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Volume: 8 (2020) Issue 1

Environmental & Socio-economic Studies

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Environmental & Socio-economic Studies

DOI: 10.2478/environ-2020-0003

Environ. Socio.-econ. Stud., **2020, 8, 1: 18-27**

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Original article

Socio-economic and environmental benefits of biofuel production development from agricultural waste in Ukraine

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ABSTRACT

Energy needs are determined by three main factors: population growth, the economic development of society, and the scientific and technical level of production processes. These needs are increasing year by year in the world and in 2018 they exceeded 13.5 billion tons of oil equivalent. More and more countries are developing and implementing plans and strategies for significant coverage, within 50-100%, of their energy needs through renewable energy sources. The findings of this study revealed that Ukraine's energy demand per year is 200 million tons of oil equivalent of energy resources. Currently, the share of renewable energy in the structure of energy consumption in Ukraine is 4.4%. The authors also acknowledged that at the same time, 115 million tons of agricultural plant waste and about 97 million tons of animal waste are generated annually in Ukraine, which makes it possible to produce 7.21 million tons of oil equivalent and 2.2 million tons of oil equivalent, respectively from these. The study found that the production of biofuels from agricultural waste will have social, economic and environmental effects. An efficiency matrix was constructed by the authors to determine these effects. Using the SWOT method of analysis, factors that will affect the development of biofuel production from agricultural waste were determined.

KEY WORDS: agriculture, waste, alternative energy, biofuels, efficiency

ARTICLE HISTORY: received 26 December 2019; received in revised form 17 February 2020; accepted 19 February 2020

1. Introduction

The level of development of the energy sector of any country has a decisive influence on the state of its economy, the rate of economic growth, the state of the environment, the solution of social problems and the standard of living of its people. Therefore, the foundation of energy security and independence is always associated with the national security of the state.

Together with the increasing population of the planet, and, accordingly, energy production are steadily increasing. In the last 100 years alone, Earth's population has quadrupled, and annual energy production has increased by 21 times. Today, on average, there are 1.75 tons of oil equivalent energy resources per capita of the planet Earth. According to preliminary estimates, the population will increase to 10 billion by 2100, and the average specific energy resources per person will be up to 7 tons of oil equivalent energy. In total, energy production will reach 700 billion tons of oil equivalent. In such circumstances, virtually all organic fuel, especially oil and gas, can be depleted.

With the growth of industrial production in the world, the amount of greenhouse gas emissions into the atmosphere has increased, which in turn has led to global climate change. To prevent this, the Kyoto Protocol was adopted in 1997, to which (as of November 2009) 192 countries were responsible for 64% of the world's greenhouse gas emissions.

An increase in the extraction of natural resources to meet the growing needs of the population

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leads to another environmental problem - the accumulation of a significant amount of industrial and domestic waste in the environment. The urgent problem arises of preventing the generation of waste, its processing and minimizing its harmful effects on the environment.

Thus, modern challenges, such as the completeness of fossil fuels and the increase in their cost, the threat of global warming from traditional energy sources, environmental pollution by wastes of various origins, make the countries of the world significantly change the structure of the energy sector. Now, two main trends can be observed: the replacement of traditional energy sources with renewable energy sources and the reduction in total energy consumption due to the introduction of energy-efficient technologies and measures.

2. Literature review

There are few assessments of bioenergy potential from agricultural waste in Ukraine. YAKUBIV (2013) described the potential development opportunities for the production of renewable energy, through the establishment of agriculture.

MIRONENKO & POLEVA (2016) explored the common aspects of bioenergy opportunities as an alternative energy source and its prospective development in Ukraine. ZULAUF ET AL. (2018) in their research calculated what proportion of agricultural land should be allocated for energy crops to meet the target of 11.5% of its primary energy supply from biomass, biofuels and waste by 2035 (ENERGY STRATEGY OF UKRAINE, 2017). GELETUKHA & ZHELIEZNA (2017) noted that Ukraine has great potential for bioenergy production.

BRUNEROVA ET AL. (2017) investigated the possibilities of production of biofuels from agricultural residues in developing countries. SADH ET AL. (2018) noted that the use of agro-industrial wastes as raw materials can help to reduce the production cost and also reduce the pollution load from the environment.

BAJWA ET AL. (2018) discussed the economics of densifying biomass, the impacts in regions where biomass utilization is implemented, the outstanding challenges, and national and global trends in biomass utilization. KALETNIK ET AL. (2019) investigated the impact of biofuel production from agricultural crops on the energy, environment and food security of the state.

BEREZYUK ET AL. (2019) research emphasised the resource potential of recycling solid waste. Their study pointed out that due to insufficient consideration of the value of secondary resource potential, lack of awareness and lack of proper marketing, underestimation of social and environmental factors, a significant part of the waste that can be used as material and energy resources is lost.

3. Aims and methods

In the course of the study the following tasks were set: 1) to summarize the dynamics of the formation and management of waste of the I-IV hazard classes in Ukraine, 2) to carry out the classification of waste from agricultural enterprises, 3) to analyze the potential of waste of plant and animal origin, 4) to identify factors for the development of biogas technologies from waste, 5) to formulate a matrix of effects from the use of biofuel waste and its subsequent use and 6) to explore the potential of energy use from agricultural wastes in Ukraine by SWOT analysis.

An abstract logical method was used to carry out a critical analysis of the research results of domestic and foreign scientists regarding biofuel production. Statistical data from state and international agencies was collected. The data obtained were analyzed using descriptive statistics and graphical methods. Strengths, weaknesses, opportunities and threats to the development of biofuel production from agricultural waste in Ukraine were identified using a SWOT analysis.

4. Results and discussion

Ukraine consumes about 200 million tons of oil equivalent and is energy deficient country. Ukraine can only cover its needs for energy consumption by between 53% and 75% and thus need to import the necessary shortfall of natural gas and 85% of crude oil and petroleum products. Such a structure of fuel and energy resources is not economically viable, it creates a dependence of the Ukrainian economy on oil and gas exporting countries and it threatens its energy and national security.

Limited internal energy resources, dependence on imports of fossil fuels and constantly rising prices for these goods necessitate the immediate transition to the use of alternative fuels, the raw materials potential for the production of which are available in our country. Previously, Ukraine only had to solve the problem of the high cost of imported natural gas, but now the possibility and conditions of its import are in question. Difficulties have also arisen with coal supplies.

In order to improve and strengthen the state's energy security, Ukraine's agriculture should be

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not only an energy consumer, but also an energy producer. According to the State Statistics Committee of Ukraine, about 1 400 thousand tons of diesel fuel and 350 thousand tons of gasoline are required each year to carry out agricultural work according to technological standards. The production of this amount of fuel requires about 3.7 million tons of mainly imported oil. In this regard, the constant increase in the value of oil leads to an increase in the cost of petroleum products and, consequently, of agricultural products. Thus, from 2000 to 2018, the costs of agricultural enterprises for the purchase of fuel increased 16 times.

The need to provide Ukraine with energy of its own production is a pressing issue to find alternative fuels. One of the possible directions for this is the development of biofuel production. For this purpose, it is important to implement measures in accordance with the Energy Strategy of Ukraine for the period up to 2035 which states "Security, energy efficiency, competitiveness".

Reforming energy companies in accordance with Ukraine's obligations under the Agreement on the Establishment of an Energy Community, increasing gas production, reducing the energy intensity of GDP and further development of renewable energy sources are the key objectives of the implementation of New Energy Strategy of Ukraine at this stage. The forecast indicators contained in the document demonstrate the development path of the energy sector and related industries. The forecast structure of energy supplies in Ukraine in accordance with the Energy Strategy of Ukraine is shown in Table 1.

Table 1. Estimated structure of energy supply in Ukraine in 2035 (Source: formed by the authors in accordance with the Energy Strategy of Ukraine for the period up to 2035 "Security, energy efficiency, competitiveness")

Type of energy	%
Natural gas	30
Nuclear energy	25
Coal	13
Biomass	12
Solar and wind energy	10
Oil products	7
Geothermal energy	2
Hydropower	1

The increased use of waste for energy production purposes will become a significant basis for achieving the target of 12% of biomass energy in the overall structure of energy supplies in Ukraine in 2035. The Strategy was developed by taking into account the geopolitical, macroeconomic, social, scientific and technical development trends of the country, which also have certain risks from identifying these factors. Therefore, it is necessary to ensure the constant monitoring of the Energy Strategy and periodically clarify the volumes and terms of the work stipulated by the strategy, taking into account the dynamics of prices for fuel and energy resources in the world and within the country, state development programs, achievements of scientific and technological progress, and the improvement of environmental legislation.

Scientists such as KOZLOVSKYI ET AL. (2018) point out that Ukraine, as well as many other countries, is suffer from the effects of climate change. Our state is threatened by abnormal temperature conditions, the transformation of the steppes of the southern region into deserts, the flooding of the coastal regions of the Black and Azov Seas, and an acute shortage of drinking water in the southern and eastern regions. This all threatens the country's economic development in the forthcoming decades. It is precisely these economic, environmental, and social consequences that compel governments to implement new environmental policies, including policies to reduce greenhouse gas emissions.

Ukraine is one of the twenty largest polluters in the world in terms of greenhouse gas emissions, but has paid little attention to solving this problem. The main obligation of Ukraine under the UN Framework Convention, the Kyoto Protocol and the Paris Agreement is the implementation of a policy to reduce gas emissions by all sectors of its economy and the formation of relevant legislation. Such work involves the Ukraine reviewing its existing development strategies for the energy, transport, industry, agriculture, housing and communal services sectors, so that further development of the economy is accompanied by a decrease in the negative impacts on the climate.

The problem of waste accumulation in Ukraine is particularly widespread and significant both due to the dominance of resource-intensive technologies in the national economy and due to the lack of an adequate response to these challenges for a long time. Significant scales of resource use and energy and raw material specialization of the national economy together with an outdated technological base has determined and will subsequently determine the high rates of waste generation and accumulation (Table 2).

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Table 2. Generation and management of I-IV hazard classes waste in Ukraine, thsd. t (Source: calculated by the author according to the State Statistics Committee of Ukraine)

Year	Generated	Utilized	Incinirated	Landfilled in specially designated places or objects (waste disposal sites)	The total amount of waste accumulated during operation in specially designated places or objects (waste disposal sites)
2010	425914,2	145710,7	1058,6	336952,2	13267455,0
2011	447641,2	153687,4	1054,5	277106,8	14422372,1
2012	450726,8	143453,5	1215,9	289627,4	14910104,7
2013	448117,6	147177,9	918,7	288121,1	15167368,9
2014*	355000,4	109280,1	944,7	203698,0	12205388,8
2015*	312267,6	92463,7	1134,7	152295,0	12505915,8
2016*	295870,1	84630,3	1106,1	157379,3	12393923,1
2017*	366054,0	100056,3	1064,3	169801,6	12442168,6
2017-2014	11053,6	-9223,8	119,6	-33896,4	236779,8
2017-2016	70183,9	15426	-41,8	12422,3	48245,5

*excluding the temporarily occupied territory of the Autonomous Republic of Crimea, Sevastopol and parts of temporarily occupied territories in Donetsk and Luhansk regions

Ukraine has a highly developed agricultural sector, including crop production, which annually generates a large amount of waste and residues. For example, the study by American specialists (ZULAUF ET AL., 2017, 2018) in the field of agriculture showed that of the total weight of corn grown for grain, about 50% ends up as field waste, about 30% ends up as processing wastes and less than 20% is the grain itself. When rice is grown, a large amount of straw is produced. Threshing rice produces 20% of husks containing 18% silica, which is difficult to dispose of by burning and therefore does not find any use. By their origin, the waste is divided into primary that is generated directly during the harvest, and secondary which is generated during the processing of crops at agricultural enterprises. The classification of primary and secondary waste is shown in Fig. 1. Waste generation from agriculture, forestry and fisheries and their share in total waste by types of economic activity and households for 2010-2018 in Ukraine are presented in Fig. 2. The amount of waste generated by the agricultural sector varies year by year, however, it has tended to decrease over the past 6 years. The share of these wastes varies between 2.9-1.7%. Table 3 shows the formation of major primary crop wastes in Ukraine, based on the gross harvest of basic crops and the waste output ratio. The waste output coefficient varies between 0.7-2.0 depending on the crop. The total volume of primary waste from the main crops in Ukraine is more than 115 million tons.

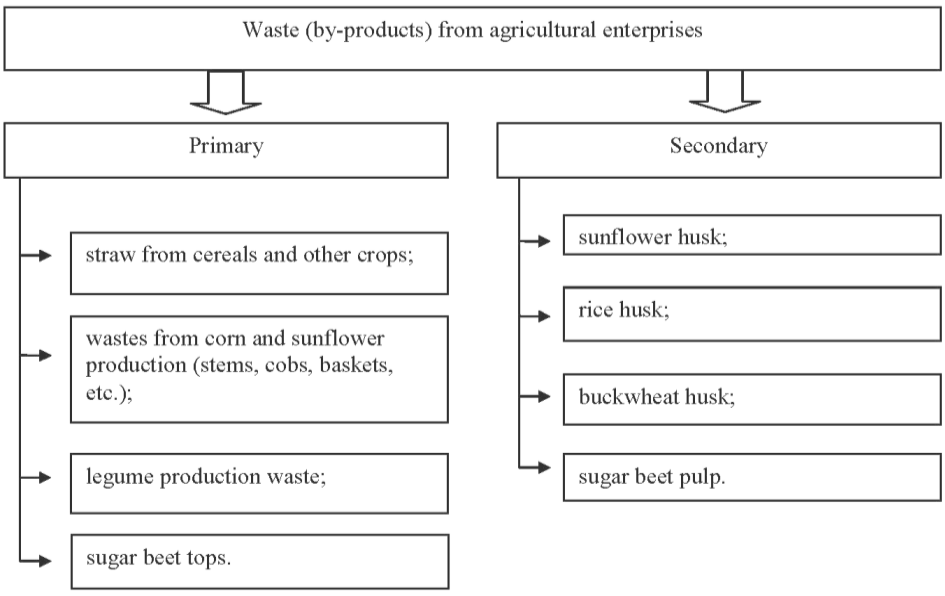

Fig. 1. The classification of waste from agricultural enterprises (Source: formed by the authors)

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Table 3. Formation of primary plant waste in Ukraine, 2016-2018 (Source: calculated by the authors according to the State Statistics Committee of Ukraine)

Crop	Waste output coefficient	2016		2017		2018		2018-2016 (+,-)	
		Gross harvest, thsd. t	Volume of waste, thsd. t	Gross harvest, thsd. t	Volume of waste, thsd. t	Gross harvest, thsd. t	Volume of waste, thsd. t	Gross harvest, thsd. t	Volume of waste, thsd. t
Wheat	1.0	26099	26099	26209	26209	24606	24606	-1493	-1493
Barley	0.8	9436	7549	8285	6628	7349	5879	-2087	-1670
Rye	1.3	390	507	505	657	394	512	4	5
Maize for grain	1.3	28075	36498	24669	32070	35801	46541	7726	10043
Rice	0.9	65	59	64	58	69	62	4	3
Millet	0.8	190	152	84	67	80	64	-110	-88
Oat	1.0	500	500	471	471	418	418	-82	-82
Buckwheat	1.9	176	334	180	342	137	260	-39	-74
Other cereal and leguminous crops	0.7	1157	810	1450	1015	1202	841	45	31
Soya beans	0.9	4277	3849	3899	3509	4461	4015	184	166
Winter rapeseed and colza (spring rapeseed)	2.0	1154	2308	2195	4390	2751	5501	1597	3193
Sunflower seeds	1.9	13627	25891	12236	23248	14165	26914	538	1023
Total	x	85146	104556	80247	98664	91433	115615	6287	11059

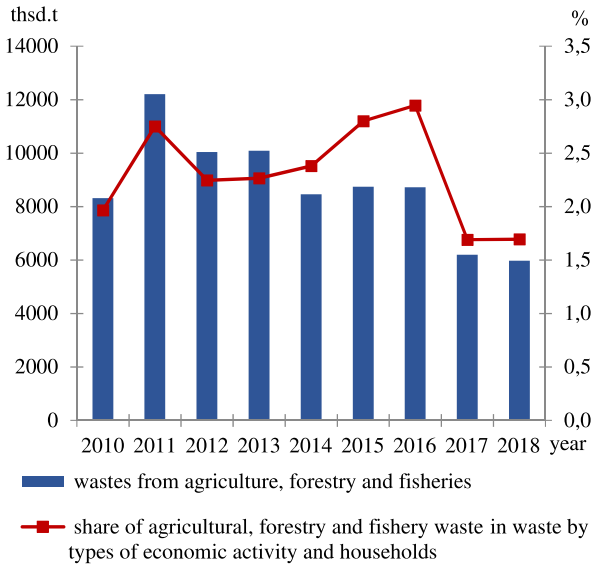

Fig. 2. Waste generation from agriculture, forestry and fisheries and their share in total waste by types of economic activity and households for 2010-2018 in Ukraine (Source: composed by the authors according to the State Statistics Committee of Ukraine

The European and world trend today is an increase in the use of waste for energy. It includes the burning of waste in order to obtain energy and may include both the burning of biomass itself and the burning of solid biofuels (briquettes and pellets). Studies on the energy use of plant waste are actively conducted in EU countries (Bajwa et al., 2018; Monforti et al., 2013). In general, they come to the same conclusion that 25-50% of straw and crop residues of corn for grain and 30-50% of waste from the production of sunflowers can be used for energy / biofuel production, the remainder should be left in the fields. A study by Zulauf, et al. (2018) showed that for US conditions it is advisable to use 30-60% of the volume of straw and waste from the production of corn for grain, for energy needs.

The opinions of Ukrainian scientists Kaletnik (2018), Mironenko & Poleva (2016), Geletukha & Zheliezna (2017) differ. Soil scientists and agricultural experts are convinced that almost the entire straw crop should be left in the fields to preserve soil fertility. On the contrary other experts believe that in Ukraine, there is an excess of straw, which is economically more profitable to use to offset the fuel and energy balance.

Calculations of the bioenergy potential of primary plant waste is carried out in tons of oil equivalents and takes into account the coefficients of technical availability (which is affected by the technology of harvesting crops and existing technologies for processing waste into energy) and the coefficient of energy use (according to the recommendation). According to this, the economic bioenergy potential of primary crop waste in Ukraine in 2018 was calculated (Table 4).

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Table 4. Bioenergy potential of primary crop waste in Ukraine, 2018 (Source: calculated by the author according to Geletukha & Zheliezna, 2017)

Crop	Volume of waste, thsd. t	Coefficient of technical availability	Technical potential, thsd. t	Coefficient of energy use	Economic potential, thsd. t	Calorific value, kcal/kg	Economic potential, thsd. t oil equivalent
Wheat	24606	0.5	12303.0	0.25	3075.8	3285	1443.4
Barley	5879	0.5	2939.5	0.25	734.9	3 190	334.9
Rye	512	0.5	256.0	0.25	64.0	3 240	29.6
Maize for grain	46541	0.5	23270.5	0.3	6981.2	3 000	2991.9
Rice	62	0.5	31.0	0.3	9.3	3 000	4.0
Millet	64	0.5	32.0	0.3	9.6	3850	5.3
Oat	418	0.5	209.0	0.3	62.7	3 000	26.9
Buckwheat	260	0.5	130.0	0.3	39.0	3 000	16.7
Other cereal and leguminous crops	841	0.7	588.7	0.8	471.0	3800	255.7
Soya beans	4015	0.7	2810.5	0.8	2248.4	3 660	1175.6
Winter rapeseed and colza (spring rapeseed)	5501	0.7	3850.7	0.35	1347.7	3 270	629.6
Sunflower seeds	26914	0.67	18032.4	0.4	7213.0	3 270	3369.5
Total	115613	x	64453.3	x	22256.43	x	10283.0

The energy potential of agricultural biomass (about 11 million tons of oil equivalents per year) in Ukraine is more than 5 times higher than the potential of wood biomass, such as firewoodand wood processing waste (about 2 million tons of oil equivalents per year). Its effective use can become the basis for reducing the energy dependence of our state.

Another source of agricultural waste generation is animal husbandry and poultry farming, where the main type of agricultural waste (by-product) is manure. In Ukraine, the livestock population is 3.3 million heads of cattle, 6.0 million pigs, and 211.7 million birds. The formation of animal by-products (livestock, pig and poultry manure) amounted to about 97 million tons as of January 1, 2019 (Table 5). The manure from animals and bird droppings is an environmental problem if handled incorrectly. Environmental problems arise, usually, on industrial farms, which have a livestock total of hundreds of thousands of animals or millions of birds per year and, accordingly, thousands of cubic metres of waste. This waste is collected in lagoons and stored from several months to a year before being taken to the fields. In Ukraine, about 50% of livestock farms are industrial. When storing large amounts of waste in lagoons, the unplanned leakage of slurry into the environment is possible due to the depressurization of lagoons, flushes, and excess from filling the lagoons past their limits. In addition, manure can be introduced into the soil at frequencies in excess of the norm. When added to soil to excess manure and litter become contaminants and enter into ground and surface waters.

Table 5. The formation of livestock by-products (manure, litter) in Ukraine on January 1, 2019 (Source: calculated by the authors according to the State Statistics Committee of Ukraine)

Category	Manure yield, t/animal/year	2017		2018		2019		2019 to 2017 (+,-)	
		million heads	volume of waste, million tons	million heads	volume of waste, million tons	million heads	volume of waste, million tons	million heads	volume of waste, million tons
Cattle	18.0	3.7	66.6	3.5	63.0	3.3	60.0	-0.4	-6.6
Pigs	3.6	6.7	24.1	6.1	22.0	6.0	21.7	-0.7	-2.4
Poultry	7.5 (per 100)	201.7	15.1	204.8	15.4	211.7	15.9	10.0	0.8
Total	x	212.1	105.8	214.4	100.3	221.1	97.6	9.0	-8.2

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Manure also contains pathogens, bacteria that are resistant to antibiotics, and can therefore cause the spread of diseases. About half of all antibiotics in the world are used in animal husbandry to prevent disease. Manure is a source of emissions of ammonia, methane and other gases into the air. When stored in open lagoons, or introduced into the fields in large quantities, the local population living near to industrial farms suffers from unpleasant and specific smells. In addition to the unpleasant odour, emissions from industrial farms are harmful to the environment and cause climate change. According to estimates by the UN Food and Agriculture Organization, livestock production accounts for 18% of all human greenhouse gas emissions – more than the emissions from transport. Manure and bird droppings cause 7% of the total emissions of nitrous oxide, which is one of the most dangerous greenhouse gases.

Considering the current energy and environmental situation, Ukraine should immediately begin the widespread introduction of bioenergy technologies which use waste, and which involves the production of various forms of biofuels - solid, liquid, gaseous. In Ukraine, the use of waste for biogas production has significant prospects, since a number of factors contribute to this (Fig. 3).

The calculations confirm the presence of significant bioenergy potential in livestock. In terms of biomethane, the potential of animal manure and poultry manure in Ukraine is 900 million m^3 of cattle manure, 394.9 million m^3 of pig manure and 1424.6 million m^3 of bird manure (Table 6).

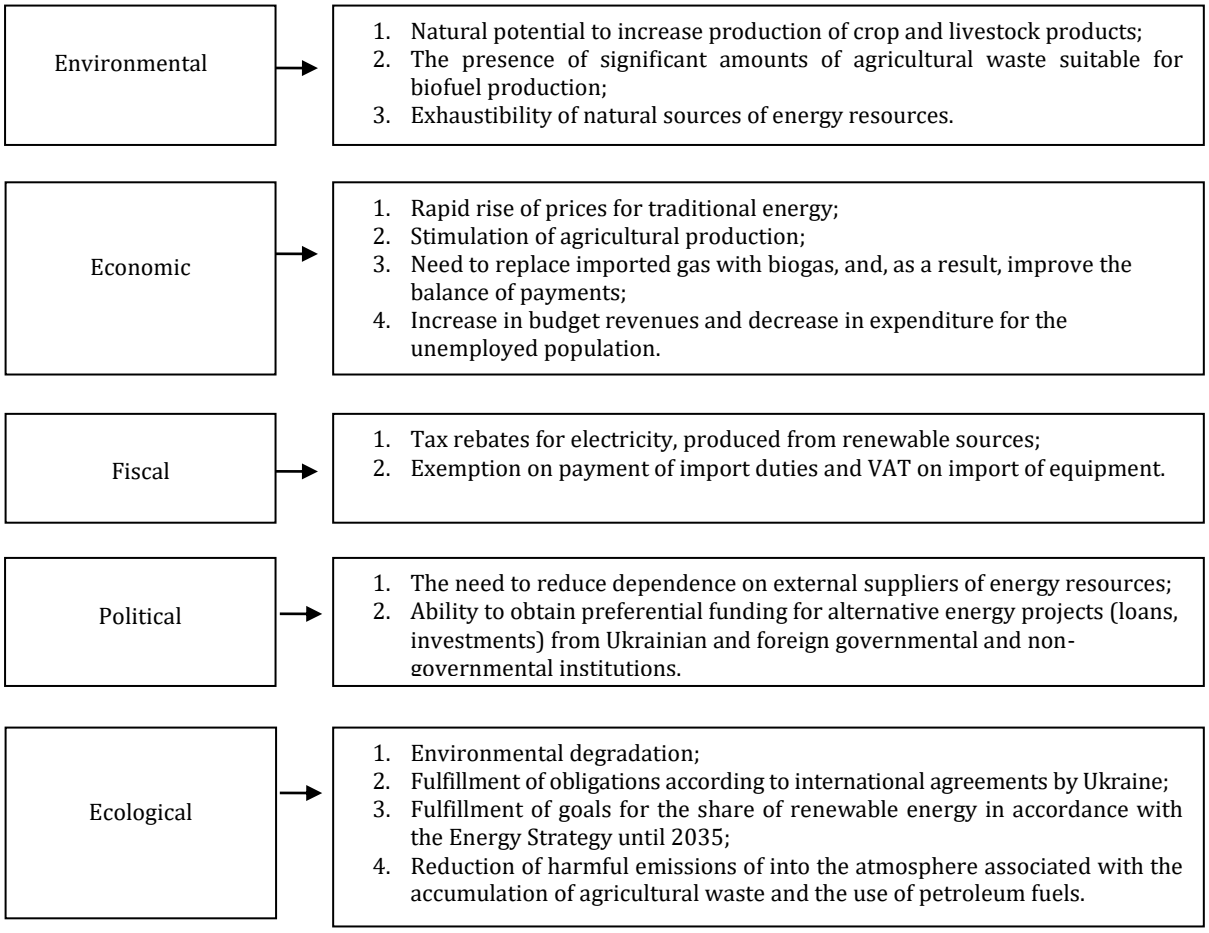

Fig. 3. Factors for the development of biofuel production from waste agricultural enterprises (Source: formed by the authors)

Table 6. Potential for biogas production in Ukraine from manure (Source: calculated by the authors, January 1, 2019)

Category	Waste volume, million tons	Biogas output from 1 ton of substrate, cubic meters	Biogas potential from waste, million cubic meters	Methane content, CH_4, %	Methane output, million cubic meters
Cattle	60.0	25	1500	60	900.0
Pigs	21.7	28	607.6	65	394.9
Poultry	15.9	140	2226	64	1424.6
Total	97.6	–	–	–	2719.58

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Given the possibility of using plant raw materials (silage, grass), as well as by-products of processing enterprises (sugar and alcohol plants, breweries, etc.), food waste, the potential of biogas production will increase significantly. The production of biogas from agricultural waste is developing at a very slow pace in Ukraine. As of January 2018, the existing biogas production capacities in Ukraine amounted to 40 MW. Of these, 15 MW are biogas plants that operate at solid domestic waste landfills, and another 25 MW are capacities producing biogas from agricultural waste. However, the potential for biogas production through anaerobic digestion of waste is much greater.

Gas consumption by the population of Ukraine in 2018 amounted to 15.4 billion m^3. The total potential for biogas production from livestock waste is 1.5 billion m^3 (13% of total population consumption). Despite the fact that in 2018 Ukraine imported 10.6 billion m^3 of natural gas, almost no biogas production potential was used in Ukraine.

The development of individual biogas plants for Ukraine has significant potential for improving economic, social and environmental conditions. The growth of the biogas sector in Ukraine depends on many factors. An analysis of the strengths and weaknesses, as well as the opportunities and threats of biogas production from agricultural waste, was carried out to determine recommendations for the further development of the industry (Table 7).

Table 7. SWOT- analysis of biofuels development from agricultural waste in Ukraine (Source: composed by the authors)

	STRENGTHS	WEAKNESSES
INTERNAL	1. Prevention of deforestation when using waste for energy purposes (deforestation area in 2010-2017 – 3.2 million hectares, in 2017 - 419 thousand hectares) (State Service of Ukraine on Agriculture, 2018) 2. Solution of the problem of organic waste utilization (primary crop waste for energy purposes – 40.4 million tons, livestock waste – 110 million tons annually) (State Service of Ukraine on Environment); 3. The possibility of receiving 100 million tons of organic fertilizers annually from biogas reactors (Table 3); 4. The need to reduce emissions of carbon dioxide into the atmosphere (for 2017 the amount of emissions was 124.2 million tons, in 2018 – 126.4 million tons) (State Service of Ukraine on Plant Growing, 2018); 5. Favourable climatic conditions of most regions for biogas production in individual reactors (average monthly temperature of January from −8 °C to + 4 °C, July - from + 17 °C to + 23 °C) (Ministry of Agrarian Policy and Food of Ukraine, 2019).	1. Residents prefer to use traditional types of energy (natural gas, coal, firewood) (Pryshliak, 2019); 2. Imperfection of mechanisms of state support of bioenergy (Kaletnik, 2018); 2. Difficulties for collecting raw materials for loading into a biogas reactor in individual installations (Tokarchuk, 2018); 3. Outdated approaches to the utilization of crop waste (burning residues in the fields) (Geletukha, 2017) 4. Reduction in the number of cattle and pigs (reduction in the volume of potential raw materials for biogas production) (Table 4.); 5. In case of interruption of the constant supply of fermentation feed to the reactor or its excessive supply, it is possible to reduce the biogas output and the need to restart the biogas plant (Skoruk, 2012); 6. Lack of experience in the construction of large plants for the production of solid biofuels and the efficient operation of pyrolysis boilers by the population (Klimchuk, 2017).
	OPPORTUNITIES	THREATS
EXTERNAL	1. Increase crop yields due to the use of organic fertilizers from biogas plants (Kaletnik, 2019) 2. Reduce the landfill area (Berezyuk, 2019). 3. Create new “green” workplaces in rural areas (construction and maintenance of biogas reactors, plants for the production of solid biofuels) (Ghosh et al, 2019) 4. Increase in consumption of energy resources (State Service of Ukraine on Energy, 2019); 5. Help meet the requirements of 12% of biomass energy in electricity generation in Ukraine (Energy Strategy of Ukraine for the period up to 2035 “Security, energy efficiency, competitiveness”, 2017) 6. High scientific and intellectual potential: 1,322 million students, 22829 post graduates at 282 universities in 2018 (Ministry of Education and Science of Ukraine, 2019)	1. Low level of investment attractiveness: Ukraine’s investment attractiveness index in 2018 was 3.1 of 5 (European Business Association, 2019) 2. High inflation level (inflation index was 9.8 in 2018) (Ministry of Economic Development and Trade, 2019) 3. Financial failure of the population to invest in the construction of a biogas reactor or the purchase of a pyrolysis boiler (the average monthly salary in Ukraine amounted to 7810 UAH for 2018) (State Service of Ukraine on Labour market, 2019);. 4. Low share of renewable energy in the structure of energy consumption in Ukraine (4.4% in 2018) (State Service of Ukraine on Energy, 2019); 5. Unfavourable credit policy in Ukraine (interest rates on new loans in national currency for households increased during the period 2017-2018 (as of December, 31) from 29.2% to 33.1% per annum; for enterprises – from 14.3% to 20.9% per annum) (National Bank of Ukraine, 2019)

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The above matrix of SWOT analysis shows that the strengths and opportunities are much greater compared to weaknesses and threats that can be easily overcome with the help of various regulatory mechanisms. In Fig. 4 summarizes the effects of the use of waste in the production of biofuels and their further use (economic, social, environmental). The use of biofuels (biogas, solid biofuels) provides the carbon dioxide cycle in nature, reduces the human pressure on the environment through the processing of organic waste. World experience convinces that the production of biofuels provides benefits for the economy of each country, in particular, it makes it possible to create new jobs not only in rural areas, but also in industrial centers, improves the environmental situation in the country, regions, etc.

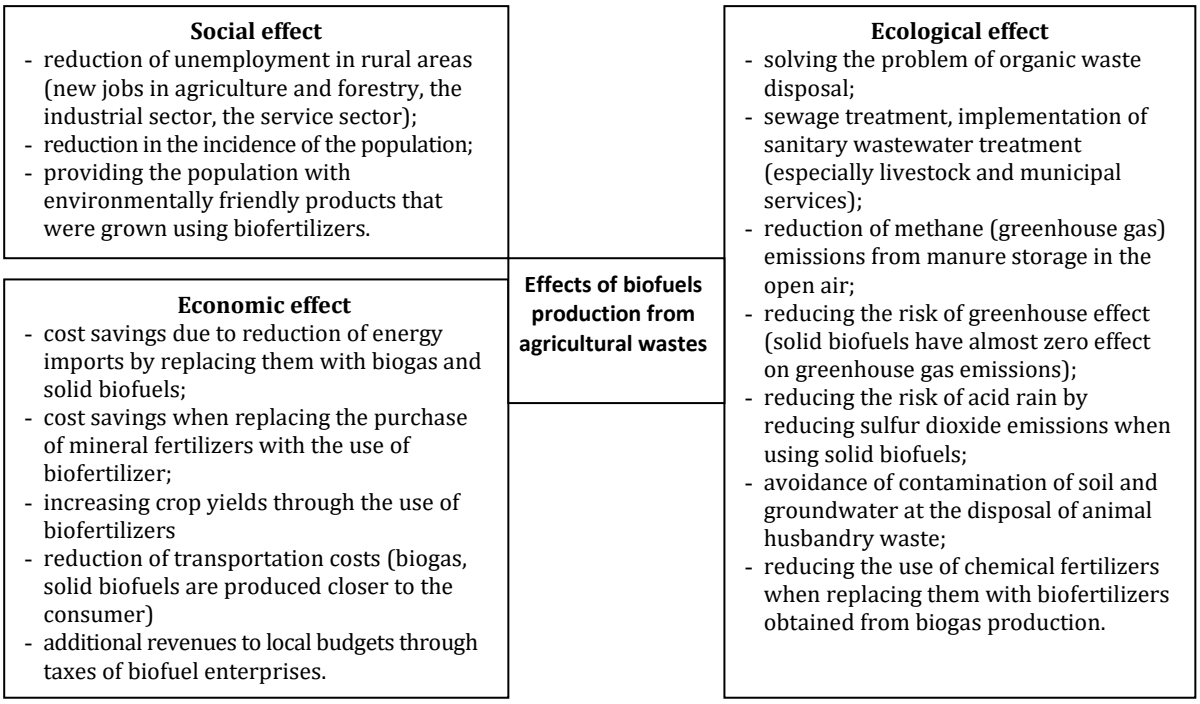

Fig. 4. Matrix of effects from the use of waste in the production of biofuels and their further use (Source: composed by the authors)

5. Conclusion

Measures aimed at reducing Ukraine's dependence on energy imports, increasing the cost of traditional energy sources and the growing negative environmental impact of fossil fuel consumption and waste accumulation are the main driving forces that cause a constant increase in the production and use of biofuels.

Ukraine has significant potential for primary crop waste – about 100 million tons a year. With effective use in compliance with recommendations for economically and ecologically reasonable share of energy use (30-40%) can receive each year 7.21 million tons of oil equivalent from renewable sources. Livestock waste (animal manure, bird droppings) is another potential source for biofuel production, which can be produced annually in the amount of 2.2 million tons of oil equivalent.

Implementation of the state energy program in our country will allow to ensure the development of energy-saving technologies and reduce energy dependence. Thus, the possibility of improving the energy efficiency of production and the development of bioenergy has an impact on the reproduction of natural resource potential. This is due to the fact that in the agricultural sector, the production process is closely related to living organisms. Given the above, the development of bioenergy is an important direction in increasing the competitive advantages of the domestic economy and preserving the environment, and creates opportunities for ensuring a balanced development of the industry.

The introduction of modern innovative technologies in the field of energy supply will reduce the dependence of the Ukrainian economy on oil and gas from the exporting countries, which, accordingly, will increase its energy, economic and national security and will help our country to reach a whole new level of relations with foreign states - oil exporters and petroleum products and position themselves as a state with a European level of economic and environmental security.

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Biofuel production in Ukraine will not only reduce dependence on energy imports, but will also help to improve the economic and environmental situation. Reducing the use of fossil fuels in favour of biofuels will help to decrease the flow of greenhouse gases into the atmosphere. The use of organic waste for energy purposes will help to solve the problems of waste accumulation and pollution of soils and groundwater. Establishing biofuel production in Ukraine will create new jobs, especially in rural areas, where the unemployment problem is now significant. In addition, the development of biofuel production will provide additional revenues to local and state budgets.

Acknowledgements

The article includes the results of the investigations according to State Theme "Development of a new concept of agricultural waste utilization for ensuring energy autonomy of agricultural enterprises" (0119U100786).

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