) of Bioenergy Association of Ukraine the biogas potential in agricultural is huge (Table 5). Thus, the huge potential of biogas production has the corn silage (biogas generation – 7406 ml m^3), the sugar factories (biogas generation – 9543 ml m^3) and the poultry farms (biogas generation – 378 ml m^3) (Biogas production, 2013).

Table 5. The potential of biogas production in Ukrainian agriculture

Activity	Number of companies in Ukraine	The total volume of the main waste, thousand tons	Capacity of biogas production from the total waste and products, million cubic meters per year
Total in Ukraine	11,667	39,727	9,543
Sugar factories	60	23,264	976
Beer factories	51	1,017	122
Alcohol plants	58	2,705	117
Farms large horned livestock	5,079	15,432	386
Pig farms	5,634	5,657	160
Poultry farms	785	4,722	378
Corn silage			7,406

Note: Assessment on 2013.
Source: Biogas production, 2013.

On the other hand, the biogas could be a good chance for Ukrainian agricultural companies to decrease the dependence from the natural gas.

Thus, the main goal of the article is to calculate the economic efficiency of the biogas installation at the Ukrainian agricultural companies.

Under this research, the authors analyzed two scenarios for Ukrainian poultry farm "Avis Ukraine", which located in Sumy region. Except of the main activities, this poultry farm has 800 hectares of farmland. The authors supposed that poultry farm has already installed the biogas unit in 2016. The costs of biogas unit presented in Table 6. The basic data for calculation are presented in Table 7. According to the findings, the estimated generation of biogas at this farm is – 10,050 m^3 per day.

Table 6. The estimated costs of installation the biogas unit and equipment

Costs	EUR
Project	173282,77
Receiver tank	300026,16
Lagoon for filter	34981,97
Tank for grinding dust	14372,44
Cupola	964683,54
Reactor for hydrolysis	367801,53
Fermenter	900853,46
Gas system	94912,32
Automation	43083,72
Electronics	45490,74
Hot water system	27660,16
TOTAL	2,967,148,8

Source: Compiled by the authors.

Table 7. The estimated productivity of biogas unit

Indicator	Value
Electricity, kWh per year	8,808,000
Heating energy, kWh per year	8,556,000
Solid waste, tons per year	12,674
Liquid waste, tons per year	15,357

Source: Compiled by the authors.

The first scenario: The whole volume of electricity generation from the biogas unit will be sold with feed in tariff – 0.111 €/kWh. The poultry farm will buy electricity from the government by the price 0.073-0.078 €/kWh. The solid and liquid fertilize will be used for own needs.

According to the findings the farm could consume 139,895 m^3 of gas for 5 months (during the heating period). This volume could be compensated by the 14 working days of biogas unit (if whole volume of generated energy will be transformed into gas). That is why the period for electricity production would be decreased by 14 days, as a result, the period for electricity production will be 351 days. The results of calculation are presented in Table 8.

Table 8. The findings for the first scenario for years 2016–2017

Indicators	2016	2017
The daily capacity of a biogas plant, kWh	754,11	
Annual capacity for the calculated period of 351-days, kWh	264692,47	
Own needs of biogas installation in electric and thermal energy, kWh	5923,13	
Electricity volume for selling using feed-in tariff, kWh	258769,34	
Revenue from electricity sales €/kWh, €	821851,44	
Salaries of servicing personnel per year, €	1596,00	1755,60
Expenditures for current services per year, €	7812,50	8593,61
Other expenses per year, €	1875,00	2062,50
Company's expenditures on electricity per year, €	147764,29	181536,00
Cost of cultivation 3,650 tons of silo, €	30796,88	33876,56
TOTAL ANNUAL COSTS, €	189844,66	227824,28
EXPECTED ANNUAL PROFIT, €	632006,77	594027,16

Source: Compiled by the authors.

According to the findings, the estimated profit in 2016 is EUR 632,006.77, in 2017 – EUR 594,027.16. Besides, taking to account the loss of opportunity, if they use their field not for biogas production from the silo, but for mixed fodder production from the maize, or further selling, the loss of opportunity is EUR 50,186.28 and EUR 55,204.91.

At the same time, biofertilizers are an integral part of biogas production. In the first scenario, it was proposed first to meet the needs of the farm, and, then, the surplus will be realized. The biofertilizers productivity per 1 hectare is 20 tons. Correspondingly, the annual need of the farm in fertilizer on 800 hectares of agricultural production is 16,000 tons. The total output of liquid and solid biofuels is 28,031 tons, the difference of 12,031 tons will be sold on the market at a price EUR 7.8-8.2 per 1 ton. Accordingly, the estimated profit will be 99,480,31 EUR and 109,428,34 EUR, respectively.

Thus, taking to account abovementioned results, the total profit (profit minus loss of opportunity and plus profit from the fertilizers) will be in 2016 681301.74 EUR in 2016 and 648250.59 EUR in 2017.

Second scenario: in contrast to the first scenario, the farm's electricity needs will be satisfied firstly, and the surplus will be sold by feed-in tariff – 0.123 €/kWh. As in the first variant, the biofertilizers will be used for own needs, the surplus will be sold. The results of calculation are presented in Table 9.

Table 9. The findings for the second scenario for years 2016–2017 year

Indicators	2016	2017
The daily capacity of a biogas plant, kWh	754,1097	754,1097
Annual capacity for the calculated period 351-day, kWh	264692,5	264692,5
Own needs of biogas installation in electric and thermal energy, kWh	5923,125	5923,125
Electricity volume for selling using feed-in tariff, kWh	98880,74	108768,9
Revenue from electricity sales, €/kWh, €	159888,6	150000,4
Salaries of servicing personnel per year, €	507806,2	476401,4
Expenditures for current services per year, €	1596	1755,6
Other expenses per year, €	7812,5	8593,613
Company's expenditures on electricity per year, €	1875	2062,5
Cost of cultivation 3,650 tons of silo, €	30796,88	33876,56
TOTAL ANNUAL COSTS, €	42080,38	46288,28
EXPECTED ANNUAL PROFIT, €	465725,8	430113,1

Source: Compiled by the authors.

Taking into account the loss of benefits and adding the profit from selling the fertilizer received profit will be EUR 484,336,56. Thus, the profit from the first scenario is higher than for the second one. That is why the further calculation for justification of green investments would be only for the first scenario.

Table 10. The findings: estimated profit and loss of opportunities, EUR

Scenario		2016	2017
TOTAL PROFIT			
First		681,301,74	648,250,60
Second		515,019,85	484,336,56
First scenario	NPV	>0	>0
	IRR	22.3%	20.7%
	PP	8.6%	9.8%
	R	1.06	1.51

Source: Compiled by the authors.

Considering that the green credit has smaller rate than other type of credits, on average, 20-24% in UAH, 6-9% in EUR (in 2016 and 2017). In order to to analyze the economic efficiency of investments, the authors calculated the main indicators: NPV, IRR, PP, R. The findings showed that, in 2016, NPV>0, IRR=22.3% (>24%), PP=8.6, R=1.06. The similar results were obtained in 2016.

However, it should be underlined that economic efficiency of investments in 2016 is higher than if farm would decide to install biogas plant in 2017. The summarized results of two scenarios with loss of profit are presented in Table 10.

The results of analysis the benefits of biogas development in the EU and current opportunities at the poultry farm "Avis Ukraine" allowed to allocate the following social, economic and ecological benefits:

- waste utilization at the farm;
- sanitary treatment of wastewater;
- reduced emissions of volatile organic compounds;
- reduction of greenhouse gases;
- stabilization of nutrients for reduced water contamination risks;
- reduction of odours;
- direct and additional profit from fertilize selling;
- free from the ecological taxes;
- increasing of investment attractiveness;
- increasing the employment in the rural area, increasing the welfare of the local society;
- developing the energy infrastructure in the local area;
- improving environment, sustainable development of the rural area;
- improving the health among society (see Fig. 2).

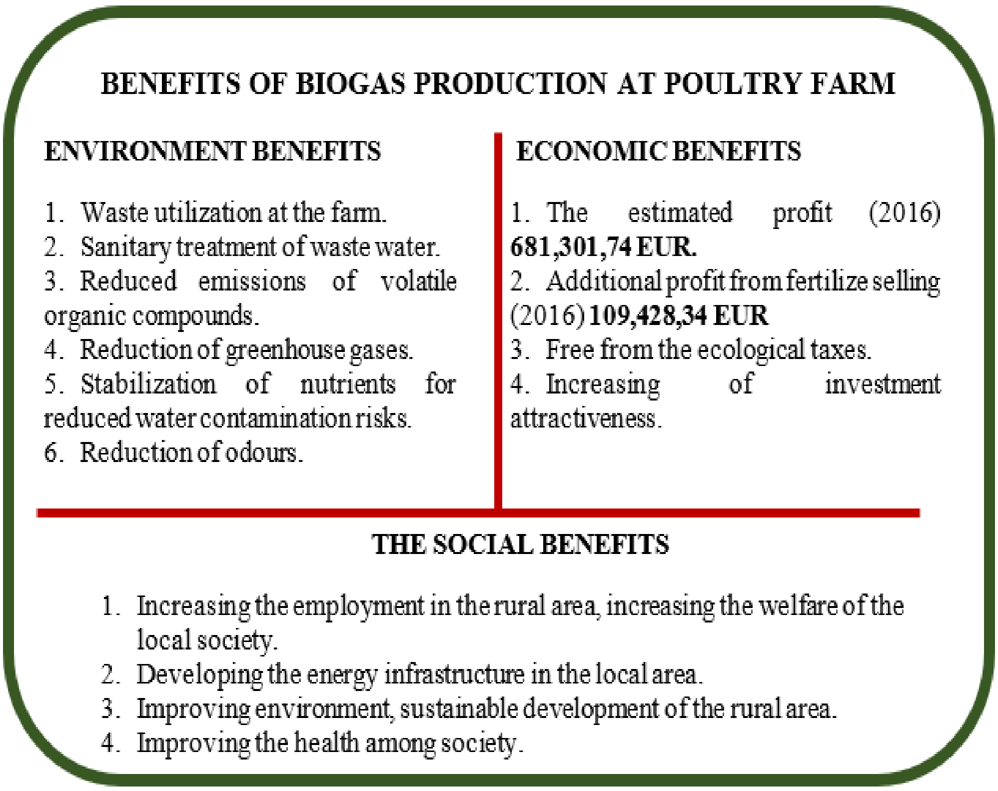

Fig. 2. Environmental, social and economic benefits from biogas production at the poultry farm "Avis Ukraine"

Source: Formed by the authors.

Conclusion

The results of analysis showed that Ukraine could be characterized as an outsider among the EU countries in the developing alternative energy resources market. Firstly, it connected with the lack of finance. The second problem is the stereotype that the green investments in the renewable energy are not attractive for investors. The abovementioned analysis showed that Ukraine as an agrarian country has the huge potential of developing the biogas as an alternative energy resource. Moreover, among the agriculture sectors, the poultry farms occupied the third position in potential of biogas production. Under this research, the authors justified the economic effect (direct and additional profit), the ecological and the social benefits. Besides, the authors approved that efficiency of biogas installation in 2016 is higher than in 2017. Moreover, the first scenario (the whole volume of energy, which was generated from the biogas unit, will be sold with feed-in tariff) is more attractive than the second variant. It allows to make a conclusion that management should make quick decision to install the biogas unit, because the economic efficiency is decreasing from year to year.

In this case, it is necessary to develop and implement marketing strategies for supporting and promoting instruments to spread the biogas by showing the possible efficiency of biogas from different points of view (economic, social and environmental).

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