

# USE OF WASTES OF THE LIVESTOCK INDUSTRY AS A POSSIBILITY FOR INCREASING THE EFFICIENCY OF AIC AND REPLENISHING THE ENERGY BALANCE

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There are several reasons for the economic and social necessity in forming and developing the biofuels market of Ukraine, starting with energy security considerations, diversification of national production, support of innovations and ending with economic and social efficiency of biofuels market development on the basis of high motivation for the agrarian sector growth, positive social bias towards rural population growth and environmental security through renewable energy. The immediate prospect of energy autonomy for agro-industrial production should be based on efficient production and use of biomass. At present, biomass is the fourth largest fuel in the world, producing about 2 billion tonnes of conventional fuels per year, which is about 14% of the world's total primary energy consumption. In some countries, this figure is even higher, but in Ukraine it still does not exceed 3%. This will help Ukraine reduce its dependence on energy imports, halt its transformation into a raw material appendage, and enable processing of such a large-scale resource while obtaining hundreds of thousands of jobs, income for the citizens and for the state budget. At this stage of state development, biofuel production is one of the determining catalysts for new global trends in Ukraine's agro-industrial complex that will contribute to its sustainable development.

**Keywords:** alternative energy resources; energy balance; food security; agriculture; biogas; livestock

## INTRODUCTION

Nowadays, scientists have analyzed many ways for agricultural enterprises to achieve strategic goals of economic development through the study of traditional peasant agriculture, incentives, labour, marketing systems, investment and innovation. Each of these aspects significantly influences the development of an enterprise. Scientists emphasize the need to develop new approaches to land reform, production, food, private and public property, and so on. However, very little attention is paid to studying the regional peculiarities of development and the assessment of agricultural enterprises development differentiation due to the regions of Ukraine; the use of wastes of livestock industry to increase the efficiency of agro-industrial complex and to replenish its energy balance.

A considerable amount of factors in Ukraine leads to the need for biofuel production and consumption, in particular: dependence on energy imports; scarcity of fossil fuels; price increases for fuel energy; utility tariffs rise; environmental degradation; availability of natural resource potential; excessive export of agricultural products, etc.

It is presumable that the biofuel production process will help stabilize the agro-industrial complex development, create new jobs, provide additional revenues for the state budget, improve the environmental situation, and ensure energy, economic independence, and food security.

The development of the market economy in Ukraine depends largely on solving the problem of uninterrupted power supply to all sectors of the national economy without exception. Under the market conditions, increasing the national wealth of our country, improving the standard of the population's living standards and its socio-economic status will mainly depend on the rational consumption of energy resources. Because of this, at the present stage of management the process of improving the use of energy and alternative energy resources is of particular relevance.

The complex of energy-saving measures should be carried out on the basis of practical realization of scientific, economic, legislative, organizational,

technical, technological and environmental components, with the purpose of rational consumption of energy resources with gradual increase and introduction into economic circulation of the most economically feasible energy resources in Ukraine's biofuels.

## Material and methods

### Monographic, calculation, mathematical and statistical

The calculation method is widely used in forecasting and planning the production and economic processes of development of the livestock industry. It involves developing several options for solving particular economic problems, evaluating them, and then choosing the best one. This method involves many techniques which ensure the relative accuracy of economic forecasts and targets for energy balance calculations.

The monographic method is used for a comprehensive and in-depth study of single phenomena, processes and the identification of causal relationships of their development. It is indispensable in the detailed study of individual observations of livestock waste.

The mathematical and statistical methods use rational methods of systematization, processing and analysis of statistical observations data of mass phenomena in order to establish characteristic statistical patterns, use them for scientific and practical conclusions, and they based on the probabilistic nature of these phenomena.

## Results and discussion

Ukraine is an agrarian country where the agro-industrial complex reveals steady economic growth. In 2018, its share in the country's gross value added was 11.9%. The industry is one of the main budget-forming sectors of the economy and takes the first place in the export commodity structure (in January-August 2019 it was 42.2%). AIC is also a major source of

currency exchange for Ukraine and a key factor in maintaining the trade balance.

Despite the overall negative trend, the decline in exports of goods in 2014–2016, the rate of decline in agri-food exports was lower than in other industries. And despite the recession after the crisis years, the historical record of agri-food exports in 2012, over the past 10 years, exports of agri-food products from Ukraine have doubled.

Over the last 5 years, the share of AIC products in the structure of Ukraine's export earnings has increased from 31% in 2014 to 39.3% in 2018. However, it should be noted that the basis of agricultural exports is still exports of raw materials. The share of these products in the structure is about 55%.

Sunflower oil accounts for the largest share in agricultural exports, with sales of 4.1 billion US dollars. Other key positions are in cereals (corn, wheat, barley) as well as oilseeds (soybeans) and oilseed products (sunflower cake). These TOP-10 products account for 81% of all agri-food exports from Ukraine.

The main market for the sale of Ukrainian agricultural products remains the Asian market (in 2018 it is 44.6%).

Agriculture is an important component of the domestic economic complex. Trends and prospects for the development of the industry are determined by the general state of the national economy, which largely affects the dynamics of the main indicators of agricultural activity. Despite the significant and long-standing problems in the sphere of financial and logistical support of the industry, there is a tendency to increase its importance in the

economic system of the country. At the same time, powerful and efficient agricultural production around the world is not one of the causes, but one of the consequences of a high level of national economic development.

Therefore, the strategic task of the Government of Ukraine is to develop all sectors of the country's economy, which will become the driver of the agro-industrial complex of Ukraine and solve a number of environmental, energy and social problems.

While establishing agricultural production, a large number of by-products and waste is generated. Many types of such wastes are environmental pollutants. So, there are serious risks to water, air, soil, biodiversity and human health. These problems can be solved by processing the above mentioned resources for biogas production, based on European experience.

According to the Intergovernmental Panel on Climate Change, in the period 2007–2016, the world's anthropogenic greenhouse gas emissions are 21%, transport 14%, energy and extraction – 35%, and the housing sector – 6%, and agriculture, forestry and land use – 23%. Agriculture, forestry and land use emissions consist of carbon dioxide (CO<sub>2</sub>) – 13%, methane (CH<sub>4</sub>) – 44%, and nitrogen oxide (N<sub>2</sub>O) – 82% (Intergovernmental Panel on Climate Change).

According to the FAO – Food and Agriculture Organization, in the structure of CO<sub>2</sub> emissions of the agro-industrial complex of Ukraine in 2017 the lion's share is represented by emissions from the livestock industry (Figure 1) (The Food and Agriculture Organization).

Livestock farms are sources of significant amounts of hazardous and pollutant substances: ammonia, the concentration of which leads to acid rain

**Table 1** Main indicators of agriculture in Ukraine

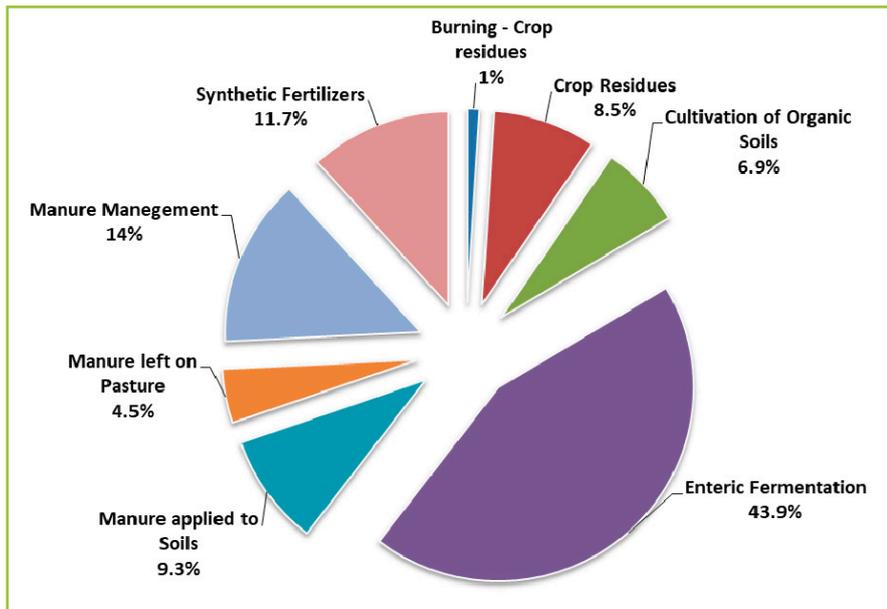
Indicator	Years			
	2016	2017	2018	January – September 2019
Agricultural product indices (%)	106.3	97.8	108.1	105.9
Volume of agricultural products (billion UAH)	637.8	707.8	843.3	539.1
Share of agriculture in the structure of gross value added (%)	13.8	12.1	11.9	4.8
Agricultural and food products in total exports of Ukraine (%)	42.0	41.1	39.3	42.2
Agri-food exports (billion USD)	15.3	17.8	18.6	13.9

Source: State Statistics Service of Ukraine

**Table 2** Emissions of pollutants into the atmosphere from stationary sources of pollution in Ukraine, thousands tons

Due to the type of economic activity	Years		
	2016	2017	2018
Total	3078.1	2584.9	2508.3
Agriculture, forestry and fisheries	81.6	80.3	78.2
Extractive industries and quarries' development	465.4	479.3	445.1
Manufacturing industry	976.7	874.3	882.9
Supply of electricity, gas, steam and air conditioning	1,414.5	1,011.0	988.8
Water supply; sewerage, waste management	14.1	15.8	16.2
Construction; wholesale and retail trade; repair of motor transport tools and motorcycles	26.6	23.0	7.6
Transportation, warehousing, postal and courier activities	60.8	60.3	58.2
Other economic activities	38.4	40.9	31.3
In the calculation: per person (kg)	72.1	60.8	59.3
per 1 km <sup>2</sup> (kg)	5338.3	4483.0	4350.0

Source: State Statistics Service of Ukraine



**Figure 1** Structure of AIC Ukraine emissions, average 1990–2017, CO<sub>2</sub> equivalent  
Source: The Food and Agriculture Organization

and the formation of health hazardous aerosols; greenhouse gases (animal husbandry produces about 18% of all types of human greenhouse gases; in particular, methane from this industry accounts for about 16% of the world's annual emissions, nitrogen oxide – 17% of total; and many other substances and compounds).

Livestock development is a priority for the agricultural sector in the coming years. However, today, cattle breeding is not considered the optimal form of business for the livestock industry. At the same time, there is a rapid development of so-called agroholdings – large producers that control the virtually complete production cycle, with powerful financial and natural resources. Such enterprises are mainly engaged in the breeding of pigs and poultry – those areas of animal husbandry that require relatively little time and labour for profit. It is these large enterprises that receive investment and government support, not small and medium-sized agricultural enterprises. Intensive livestock enterprises in a restricted area can hold hundreds and thousands of animals and millions of birds at the same time. Thus, without proper management, it causes significant risks to the quality of water, air, soil, biodiversity and human health.

Today, for example, the poultry market in Ukraine is oversaturated by the production of one enterprise “Myronivskiy Bakery”, which produces over half a million tons of meat per year. The enterprise exports almost a quarter of its products. This makes the enterprise the largest poultry producer in Europe. Such industrial farms consume vast quantities of natural resources and

produce emissions and waste on a much larger scale than can be disposed of locally.

The activities of large producers and their economic indicators are now relegated to the environment and society. If we talk about large-scale agricultural production, all its types lead to specific pollution. Also, when evaluating the entire production and transportation chain, industrial (intensive) livestock farming is the most problematic.

In the areas where the high livestock density and large-scale enterprises are, it is advisable to set up bio-energy clusters for biogas production. These clusters should combine powerful biogas power plants, power plants based on cogeneration plants and biogas treatment plants for the production of gaseous fuels.

In order to address the environmental and social problems of intensive livestock farming, Ukraine needs to approximate its legal framework to the EU law, drawing on the experience of the EU Member States.

Taking into consideration the issues of livestock wastes, managing them requires tight regulations, especially for industrial farms. For example, in the European Union countries, the Directive 2010/75/EU on industrial pollution regulates environmental requirements for farms with a capacity of more than 40,000 chickens, 2,000 pigs and 750 sows. The requirements imposed on industrial farms on waste management and pollution prevention make it impossible to collect and accumulate wastes in open lagoons in volumes typical for Ukraine. Therefore, enterprises are looking for alternative ways of

utilization. Under these conditions, the most anaerobic processing of livestock waste (alone or in combination with other substrates) can be considered as the best available technology, since the processing of livestock wastes at biogas plants can partially reduce environmental problems and have significant economic benefits in the form of renewable energy production.

Ukraine has an untapped potential for the production of its own energy from renewable sources – the processing of animal waste (animal manure and poultry manure) with the formation of biogas, which can then be used to produce electricity, heat or fuel – analogues of natural gas (in particular, for transport). The production of biogas energy is not harmful to the environment as it does not cause additional greenhouse gas CO<sub>2</sub> emissions and reduces the amount of organic waste. Unlike wind energy and solar radiation, biogas can be produced regardless of climatic and weather conditions.

The processing of animal wastes with biogas production will not only solve the environmental problems of large scale waste production on industrial farms, but also benefit from decentralized renewable energy production.

Unlike fossil fuels, biogas in Ukraine has a renewable potential of 3.2 billion cubic meters, which remains unused (State Agency for Energy Efficiency and Energy Saving of Ukraine). The production of biogas is based on a waste of crop, livestock complexes, poultry farms, food and processing industry. First of all, this concerns waste that is prone to biodegradation. Biogas as a biodegradation product with a high methane content can be converted into: heat, hot water and electricity, which in turn is sold at a “green tariff”.

For example, in the spring of 2012, “Myronivskiy Bakery” launched its work from constructing the first biogas station at the “Oril-Leader” poultry farm in the Dnipropetrovsk region. Already in December 2012, the enterprise put into operation the first fermenter. In 2013 a biogas plant was launched with a capacity of 5 MW/h (equivalent to 15,000 apartments and 1,500 apartments). At the end of 2014, the biogas plant reached its full capacity of 5.5 MW (10 biogas fermenters and 5 cogeneration units generating electricity).

It is the first biogas plant of such capacity and level of technology in Europe, which operates on poultry manure and wastes from a broiler farm. International organizations have confirmed the effectiveness and relevance of the project in terms of environmental and safety standards. The cost of the project is \$ 15 million.

**Table 3** Grouping the enterprises due to the amount of farm animals on 1 January 2019

Indicator	Amount of enterprises		Amount of animals	
	units	as % due to the total amount	thousand animals	as % due to the total amount
<b>Cattle</b>				
Enterprises, total amount	2,296	100.0	1,138.1	100.0
To 50	633	27.6	12.3	1.1
50–99	210	9.1	15.0	1.3
100–499	741	32.3	202.9	17.8
500–999	394	17.1	274.7	24.1
1,000–1,499	144	6.3	177.0	15.6
More than 1,500	174	7.6	456.2	40.1
<b>Pigs</b>				
Enterprises, total amount	1729	100.0	3,395.6	100.0
To 100	382	22.1	8.6	0.3
100 – 199	206	11.9	14.9	0.4
200 – 499	539	31.2	134.0	3.9
500 – 999	195	11.3	141.8	4.2
1,000 – 4,999	283	16.3	640.8	18.9
5,000 – 9,999	50	2.9	348.6	10.3
More than 10,000	74	4.3	2,106.9	62.0
<b>Sheep and goats</b>				
Enterprises, total amount	688	100.0	182.3	100.0
To 50	243	35.3	5.5	3.0
50–99	112	16.3	7.9	4.4
100 – 199	132	19.2	18.4	10.1
200 – 499	113	16.4	34.7	19.0
more than 500	88	12.8	115.8	63.5
<b>Poultry</b>				
Enterprises, total amount	449	100.0	11,8812.9	100.0
To 4,999	187	41.6	186.6	0.2
5,000–49,999	113	25.2	2,378.9	2.0
50,000–99,999	25	5.6	1,800.7	1.5
100,000–499,999	87	19.4	21,150.1	17.8
More than 500,000	37	8.2	93,296.6	78.5

Source: State Statistics Service of Ukraine.

In March 2017, a project for the construction of a new biogas complex at Vinnytsia Poultry Plant was announced, which will end in 2020. The design capacity will be 20 MW. It can become the largest biogas complex in the world. The cost of the first stage of construction is \$ 27 million.

In 2018 the enterprise implemented the following projects:

- Biogas complex with capacity of 12 MW, VE Biogas Ladyzhyn LLC “Vinnytsia Poultry Farm” – 12 fermenters for biogas production, gas transmission system, 6 cogenerators for green energy generation.
- Roof solar power plant with a capacity of 4.5 MW.
- Since 2018 the company is an electricity sales operator, which has been licensed to sell electricity and is a member of the Ukrainian energy market.

Activity in 2018:

- more than 100 thousand tons of organic waste (poultry waste, sludge, etc.) are disposed of;
  - 45 million kW of green electricity was generated;
  - 1 million 120 thousand m<sup>3</sup> of gas have been replaced;
  - 30 thousand tons of organic fertilizers produced.
- The main components that are processed for biogas:
- bird droppings – 180 tons/day (66,000 tons/year);
  - flotation sludge (liquid) – 40 t/day (14,600 t/year);
  - slaughterhouse waste – 35 t/day (13,000 t/year);
  - sorghum silo weight – 50 t/day (18,000 t/year);
  - water from treatment plants – 350 m cube/day (128,000 m cube/year) (Group of enterprises of “Myronivskiy Bakery”).

**Table 4** Potential for biogas production from livestock wastes in Ukraine 1. 1. 2019

Indicator	Livestock (million animals)	Manure or litter output (m <sup>3</sup> /animal/place/year)	Biogas output (Nm <sup>3</sup> /t of substrate)		Methane content (%)	Biogas output (Nm <sup>3</sup> /year)		Biogas output (Nm <sup>3</sup> /year)
			measurement range*	average		min	max	
Cattle	3.5	7.5–21.0	20–30	25	60	525	2,205	315
Pigs	6.2	1.2–6.0	20–35	28	65	148.8	1,302	96.7
Poultry	243.7	7.5 (×100 animal place per year)	130–270	140	64	2379	4,941	1522.6

Source: State Statistics Service of Ukraine

**Table 5** Top 10 biogas complexes in the world

Country	Stage of operation	Power, MW	Raw materials for biogas production
Mexico (Mexico City)	under construction	115	food wastes
United States (Warsaw)	has been in operation since 2017	35	pig manure and food waste
Brazil (Kairos)	has been in operation since 2016	29.5	food waste
Denmark (Corskro)	under construction	26	livestock waste
Germany (Gustrow)	has been operating since 2010	22	corn silage (80%), straw, cereals (substandard)
Germany (Penkun)	has been operating since 2007	20	corn silage (80%), liquid manure
Germany (Schwedt)	under construction	16.5	Straw
Ukraine (Teofipol)	has been in operation since 2017	15.6	pulp, manure, corn silage
Sweden (Iordberg)	has been in operation since 2015	15	beet buds, substandard corn and beets, radish, mustard
Ukraine (Hlobyno)	has been in operation since 2014	14	beet pulp, manure, crop residues, soy hydrofuse

Source: the table created by the author according to the Bioenergy Association of Ukraine

**Table 6** Biogas stations of Ukraine producing electricity at green tariff in 2018

Enterprise	Area	Installed capacity, MW	Electricity generation in 2018 million kWh
"Latex" Enterprise	Transcarpathian	0.6	0.782
"Goodwell Ukraine Ltd"	Ivano-Frankivsk	1.166	6.642
"Ecoprod LLC"	Donetsk	1.487	6.703
"Rokytne Sugar Factory LLC"	Kyiv	2.382	11.650
LLC "Horodyshe-Pustovariv Agrarian Company"	Chernihiv	2.406	2.304
"Commerzstroyplast LLC"	Kherson	3.12	11.134
"Theophipol Energy Company"	Khmelnyskyi	5.109	31.672
"Oril-Leader LLC"	Dnipropetrovsk	5.692	42.239

Source: the table created by the author according to the Bioenergy Association of Ukraine.

**Table 7** Stimulating the development of biogas production in EU countries

Incentive	Ukraine	EU countries
Cheap loans for the construction of biogas plants	<ul style="list-style-type: none"> <li>foreign currency bank loans for the construction of biogas stations are mainly domestic banks lending at high interest rates (over 20% per annum)</li> </ul>	<ul style="list-style-type: none"> <li>in most European countries, farms set up biogas plants with a capacity of 50–100 kW, which is profitable and is a mass phenomenon, as the average interest rate on loans to biogas and biomethane plants is 0.5% per annum. But locally, it can be installed below</li> <li>in European countries, there is a green tariff for electricity from biogas, set in a differentiated form – the highest tariff is issued for low-power installations</li> <li>GERMANY – a green tariff for electricity from biogas in the amount of 0.134–0.237 euros per 1 kW/h</li> <li>AUSTRIA – a green tariff for electricity from biogas of € 0.156–0.186 per 1 kW/h</li> <li>FRANCE – a green tariff for electricity from biogas – € 0.15–0.175 per 1 kWh</li> <li>In GERMANY there is a technological bonus of € 0.03 per 1 kW/h if biogas is purified</li> <li>AUSTRIA technological bonus is € 0.02 per 1 kW/h</li> <li>ITALY – biomethane premium to the market price for natural gas of EUR 0.796 per cubic meter</li> <li>DENMARK – Biomethane premium to the market price for natural gas of EUR 0.735 per cubic meter</li> <li>UK – market price premium for electricity (EUR 0.1–0.116 per 1 kWh) and biomethane premium (EUR 0.56 per 1 cubic meter)</li> <li>FRANCE – a green tariff for electricity from biogas – EUR 0.15–0.175 per 1 kWh, biomethane tariff for agricultural enterprises – EUR 0.85–1.25 per 1 cu. m</li> <li>THE NETHERLANDS – five tariff categories for biomethane – from EUR 0.483 to EUR 1.035 per 1 cubic meter</li> </ul>
High green tariff for the sale of electricity produced from biogas	<ul style="list-style-type: none"> <li>in Ukraine, the lowest green tariff is not divided depending on the capacity of the plant</li> <li>in Ukraine, the green tariff for electricity from biogas is 12.38 euro cents/kWh. From January 1, 2020, according to the legislation, it is expected to decrease by 10%, and from January 1, 2025 – by another 10%</li> </ul>	
Premiums for selling biomethane (i.e. purified biogas) to low pressure distribution networks.	<ul style="list-style-type: none"> <li>there are no premiums in Ukraine for the sale of purified biogas</li> </ul>	

Source: the table created by the author according to the Bioenergy Association of Ukraine

Modern European agriculture and biogas technologies have already become inseparable concepts. According to estimates of the European Biogas Association, about 50% of European farms have biogas plants installed. In Germany, there are about 10,000 farmer biogas plants of varying capacity. The share of biogas in primary energy supply in Denmark has already reached 22% – in fact, the country has come close to replacing natural gas with biogas.

In 2016, more than 30 million small and medium-sized biogas stations using animal waste were used in China, and 10 million in India. Small family facilities are widely used in Nepal, Vietnam, and Japan. In Italy, from 1,591, the existing 1,466 biogas stations are located on farms and use livestock waste. Of the 301 biostations in Poland, 75 use cow and pig manure. The same trend is observed in the largest biogas complexes in the world.

Overall, in the EU, biomass receives 14% of the total energy requirement annually. The European market for biogas plants is estimated at \$ 3 billion, and is projected to grow to \$ 25 billion by 2020, with 75% of biogas coming from agricultural waste, 17% from organic waste from private households and another 8% from sewage treatment plants.

Ukraine's biogas sector remains underdeveloped due to a number of factors. In Ukraine, the share of bioenergy is about 3%, but potentially "green" electricity can satisfy all the needs of the population. In April 2018, the total capacity of domestic biogas plants, according to the Bioenergy Association of Ukraine, reached only 40.6 MW. At the same time, about a half of the biogas capacity falls on stations installed on landfills of solid household waste, that is, urban landfills. The agro-industrial complex and the food industry have about 20 MW of capacity (Table 7). And this all is despite the fact that already at the expense of biogas technologies, agricultural enterprises can replace about 3.2–4.6 billion cubic meters of natural gas per year, which fully covers the needs of Ukrainian agriculture (Bioenergy Association of Ukraine).

In order to address the environmental and social issues of intensive livestock farming, Ukraine needs to approximate its legal framework to the EU law, drawing on the experience of the EU Member States. The EU experience shows that in most European countries, farms install biogas plants with a capacity of 50–100 kW, which is profitable and is a widespread phenomenon. The reason for this paradox is very simple – it is the level of stimulation of the biogas direction (Table 7).

## Conclusions

There is no doubt in benefits of biogas technologies, as it is evidenced by their rapid development in the world. Similarly, such technologies should be implemented in Ukraine. For Ukraine, this is a relatively new trend that is gaining popularity among local economies, considering its prospects. Modern technologies make it possible to turn biogas production into a profitable business.

For this purpose, it is necessary to remove barriers at the legislative level, in the field of permitting documentation, to make a transparent and unambiguous mechanism for obtaining tax benefits when importing equipment for renewable energy projects and for intensifying support from the state.

Biogas production in agricultural enterprises will solve a number of problems and prospects for agricultural production:

- new opportunities are created for agricultural enterprises to obtain additional cash income;
- food and energy security of the state is ensured;
- reducing the farmers' dependence on fuel imports;

- solve social problems in rural areas by creating new jobs and preserving existing ones;
- reduce pollution of the environment by hazardous substances, including waste from livestock farms.

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