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EVALUATION OF THE POSSIBILITY OF OBTAINING SOURCES OF POWER FROM ORGANIC WASTE, TAKING INTO ACCOUNT TECHNOGENIC LOAD ON THE ENVIRONMENT

Processes of waste formation in various branches of industry and agriculture have been analyzed; possibilities of sources of power production from organic waste are evaluated, technogenic impact on the environment while sources of power from waste production has been taken into account.

***Key words**: organic waste, biogas pyrolysis, gas generation, biodiesel, technogenic load.*

Introduction

As a result of rapid depletion and rise in prices of primary sources of energy as well as considerable deterioration of ecological situation on the planet, special attention is paid to the problems dealing with production of alternative energy resources and efficient methods of organic waste utilization.

According to the Law of Ukraine "Waste act" waste are any substances, materials and objects, formed in the process of production or consumption, as well as goods (products) that completely or partially have lost their consumer properties and are not used at the place of their formation or revealing, the owner of these products gets rid of them, is going or must get rid of them by means of utilization or removal [1].

In its turn, utilization provides the usage of waste as secondary material or energy resources.

In general, any waste can be considered as recoverable resources. But at the given stage, the processing of not all waste is economically expedient, although their reuse could reduce technogenic impact on the environment, depletion of material or energy resources for their processing.

Special class of waste – organic waste, i.e., waste, consisting of organic substances, with carbon-carbon bonds [2]. Nowadays, the most widely used methods of management of collected and sorted organic waste are burial or deposition, composting or burning with burial of residues. Special attention should be paid to organic waste, suitable for decay (fermentation) – waste of plant-growing, stockbreeding, food industry, processing industry. Conventional methods of their recycling lead to chemical and biological contamination, worsening of labour conditions of the staff.

The waste, that cannot be used for production of non-energy production, can be utilized with the production of power sources– liquid biofuel, pyrolysis, generator gas, biogas, thermal and electric energy, Especially this concerns utilization of toxic waste.

The aim of the given research is evaluation of the possibilities of production of energy resources from organic waste, taking into account technogenic impact on the environment.

Classification of energy sources from waste and methods of their preparation

In the process of waste usage for energy purpose, various energy sources can be obrained:

– gaseous –pyrolysis gas, synthesis-gas biogas, methane;
– liquid – combustible resins, biodiesel, bioethanol, etc.
– solid – charcoal, coal residue, coak, etc;
– thermal energy in thermogenerators, gas generators, pyrolysis and cogeneration installations;
– electric energy in steam turbine, gas turbine and gas piston engines.

One of the widely used methods of electric utilization of waste is direct burning, followed by burial of residual waste. Almost all organic waste can be used as fuel. Low limit of heat value of waste, that can be burnt without additional expenditures of fuel is 3,35…4,19 MJ/kg. According to Tanner [3], the condition of substance burning is: humidity is not greater than 50%; ash content is not greater than 60%; content of burning substances is not less than 25%.

As a result of direct burning of waste we can obtain thermal or thermal and electric energy. Average temperature of burning of hard domestic waste is 6.3 MJ/kg. According to the results of research [4], waste, before burning, must be sorted, since burning of certain organic components, for instance textile, plastics produces more harmful influence on the environment, than the effect from substitution of primary energy resources.

Analysis of the efficiency of various methods of organic waste recycling, performed by the authors [5], showed that refuse incineration technologies can produce great quantity of heat, but their energy generation efficiency factor is law. Besides, such systems are characterized by great toxicity of emissions and large investment expenses.

Systems of pyrolysis and gas generation of waste are more promising, in authors opinion [4]. They allow to obtain fuel gas with heat of combustion 5…20MJ/m^3 [6]. This gas can be transported or used as motor fuel after careful purification. Additional product of such recycling is coal refuse.

Realization of the project dealing with the pyrolysis of 75t/day of wood waste in Mexico showed low concentration of harmful substances while recycling (2…9 times less than admissible level) and rather high economic indices: capital investment 11.3 ml $US payback period – 4…5 years [7].

One of the most promising, in our opinion, methods of organic waste recycling is anaerobic fermentation. As a result of anaerobic fermentation, depending on waste composition (see Table 1), fuel gas of high quality with the heat of combustion 20…24MJ/m^3 is obtained.

Table 1

Biogas output and content of the methane in it depending on raw material

Class of substances	Biogas output, l/g substrate	Content of methane, %
Carbonhydratees	0,83	50
Proteins	0,72	71
Fats/oils	1,43	70

Output of biogas from different organic waste depends on morphologic and elementary composition, approximate output of biogas is [8], m^3/t: manure of cattle-40; manure flow of cattle – 20; manure of pigs -35; manure flow-of pigs -15; sediment of sewage – 5; poultry excrement- 40; vegetable waste – 48; dairy waste – 50; brewing waste – 200; restaurants waste – 189; waste of processing of fish and fish fat – 300; refinery waste – 500; gross (dry substance 33%) – 165; sunflower (dry substance 23%) – 90; rape cake (dry substance 90%)-620; grains (dry substance 31%) – 250.

Biogas technologies require more qualitative organic waste. Unlike thermal methods of utilization, in biogas installations it is necessary to provide biochemical quality of raw material, its unoxidizability. Biogas can be transported, burnt in gas boiling installations after rather simple regulation of burners [9], used as motor fuel. Comparative analysis of motor fuels, from the point of view of technogenic impact [10] showed, that methane, obtained from organic waste, using anaerobic fermentation, exercises the lowest negative impact on the environment as compared with other biofuels, petrol, diesel fuel.

After removal of CO_2 biogas can be supplied to the gas line of natural gas. Realization of such project [11] proved its economic expediency and decrease of technogenic impact on the environment.

Biogas installations allow to obtain high quality fermented substrate, that can be used for direct introduction in the soil, obtaining fodder additives, etc. Economic effects as a result of usage of fermented substrate can considerably exceed the effects of biogas usage.

Foreign researchers [12] established economically expedient nowadays and in future nontraditional energy technologies (Table 2).

Table 2

Expenses on various renewable sources of energy

	Expenses 2005 boundaries € / GJ	Expenses 2005 on average €/GJ	Expected decreases of average expenses till 2030, % of expences2005 p.
Solar energy	8 – 226	52	-42
Solar thermal energy branch and refrigeration supply	11 – 307	66	-44
Biopower, generation, heating with pallets	8 – 99	26	-5
Biopower generation, anaerobic bioconversion	6 – 32	15	-3
Geothermal generation, average depth	0,5 – 11	2	+11
Geothermal power generation, large depth	1 – 24	3	-13

Further development of bioconversion systems must be directed at the increase of recycling process efficiency (increase of the share of substances transformation) and more efficient usage of the obtained energy resources, Nowadays technologies of motor fuel production – biodiesel, using oil of oil crops: rape; sunflower, maize, palm oil, etc.

However, the volume of research aimed at study the usage of organic waste, as the raw material for production of biodiesel is not sufficient.

In this connection, we investigated the possibilities of usage of distillery organic waste, as the components of biodiesel synthesis – alkyl esters, saturated and non saturated carbon acids from maize oil. This allows to obtain biodiesel with far less cost, use instead of methanol non-toxic alkyl alcohols, reduce ecological problems, connected with large areas of filtration fields, where waste from Ukrainian distilleries are directed.

The extraction of extraagent (C_5) from rectified fraction of ethanol for concentration of maize oil from distiller's grains at SE "Nemyriv destillery" was carried out by the method of fractional and rectification distillation .

Distillation of rectified fraction was carried out at two installations, differing by temperature intervals of fractions extraction, composition of taken alcohol fractions and time of separation process duration.

At the second stage the filtrated distiller's grains was extracted by the solvent (C_5), obtained in the process of fractional distillation of rectified fraction [14], and concentrated maize oil was sent to reesterification stage (Fig. 1). Reesterification reaction was carried out in mixing reactor of periodic action.

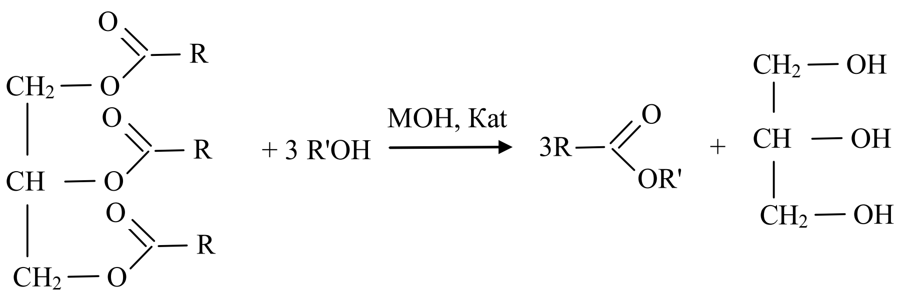

Fig. 1. Reesterification reaction of corn oil

It is not sufficient to produce energy resources from waste. It is necessary to provide their production with high energy and ecological efficiency. The problem of coordination of energy generation and its consumption is also very important.

The most efficient is the variant, when near the system of energy resources production from waste, there are heated or other thermal technological consumers, for instance, driers, evaporators, furnaces or equipment for usage of obtained motor oils.

If there is no thermal technological consumer, then the most efficient is generation of electric energy.

According to preliminary assessments, usage of pyrolysis gas, synthesis gas and generator gas in heat engines of small power is, nowadays, not efficient, since expensive and complex system of purification, prepration and cooling of generated gas is required. Systems of biogas purification are simpler, biogas heat of combustion is higher, that is why, the highest efficiency can be reached if it is burnt in heat engines, accompanied by generation of thermal and electric energy.

Formation of waste in various branches and possibilities of energy resources generation

Organic waste can be classified according to main branches of production and consumption:

- agriculture (plant growing, stock breeding);
- food, processing industries;
- woodwork and timber industry;
- municipal sector.

In agriculture, organic waste can be divided into plant growing waste and stock breeding waste. For energy generation any plant waste with high content of cellulose can be used – straw, stalk of corn, sunflower and other crops. Polysacharide is constructed of elementary chains of anhydro-D-glucose, that is poly-1, 4-β- D glucopyranosyl- D-glucopyranose. Compound (polysacharide – I – Fig. 2) is main componenets of walls of such plants as: cotton (97-98%), wood (40-50% per dry substance), bark of plants (80-90%) stalks of annual crops: corn, sunflower (30-40%) etc.

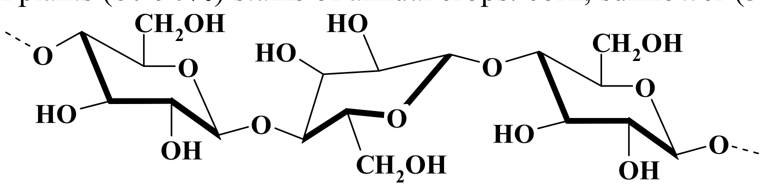

Fig. 2. Polysacharide – I

Technologies of direct burning of bale straw and other waste have been developed in Ukraine. But energy and ecological efficiency of such technologies is not very high. However, the usage of biogas technologies for fermentation of stock breeding waste and their mixtures with plant waste or even energy plants is very actual nowadays [15].

Recycling of only stock breeding waste in production quantities in Ukraine enables to obtain more than 3 bil m^3 of biogas, that is equivalent to 2 bil m^3 of natural gas per year. According to [15], total energy potential of organic waste in agriculture exceeds 34 bil m^3/yr.

Evaluation of the possibilities of energy generation from stock breeding waste in Vinnytsia Region is given in Table 3.

Table 3

Potential possibilities of anaerobic processing of stockbreeding waste of Vinnytsia Region (on 01.01.2011)

Value	Pigs	Cows	Other cattle	Poultry	Sheep, goats	Total
1. Live stock	439 600	179 100	138 100	10 285 300	37 700	
2. Maximum daily volume of waste, to be processed , thousand tons / daily	6,59	8,96	4,83	4,11	0,38	24,87
3. Annual volume of waste, bil. tons / annually	2,41	2,42	1,76	1,50	0,10	8,19
4. Daily output of biogas, that can be obtained while anaerobic processing , thousands. m^3	156,94	90,09	82,17	524,55	4,74	858,5
5. Annual output of biogas, mil. m^3	56,50	32,43	29,58	188,84	1,71	309,06

6. Annual volume pf tradeable electric energy, mil·KW/h	102,72	58,96	53,78	343,32	3,10	561,88
7. Annual price of generated electric energy(price of 1 KW/h· 0,5 Htr), mil. UHr/yr	51,36	29,48	26,89	171,66	1,55	280,94
8. Annual volume of tradeable thermal energy, thousand, GJ	512,7	294,3	268,4	1 713,7	15,5	2 789,2
9. Annual price of generated thermal energy (price of 1 GK 300 Hr), thousand. UHr/ yr	36,7	21,1	19,2	122,7	1,1	200,81
10. Annual output of organic fertilizers, mil. m^3/yr	2,36	2,37	1,73	1,47	0,10	8,04
11. Ratio of the effects, while operation of BGI, energy resource +supply stability: fertilizers: ecology	18+8:72:2	18+16:64:2	18+8:72:2	18+8:72:2	18+8:72:2	
12.Common effect of bioconversion process, mil Hr/yr	489,26	280,86	256,17	1635,33	14,78	2676,40
13. Value of simple period of recoupment, yr	3,5…10,5					

The reasons of insufficient usage of installations, intended for processing of agriculture waste is the lack of state financial support, considerable initial expenditures. Capital investments in 1 m^3 of working area of bioreactor of foreign production can reach € 500…1000. Such technologies can be available only for powerful organic complexes, where there is a possibility to use generated energy and produced fertilizers. Such enterprises have the right for ”green tariff” on electric energy sale to common network. Taking into account all theses factors, there exists the possibility to obtain minimal term of capital investments recoupment (up to 3 years).

In food and processing industries large volume of solid and liquid waste are formed.

The waste of these industries, include waste of meat and dairy industries, fruit, vegetables, alcohol production, manufacturing of oils at dairy enterprises, etc. The waste include presscake and oil-containing waste, formed in the process of oil refining (acidified soupstock, worked out filtration powders as well as distillate, formed while oils deodoration);

In meat industry – waste of animal fats; in fruit vegetable – waste of fruit, vegetables, seeds while their processing; at distilleries--oils and distillers grains. Utilization of such waste requires considerable financial and energy resources.

At the same time, bioconversion of organic waste, for instance, from distilleries, dairy plants, meat preserving factories allows to generate biogas in volumes, sufficient to cover needs of the enterprise.

Utilization of distillers grains, produced at Nemirov distillery, in reactors of bioconversion system, allows to obtain more than 82% of annual consumption of natural gas by the enterprise.

In timber and woodwork industries various wood waste are formed. Starting from provisions of wood (unmarketable raw material, knots, tops, stubs) its processing (waste of logs sawing: edgings, half logs, sawdust, chips) and technological processing: pulp and paper, rosin, turpentine, tanning-extraction production - at all stages considerable volumeof waste is accumulated, waste can be used for generation of energy.

The most efficient methods of such waste recycling are pyrolysis and gasification, with possibility of obtaining hydrogen, inflammable gas mixtures, activated carbon etc.

Recycling of solid domestic waste becomes actual in recent years. Technologies of garbage sorting and its part recycling into recoverable recourses are introduced. Food waste and other organic waste, suitable for fermentation can by recycled in biogas installations and marketable energy resources can be obtained.

Recycling of the part of solid waste, suitable for fermentation in Vinnytsia (approximately 45 thousand tons/year), enables to generate more than 8.8 mil m^3/yr of biogas or more than 20 mil kW/h of electric energy.

Conclusions

In Ukraine problems, dealing with production of energy resources and increasing the efficiency of their usage become more and more actual.

Rapid worsening of ecological situation due to accumulation of waste in various branches of industry, agriculture, municipal sector, including stationary and unauthorized dumps, require drastic introduction of long-term methods of domestic and industrial waste utilization.

Organic waste suitable for fermentation are of great danger. Their dumping leads to considerable chemical and biological contamination of the territory.

It is not sufficient to recycle the waste, containing energy resources. It is necessary to use technologies with low technogenic load on the environment. Garbage burning technologies hold` negative impact on the ecology.

Generated thermal energy must be used on the place of generation, and this is not always convenient.

Gas generation and pyrolysis of organic waste allow to obtain gas energy resource, which after expensive cleaning can be used in cogeneration installations as motor oil for transport, etc.

Biogas installations, in our opinion are most efficient for utilization of organic waste, suitable for fermentation.

Maximum efficiency can be reached if consumers of qualitative organic fertifizers and consumers of thermal and electric energy are available.

Anaerobic recycling of organic waste of stockbreeding in Ukraine allows to save more than 2 bil m^3 of exported natural gas. Production of biodiesel for organic waste of distilleries in Ukraine will allow to solve partially ecological problems, appearing on sewage filtration fields, clear the place for production of food. Further development of bioconversion systems should be directed at the increase of recycling process efficiency (increase substances conversion ratio) and more efficien usage of energy resources obtained.

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