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Biogas resources in industrial production of pork

Zasoby biogazu w przemysłowej produkcji wieprzowiny

Summary. The article analyzes the use of renewable sources of energy – biogas in the European Union and Ukraine. It is shown that the agro-industrial sector of Ukraine, producing a significant amount of organic waste, potentially has the resources to produce biogas and can replace 2.6 bln m³ PG/year. The contribution of organic waste in industrial production of pork can be 0.32 Mt of fuel. The authors believe that the main barrier to the implementation of bioenergy systems in industrial production of pork in Ukraine are large capital investments and operating costs as well as suboptimal substrate for fermentation parameters. Strategieses to ensure the reduction of capital investment and implementation of technologies of using sewages from the industrial production of pork to obtain renewable energy should be promoted more strongly. The technological process includes separating sewage, sediment compaction, resulting in a thin layer of its subsequent methane fermentation to produce biogas, electricity and heat. It is shown that the proposed approach can reduce capital investment at 30%.

Key words: drains, technology, biogas, capital investment, industrial production of pork

INTRODUCTION

One of the main problems in the world is the issue of energy [Rjabov 2005]. The growing population and its needs leads to an increase in energy use. However, these needs are limited to a disastrous decline in stocks of natural energy and tend to increase their value [Sorokin 2005]. Rising global energy crisis will not bypass Ukraine, which imports about 75% of the required natural gas. With stable growth trends in energy prices and significant dependence on imports points to the importance of enterprises reorientation to alternative energy sources [Kozyr *et al.* 2009]. Today, renewable energy sources (ENP) occupy an important place in the energy world. As evidenced by the international Energy Agency, 13.1% of primary energy worldwide in 2010 was made of ENP. Most of the biomass which was 9.9% [Geletuha *et al.* 2014]. One of the important sectors of VAT is the world's energy production and use of biogas. The leader in the production of biogas can be considered the EU in general and Germany in particular. The total production of biogas in the EU in 2010 amounted to 10.9 Mt (equivalent to 13.5 B cubic meters of natural gas), of which 6.7 Mt produced in Germany. This increase in relation to 2009 was 31.3% [Geletuha *et al.* 2014].

We know that the process for conducting methane fermentation of juice in the industrial production of pork optimum moisture drains is 90–92%. However, moisture drains in industrial production of pork can be up 97–98%. Even keeping pigs in industrial production of pork in the slotted floor with bathtub drains get humidity 95–97%. Therefore, the use of traditional technologies of biogas production with initial wastewater entering to methane tank for methane fermentation has shown that such technologies require large capital investments. Technologies and equipment developed by ZORG (Germany) for the processing of 945 m^3 of wastewater using a methane tank of 3600 m^3 and cost just over 2 million €, the payback period is 32 years [http://energetyka.com.ua/slovarterminov/293-biogaz, http://www.myshared.ru/slide/1034167/].

In Ukraine, there are some examples of biogas technology in a production environment. First acting today, BSU was built in 1993 on a set to pork production plant Zaporizhstal. Then were commissioned biogas installation companies Agro-Oven, Elite, "Ukrainian Dairy Company". In 2012 the agricultural enterprises of Ukraine were 4 biogas plants. In 2011was started in exploitation the construction of a biogas plant at the pig farm in s. Kopanky Kalush district, Ivano-Frankivsk region. Owner of the company and biogas installation – Danish company Danosha Ltd. Characteristics of the pig farm biogas plant at the company Agro-Oven [Matvjejev and Geletuha 2004]:

– biogas plant is based on technology and equipment company BTG (BBC TIGI) from the Netherlands,

– plant designed to process 80 t/day waste water from manure from 15 thousand pigs,

– scheduled dry matter content in the wastewater should be ranged from 10 to 12%,

– secondary fermentation time is about 25 days,

– capital expenditure 413.3 thousand USD,

– operational expenses 21.2 thousand USD/year.

The analysis of the implementation of the biogas plant by Agro-Oven in conjunction with livestock 14 000 pigs per year in the framework of technical assistance to the Government of the Netherlands has shown that capital investments totaled 413.3 thousand USD during processing 80 t of manure per day of wastewater. It was built two digesters 1000 m^3 each. Familiarity with this installation work showed that digestion of sewage subjected humidity 97–98%. Dry matter content in the substrate for fermentation was increased only 6–7% through the use of additional resources.

In a research note number 3 Bioenergy Association Ukraine [Geletuha and Zhelezna 2013]. The main barriers to bioenergy development in Ukraine:

– unreasonably low rate of ”green” tariff for electricity from biogas,

– incorrect meaning of the term ”biomass”,

– unreasonable requirements on local content share of equipment, materials and services in the total project cost,

– terminological error in the description of the main items of equipment for electric power facilities that use biogas energy.

We believe the main barrier implementing bioenergy plants in the industrial production of pork are large capital investment and operating costs and suboptimal substrate for fermentation parameters.

The aim of this study was to suggest and evaluate the approach to ensure the reduction of capital investment in the development and implementation of technology training wastewater for use in obtaining renewable energy in the industrial production of pork.

MATERIAL AND METHODS

The analysis of data on the use of renewable energy, including biogas in the European Union and Ukraine. Approach was developed and conducted assessment of the effectiveness of the proposed approach to ensure that the reduction in capital investments in the development and implementation of technology training wastewater for use in obtaining renewable energy in the industrial production of pork based capital investment and operating costs.

Research on the ranges were based on an agricultural enterprise “Shakhter” branch of ”Chervona Zirka” Donetsk region with a herd near 30 000 pigs and PJSC “Slobozhans’kiy” Kharkiv region with a herd near 12 000 pigs. Studies were conducted in the laboratory and in the complexes. Advancement of the treatment was conducted up to 6 h. In terms of the production of sediment sampling was conducted through 1 h. Conduction the evaluation of runoff on humidity [ISO 6496:2005], dry substance [ISO 6496:2005], ash [ISO 5984:2004]. Analysis and statistical calculation of results was carried out on a single in Ukraine certified by ISO/IEC 17025:2006 Laboratory of the Institute of Animal Science of NAAS.

The results were statistically analyzed using Statistica and MS Excel programs.

RESULTS AND DISCUSSION

The agricultural sector of Ukraine, producing a significant amount of organic waste (tab. 1) from slightly more 1 Mt at brewery plants to more than 23 Mt at sugar factory, and, for animal production farms, from minimal value at poultry farm to maximal – at sheep farm. Especially, at industrial pork production the total wastes value is 5 656 700 t with biogas produce potential at 160.3 Mm^3 per year with proportion of the economically viable potential – 30%. In this regard, the research was aimed at ensuring an increase in the economic attractiveness of the renewable energy sources, in particular biogas.

Table 1. The potential of biogas production in selected sectors of agriculture of Ukraine
Tabela 1. Potencjał produkcji biogazu w wybranych sektorach rolnictwa Ukrainy

Sectors of agriculture Sektory rolnictwa	The total number of enterprises in Ukraine Łączna liczba przedsiębiorstw na Ukrainie	The volume of primary products (thous. t/head) Ilość produktów podstawowych (tys. t/jednostka)	The total volume of the main waste (thous. t) Całkowita objętość głównych odpadów (tys. t)	The potential of biogas production with a total volume of waste/ products (Mm³/year) Potencjał produkcji biogazu przy całkowitej ilości odpadów/ produktów (Mm³/rok)	The proportion of the economically viable potential, BSU with mini-TIC 0.1 MW (%) Udział ekonomicznie opłacalnego potencjału, BSU z mini-TIC 0.1 MW (%)
Sugar factories Fabryki cukru	60	1 546.0	23 263.5	975.5	46
Brewery plants Rośliny browarne	51	3 100.0	1 016.8	121.8	10
Plants for alcohol production Rośliny do produkcji alkoholu	58	204.7	2 705.0	116.8	13
Sheep farms Fermy owiec	5079	1 526.4	15 431.6	385.8	97
Pig farms Fermy świń	5634	3 625.2	5 656.7	160.3	30
Poultry farms Fermy drobiu	785	110 561.3	4 721.5	377.7	68
Silage corn Kiszonka z kukurydzy	growing on 50% free arable land uprawa na 50% bezpłatnych gruntów ornych	41 140.4	–	7 405.5	–

The results of our research at the farm of 54 000 cwt pork per year production (”Chervona Zirka” Donetsk region) highlights the industrial production by non-litter technology makes it possible to obtain outgoing drains humidity at the level of 96.54 ±0.15%. The technology of wastewater preparation with liquid and solid fractions separation on a Bauer press filter and separate storage of the liquid fraction in the storage pond and solid fraction in a special area makes it possible to obtain liquid fraction humidity at 98.26 ±0.08% and solid fraction humidity 72.08 ±0.15%.

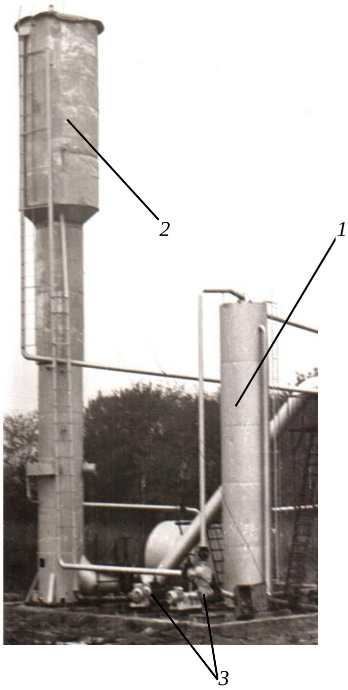
Researches showed that when asserting, in laboratory conditions, the outgoing drains is formed by residue humidity 91.58 ±0.46% as liquid fraction after a separator creates sludge moisture 92.37 ±0.59%. Organic matter in the waste water source is 70.68 ±3.22% of the dry matter content. In the same time, the organic matter in sludge, which is highlighted with a liquid fraction after splitting the weekend runoff, is at 98% and the liquid fraction at 99% of the dry matter. The general view of the laboratory equipment, which we used for the process of liquid fraction defending, is shown in photo 1.

1
2

4
3

Phot. 1. Settling of outgoing drains and liquid fraction from press-filter Bauer: *1* – outgoing drains after settling, *2* – liquid fraction after settling from press-filter Bauer, *3* – boundary sediment section and the lighted substance after liquid fraction settling from press-filter Bauer, *4* – boundary sediment section and the lighted substance during outgoing drains settling (aut. V.I. Piskun)

Fot. 1. Osad odpływów i frakcji płynów z filtra prasującego Bauer: *1* – odpływy spustowe po opadnięciu osadu, *2* – frakcja ciekła po osadzaniu z filtra prasującego Bauer, *3* – graniczny odcinek osadu i substancji po osiadaniu frakcji ciekłej z filtra prasującego Bauer, *4* – graniczny odcinek osadu i substancji podczas spływania osadów wychodzących (aut. V.I. Piskun)



Phot. 2. Section of a technological line for the separation of waste in the industrial production of pork: *1* – buffer capacity, *2* – device for the separation of waste, *3* – pump equipment (developed by V.I. Piskun)
Fot. 2. Fragment linii technologicznej do separacji odpadów w przemysłowej produkcji wieprzowiny: *1* – pojemnik buforu, *2* – urządzenie do separacji odpadów, *3* – pompa (oprac. V.I. Piskun)

For the preparation of the waste for use in industrial pork production we have developed the technology which includes process separation of waste. The process includes: a preliminary selection of large particles, outgoing drains thin settling, compatible compression of large particles and sludge obtained at outgoing drains thin settling to humidity not above 92%, and dehydration without reagents of this settling by gravity filtration [Piskun 2013]. The overall appearance, including a device to separate the treatment has shown photo 2. Results exploitation technologies in open agricultural joint stock company Agricultural Complex ”Slobozhanskiy” are listed in table 2. The data in table 3 indicate that initial wastewater entering with a humidity between 98.31 and 98.51% to the a device for separation with productivity 60 m^3 per hour were obtained a liquid fraction humidity between 99.28 and 99.45% and sediment humidity between 84.0 and 92.0%. Such technology allows obtaining sediment with a humidity of 90–92%, which is optimal for methane digestion of pig wastewater.

Table 2. Results of own-developed technology exploitation in open agricultural joint stock company Agricultural Complex ”Slobozhanskiy”
Tabela 2. Wyniki wykorzystania własnej technologii w otwartej spółce akcyjnej Kompleks Rolniczy „Słobozhanskij”

Humidity – Wilgotność		Value indices (%) Wskaźniki wartości (%)
Outgoing effluent – Wypływające ścieki		98.31–98.51
Liquid fraction Frakcja płynna	a) install – podłączenie	99.28–99.45
	b) quarantine tanks – zbiorniki kwarantanny	99.51–99.71
Sediment from the device waste water separation Osad z urządzenia do separacji ścieków		84.0–92.0
Line capacity – Pojemność linii: 60 m³/year – m³/rok		

Table 3. The cost of processing effluent (146 000 t) for biogas
Tabela 3. Koszt przetwarzania ścieków (146 000 t) na biogaz

Classification of costs Klasyfikacja kosztów		Options Opcje			
		new nowa		base podstawowa	
		UAH hrywna	%	UAH hrywna	%
Capital expenditures Nakłady inwestycyjne		17 549 496	100	25 801 300	100
Production costs Koszty produkcji	wages płace	102 000	6.19	84 000	3.58
	deductions for social costs potrącenia na koszty socjalne	23 500	1.43	19 320	0.82
	energy costs koszty energii	142 884	8.67	214 620	9.15
	the cost of heat koszt ciepła	119 837	7.27	199 728	8.51
	depreciation in total amortyzacja łącznie	877 475	53.24	1 290 065	54.98
	current repair in total bieżący serwis – razem	350 510	21.27	516 026	21.99
	low-value tools (hand tool and other consumables) narzędzia o niskiej wartości (narzędzia ręczne i inne materiały eksploatacyjne)	11 500	0.69	6 000	0.25
	general operating expenses ogólne koszty operacyjne	20 400	1.24	16 800	0.72
	total production costs całkowite koszty produkcji	1 648 106	100	2 346 559	100
	costs reduction (%) obniżenie kosztów (%)	29.8	–	–	–

The figure 1 shows the dependence of the humidity precipitate obtained during the separation of the initial wastewater from the time of its compaction in open agricultural joint stock company Agricultural Complex "Slobozhanskiy". Photo 3 shows the precipitate obtained after sealing device for wastewaters separation. This precipitate with humidity between 90 and 92% should be used with methane fermented.

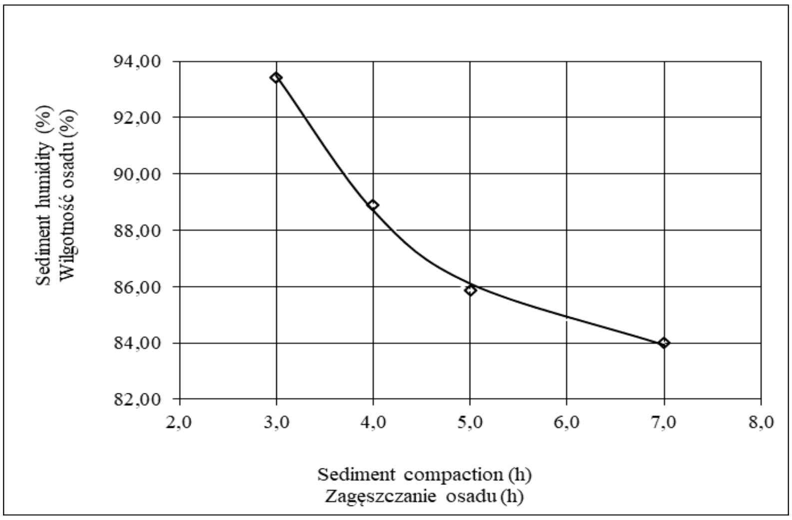


Fig. 1. Sediment compaction time impact on its humidity
Rys. 1. Wpływ czasu zagęszczania osadu na jego wilgotność

Phot. 3. Sludge from sludge separation device: *1* – sludge duct, *2* – the bunker-dehydrator; *3* – sludge (aut. V.I. Piskun)
Fot. 3. Szlam z urządzenia do rozdzielania osadów: *1* – kanał osadowy, *2* – zbiornik-dehydrator, *3* – szlam (aut. V.I. Piskun)

According to our researches the scheme of technological process of methane fermentation wastewater treatment in industrial production of pork was developed, which ensures reduction of capital and operating costs at new energy sources obtaining. The technological process includes: separation of runoff, sediment compaction, obtained at thin settling with his methane fermentation of biogas to produce electricity and heat (fig. 2).

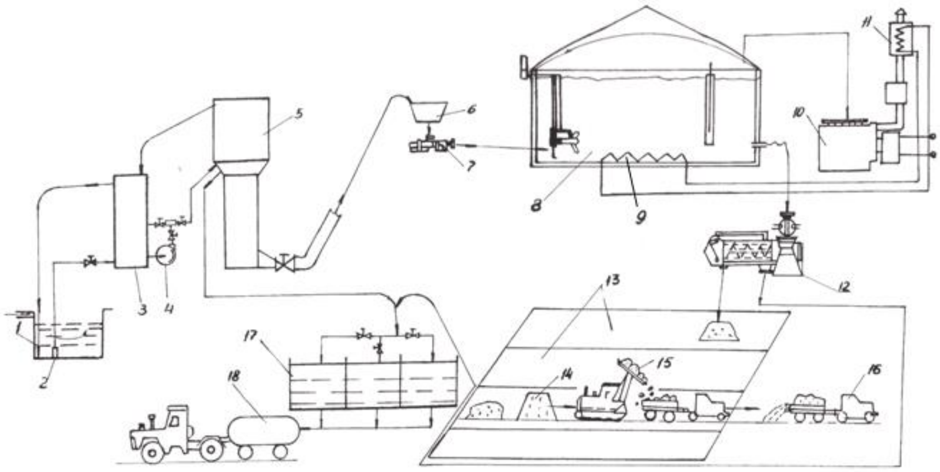


Fig. 2. Drains preparation for use during the renewable energy receiving (biogas): *1* – the receiving reservoir; *2, 4, 7* – submersible pumps; *3* – buffer capacity; *5* – device for the separation of waste; *6* – capacity; *8* – methane tank; *9, 11* – heat exchangers; *10* – cogeneration plant; *12* – press-filter; *13* – section area; *14* – burt solid fraction; *15* – loader; *16* – spreader manure; *17* – drive liquid fraction; *18* – unit for liquid fraction in soil (aut. V.I. Piskun)

Rys. 2. Przygotowanie ścieków do wykorzystania w produkcji energii odnawialnej (biogazu): *1* – zbiornik odbiorczy; *2, 4, 7* – pompy zatapialne; *3* – pojemnik buforu; *5* – urządzenie do oddzielania odpadów; *6* – pojemnik; *8* – zbiornik z metanem; *9, 11* – wymienniki ciepła; *10* – instalacja kogeneracyjna; *12* – filtr prasujący; *13* – obszar przekroju; *14* – sucha frakcja stała; *15* – ładowarka; *16* – rozrzutnik obornika; *17* – płynna frakcja napędowa; *18* – jednostka dla frakcji ciekłej w glebie (aut. V.I. Piskun)

Drains are removed using the hydraulic manure removal system of the bottom shaped gate with complex coming in the receiving tank (*1*). In the future, with the receiving tank (*1*) pump (*2*) and periodically served in methane tank (*8*), which passes through fermentation treatment system and biogas obtaining. Biogas from methane comes to cogeneration plant (*10*) where electricity which is received is used for technological needs. The temperature of the exhaust gases of cogeneration plant (*10*) through a heat exchanger (*11*) is used for heating the biomass methane tank.

Fermented mass, which dropped from methane, according to the cycle serves on the press-filter (*12*) for separation with liquid and solid fractions. The solid fraction is served on the ground to prepare the solid fraction in organic fertilizers. Further organic fertilizers are made by organic fertilizers spreader (*16*) on farmland. The liquid fraction enters the drive liquid fraction (*17*). Subsequently, after the extract, liquid fraction of aggregate (*18*) expelled on farmland as fertilizer. Wastewater preparation technology for use with the receipt of renewable sources of energy and organic fertilizers is presented in photo 1 and consists in the filing of all outgoing waste to methane tank. The implementation of such a development started in the Donetsk region. Evaluation costs presented in table 3.

Assessment of the proposed technology for liquid manure for use in conjunction with the production of pork in obtaining renewable energy has shown that the processing 146 000 t per year capital investment by technology are 17 549 496 USD, and the base 25 801 300 USD. That is, the technology of preparation of liquid manure to be used in conjunction with the production of pork in obtaining renewable energy investments will reduce about 30%.

CONCLUSIONS

1. Studies in laboratory and industrial conditions showed that the outgoing wastewaters fractions gravity separation in industrial pork production it is possible to get a precipitate with humidity of 88–92%, which formed the basis for the concept of resource-saving technologies for renewable energy (biogas) development.

2. Assessment of the proposed technology for liquid manure for use in conjunction with the production of pork in obtaining renewable energy shows that the use of technology will reduce capital investment at 30%.

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Streszczenie. W pracy dokonano analizy wykorzystania odnawialnych źródeł energii na Ukrainie na przykładzie biogazu. Wykazano, że sektor rolno-przemysłowy, wytwarzający znaczną ilość odpadów organicznych, ma potencjalne zasoby do produkcji biogazu i może dostarczyć 2,6 mld m³ PG/rok. Odpady organiczne z przemysłowej produkcji wieprzowiny mogą przynieść 0,32 Mt paliwa. Główną przeszkodą we wdrażaniu systemów bioenergetycznych w przemysłowej produkcji wieprzowiny na Ukrainie są duże nakłady inwestycyjne i koszty operacyjne oraz suboptymalne podłoże dla parametrów fermentacji. Silniej powinny być wspomagane strategie zapewniające zmniejszenie inwestycji kapitałowych i wdrażanie technologii wykorzystania ścieków z przemysłowej produkcji wieprzowiny do pozyskiwania energii odnawialnej. Proces technologiczny obejmuje oddzielanie ścieków, zagęszczanie osadów, co sprzyja późniejszej fermentacji metanowej w celu wytworzenia biogazu, energii elektrycznej i ciepła. Wykazano, że proponowana koncepcja może zmniejszyć inwestycje kapitałowe o 30%.

Słowa kluczowe: dreny, technologia, biogaz, inwestycje kapitałowe, produkcja przemysłowa wieprzowiny

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