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The Empirical Research of the Potential, Awareness, and Current State of Agricultural Waste Use to Ensure Energy Autonomy of Agricultural Enterprises of Ukraine

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Abstract:

Today, the issues of waste management are complex, because they relate to various aspects – resource conservation, environmental safety of mankind, ensuring competitiveness at micro, macro and mega-levels. The study is devoted to the analysis of the potential, awareness and current state of use of agricultural waste to ensure energy autonomy of agricultural enterprises of Ukraine on the basis of the experimental study, conducted by the authors using a mixed method. The main tool in the study was the survey developed by the authors, which was filled out by the owners of agricultural enterprises in Ukraine. The development of the survey was accompanied by the authors' hypotheses regarding the need for energy autonomy of agrarian enterprises; main sources of information on opportunities and state support for energy use of waste; potential and current state of bioproduction in agrarian formations. Authors acknowledged that both the crop and livestock industries lead to the generation of waste that has the potential to produce biofuels (solid – pellets, briquettes; gaseous – biogas). The study confirmed that the costs for providing agrarian enterprises themselves with fuel and energy resources in Ukraine are quite high, and the bioenergy potential of waste to replace traditional energy resources is practically not used. Further studies will cover a range of questions regarding the extension of the geography of the survey to the whole territory of Ukraine, the specification of hypotheses based on the preliminary questionnaire, the hypothesis testing and the correlation between different indicators of the agrarian waste potential for biofuel production and the efficiency of substitution of traditional energy with biofuels.

Keywords: agricultural waste; potential; energy autonomy; biofuels; agricultural enterprise; survey.

JEL Classification: C12; C35; C23; Q12; Q13; Q16; Q18; Q2; Q21.

Introduction

Crops generate a significant amount of waste that is increasing globally. These wastes indicate not only a loss of resources, but also a missed opportunity to increase the income of agricultural enterprises (Devi *et al.* 2017).

Directions and methods of using waste products from crop production are being researched by scientists all over the world in such fields as textile composites, electricity production, biogas production, animal feed production, compost and lean manure production. The growing demand for bioenergy cogeneration plants, an increase in demand for animal feed and the growing trend of organic farming indicate a competitive possibility of using crop waste in agriculture. It should be noted that the use of crop waste is a complex technological process, with high complexity of measuring economic efficiency. For example, straw can be used as bedding for animals, and then as fertilizer. Given this, the main goal of this study was to determine the most common ways of using livestock waste by the enterprises studied to develop the goals of the marketing policy of agricultural enterprises for the production of biofuels.

1. Literature Review

The development of crises in the energy sector, climate change and the growth of carbon dioxide emissions from the use of fossil fuels are of great concern to the world community and encourage the search for energy sources with low carbon content (International Energy Agency 2020).

As a result of the development of the biofuel market, changes lead to the fact that the business environment is characterized by an unprecedented level of diversity, wealth of knowledge and turbulence (Polonsky 2001). There is a need to modify production systems and models based on new technologies. Technological development has turned the world into a market without borders. In other words, technological development has created global competition for participation in which a clear and integrated marketing policy is required for the interaction of entities in value and supply chains (Center for Profitable Agriculture 2007).

Zulauf *et al.* (2018) emphasize that in the context of determining sustainable development goals for Ukraine and the obligation to provide 11.5% of biomass-based energy production by 2035, a change in Ukraine's course in the export of raw materials to biofuel production will attract land, which now not processed for production, and increase productivity.

A significant contribution to the development of the theory and practice of biofuel production and consumption in Ukraine has been made by scientists at Vinnitsa National Agrarian University. Kaletnik (2018), Kaletnik and Lutkovska (2020) emphasizes that small part of biofuels is available on international markets, since most of it is consumed in domestic markets. However, biofuel trade is expected to grow rapidly, as many countries do not have domestic capacity to meet the needs of domestic demand. One of the key findings is that governments need to create the conditions for production growth and trade development in this area. Kaletnik *et al.* (2019) also note that the dynamic production of biofuels requires the creation of a market for energy crops (feedstock for its production), and the use of agricultural land. In this case, it is necessary to maintain a stable level of production of agricultural food products.

Berezyuk *et al.* (2019) note that in the context of an increasing number of changes and an increase in the complexity of the market environment in the process of developing the biofuel market, the issues of ensuring the conformity of the internal and external environment of the enterprise become urgent. In this context, particular attention is paid to agricultural enterprises as subjects of one of the leading sectors of the national economy, which is the source of feedstock and ready goods in the biofuels sector (Pryshliak *et al.* 2019). Now an important theoretical and methodological task is to resolve issues on the rationale for the formation of the marketing policy of agricultural enterprises for the production of biofuels.

This topic is widely explored by other Ukrainian scientists. In particular, Geletukha & Kramar (2016) consider the problematic aspects that accompany the production and consumption of certain types of biofuels: physicochemical properties, production of feedstock, external factors such as global demand and profitability production. In particular, in this study, highlights problems in the field of logistics, access to resources, ensuring investment attractiveness, a study of market development trends etc. A significant contribution in calculating the economic and energy efficiency of biomass production, as well as the output of solid biofuel, its energy intensity and energy output was made by Kulyk *et al.* (2020).

Tormosov *et al.* (2015) in their study disclose the technical, legal, organizational, environmental, financial, economic and social aspects of replacing non-renewable energy sources with biofuel in municipal heat power engineering. In particular, the paper considers topical issues of creating a resource and logistics infrastructure for projects using biofuels in central heating systems.

Tokarchuk (2016) investigated investment support of biofuel production, with major attention in participation in numerous European programs of concessional lending. The basic of the programs, which operate in Ukraine and can be used by agrarian enterprises while production of biogas at favorable terms are analyzed.

In previous research of the authors (Pryshliak and Tokarchuk 2020) was found that the production of biofuels from agricultural waste will have social, economic and environmental effects. Using the SWOT method of analysis, factors that will affect the development of biofuel production from agricultural waste were determined. It was justified by the authors (Tokarchuk et al., 2020) that the use of biogas is one of the ways to supplement and partially replace traditional fuels in rural areas and solve ecological problems. The feasibility of farms energy supply from their own energy source and the need to reduce harmful emissions into the environment make the biogas plant an indispensable element of modern livestock complexes.

Based on the urgency of development of bioproduction in Ukraine marketing study of the potential, awareness and current status of the use of agricultural waste to ensure the energy autonomy of agricultural enterprises is of great importance. Such a study will allow us to assess the prospects of bioenergy in Ukraine and to give the development of the concept of the potential for production and use of biofuels in Ukraine.

2. The Aim and Objectives of the Study

This study is devoted to an experiment to determine the potential, awareness and current status of the use of agricultural waste to ensure energy autonomy of agricultural enterprises in Ukraine. This study was carried out as part of the scientific work of young scientists: "Development of a new concept for the use of agricultural waste to ensure the energy autonomy of agricultural enterprises" 2019-2021, which is carried out at the expense of the General Fund of the State Budget of Ukraine (011U100786) according to the orders of the Ministry of Education and Science of Ukraine No. 1439 dated 12/22/2019 and No. 96 dated 01/31/2019.

To achieve the goal, the following objectives were set:

- to form hypotheses for characterizing the potential, awareness and current state of agricultural waste management;
- to develop a questionnaire for conducting a survey within the experimental group of heads of agricultural enterprises;
- to conduct a survey of heads of agricultural enterprises;
- to check the validity of hypotheses, hypothesis adjustments and planning for further studies.

3. Methodology

To determine the goals of marketing policy, the potential and current status of the use of agricultural waste to ensure energy autonomy of agricultural enterprises, the Mixed Method Research (MMR) was used based on questionnaires and statistical processing of the results using correlation analysis, as well as content analysis of the obtained data.

The mixed method of scientific research is a growing area of scientific methodology used by many scientists and researchers from different fields of knowledge (Tashakkori and Teddlie 2010).

The definition of MMR is now a debatable issue. Johnson *et al.* (2007) in their study showed that the definition of MMR was diverse and differentiated in terms of what exactly is being mixed (mixed), the definition of the stage in the research process, where exactly is mixing, the scale of the combination of methods (mixing), the purpose of the combination (mixing) and the sequence of the study. As a result, for this work, we settled on determining what is used by recognized methodologists in the field of MMR.

Journal of Mixed Methods Research (JMMR) defines mixed methods and research in which the researcher collects, analyses, mixes and formulates conclusions based on quantitative and qualitative data in one study or in one research program. A more comprehensive definition is provided by Creswell and Plano Clark (2007), who define a mixed method as a research project with philosophical assumptions. As a methodology, it provides philosophical assumptions that govern the direction of data collection and analysis and the mixing of qualitative and quantitative data in one study or series of studies. Its main premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of the research problem.

Teddlie and Tashakkori (2010) define the MMR methodology a broader research logic, manage the selection of specific methods, and is based on conceptual positions that are common to practitioners of mixed methods.

According to a study social and behavioral sciences specialists (Alise and Teddlie 2010; Mertens 2011), 77% of all sociological studies were conducted as part of a quantitative approach. Of these, 71% are correlation studies or studies devoted to the study of the links between social phenomena. The simplest type of correlation research is the study of pair relationships or the joint variability of two variables. Such studies are suitable for solving two scientific problems:

- evidence of the existence of causality between variables (the presence of a relationship is an important, but not the only, condition for a causality);
- prediction: when there is a relationship between variables, we can predict the value of one variable with a certain degree of accuracy, if we know the value of another.

Paired bonds have three important characteristics: strength, direction, and shape (Bazeley 2010).

Strength shows how consistent is the variability of the two variables. Strength can vary from 0 to +1 (if at least one of the variables refers to the nominal scale) or from -1 to +1 (if both variables belong to the ordinal scale). Moreover, 0 and values close to it indicate the absence of a relationship between the variables, and values close to 1 (direct connection) or -1 (feedback) indicate a strong connection. The strength of the bond is determined using correlation coefficients. Correlation coefficients include, for example, Phi and V-Cramer (nominal variables, few categories / tabular view), Gamma (ordinal variables, few categories / tabular view), Kendall and Spearman (ordinal variables, many categories), Pearson (metric variables, many categories) (Cameron 2011).

The direction indicates the nature of the mutual change in the categories of variables. If with increasing values of one variable the values of another variable also increase, then the connection is direct (or positive). If the situation is the opposite and an increase in the values of one variable leads to a decrease in the values of the second, then the relationship is inverse (or negative). The direction of connection can take place only in those cases when it comes to ordinal and / or metric variables (variables whose values can be ordered from smaller to larger or vice versa). Thus, if at least one variable refers to the nominal scale, then we can only talk about the strength of communication and its shape, but not about the direction. The direction of communication can be determined either using contingency tables (few categories), using a scatter chart (many categories), or using the sign of the correlation coefficient (the number of categories of variables does not matter) (Cameron and Molina-Azorin 2011).

The form of communication indicates the peculiarities of the joint variability of two variables. Depending on which scale a variable belongs to, the form of communication can be analyzed either using a bar chart / contingency table (if at least one variable is nominal) or using a scatter chart (for ordinal and metric scales) (Morse 2010).

The method of collecting primary information (questionnaire using open and closed questions of the choice of answer options from the above) was used to conduct the study. Type of questionnaire - online questionnaire. Methods of processing the received data: grouping; paired and multiple regression analysis with the calculation of the correlation coefficient and its significance, with the calculation of the elasticity coefficient (estimate of bond strength), with the calculation of β -coefficient (estimate of bond strength); Content Analysis

The survey was conducted by filling in an electronic form on the Survio resource. When forming the sample of enterprises for the survey, we proceeded from the natural and economic conditions of Ukraine. The territory of the state is divided into South, North, Center, West and East. Each part has specific natural and climatic conditions and differs in the specialization of agricultural enterprises. Most agricultural formations are concentrated in the South, East and Center, so two companies from each region were interviewed. Instead, one company from the North and the West took part in the survey. This sample is not fully representative, but will test the main hypotheses of the study to improve the questionnaire and conduct a broader study. For the implementation of the survey, a direct link to the questionnaire was sent to the email addresses of agricultural enterprises. This allowed us to collect data in experimental groups of representatives of agricultural enterprises of different sizes and forms of ownership.

The duration of the survey was 134 days (from 05/28/2019 to 08/10/2019). Answers received – 8. Total number of visits to the questionnaire – 75. The total share of the occupancy of the questionnaire among the visitors is 10.7%. 75% of respondents spent 10 to 30 minutes completing the questionnaire.

Structure of the survey.

The survey contains the title (“Analysis of the potential, awareness and current status of the use of agricultural waste to ensure the energy autonomy of agricultural enterprises”), an appeal and 53 questions, divided into 5 substantive blocks:

- (1) “General unit” – for setting the name and location of the enterprise; questions for collecting information about the head of the enterprise (age, gender, education, duration of work in the agricultural sector, duration of work in a managerial position); questions for collecting information about the economic activities of the enterprise;

▪ (2) “Awareness in the field of production and use of biofuels” - intended to establish the fact of knowledge about the Law of Ukraine "On alternative fuels", "green" tariff, the possibility of exemption from import duties and VAT in the production of biofuels, exemption from taxation of profits on the sale of biofuels; about types biofuels, opportunities for their production by agricultural enterprises, opportunities for obtaining credits on preferential terms and sources for obtaining information on various aspects of production, use and sale of biofuels;

▪ (3) “Potential of the enterprise for the production and use of biofuels” – intended to establish the fact of growing crop and livestock products by agricultural enterprises; the types of waste generated in the course of economic activity of the agricultural enterprise; directions of waste use, as well as to establish the presence of subjects of innovation creation, intellectual property for biofuel production and free funds for investment in innovations in the agricultural enterprises;

▪ (4) “Introduction of biofuel production and use by the enterprise” – intended to establish the state of the introduction of biofuel production in the agricultural enterprise, straw bale its further burning technologies, production of solid biofuel, anaerobic digestion of waste technology with biogas production;

▪ (5) “Readiness of the enterprise for the production and use of biofuels” – designed to establish the state of readiness of the agricultural enterprise to invest in biofuel production, cooperation with subjects of biofuel production organization, the conclusion of business agreements, license agreements, advanced training of employees in the field of bioenergy.

Hypothesize.

1. Agricultural enterprises spend significant funds on the purchase of fuel and energy resources, and affect the cost of final products.

2. Agricultural enterprises have significant potential for crop wastes and livestock by-products for biofuel production.

3. The bioenergy potential of agricultural enterprises is represented by the raw material component (waste that can be used for biofuel production).

4. The available feedstock bioenergy potential is practically not used.

5. The level of awareness of waste-based biofuels is low; it is a bit higher among managers under the age of 45 years and higher education.

6. The main source of information on the possibilities of energy use of waste is media.

7. Company managers practically do not have information on state support for bioproduction (legislative acts, support programs, tax and other benefits, “green” tariff, the possibility of using credit support from international financial organizations).

Table 1. Correspondence of the hypotheses set in the survey

Hypothesis	Questions that fits the hypothesis	Answers to support the hypothesis	Answers that refute the hypothesis	Signal responses
1	22	3,4	1,2	
	18	2,3		1
2	32	1	2	
	38	1	2	
3	33	1-7		8
	39	1-6		7
4	34	6		1-5
	35	6		1-5
	36	6		1-5
	37	5		1-4
5	40	3,4		1,2
	27	2	1	
	28	2	1	
6	29	2	1	
	30	3		1,2,4-7
7	23	2	1	
	24	2	1	
	25	2	1	
	26	2	1	

Source: composed by the authors

Base for hypothesis testing.

To confirm the hypotheses put forward, the questionnaire includes answers to which can serve as the basis for the formation of a clear understanding of the state of the problem under study and can confirm or refute this hypothesis. Also, some questions that correspond to the presented hypotheses contain signal answers, the choice of which by the managers of the studied agricultural enterprises indicates the need for further research in a certain direction. Correspondence of hypotheses to the questions posed in the questionnaire is given in Table 1.

4. Results of the Research

To test the set hypotheses, primary information was collected in the form of a questionnaire survey of enterprise managers (Table 2).

Table 2. The list of enterprises in which primary information was collected

№ 3/п	Name of the Company	Type of ownership	The main activity according to the Classifier of Economic Activities
1	2	3	4
1	Enterprise 1	Private enterprise	01.30.0 Mixed farming
2	LLC "Kurland"	Limited Liability Company (LLC)	01.11 Growing of cereals (except rice), legumes and oilseeds
3	LLC "Ukraine"	Limited Liability Company (LLC)	01.30.0 Mixed farming
4	Enterprise 4	Private enterprise (PE)	01.11 Growing of cereals (except rice), legumes and oilseeds
5	PAE "Podilla Agro"	Private agricultural enterprise (PAE)	01.11 Growing of cereals (except rice), legumes and oilseeds
6	PE "Golden ear"	Private enterprise (PE)	01.11 Growing of cereals (except rice), legumes and oilseeds
7	ALLC "Russia"	Agricultural Limited Liability Company (ALLC)	01.30.0 Mixed farming
8	PAE "Ukraine"	Private agricultural enterprise (PAE)	01.11 Growing of cereals (except rice), legumes and oilseeds

Source: developed by the authors

According to the results of the study, it was found that 88% of the studied enterprises carry out the cultivation of grain, legumes and seeds, and 12% carry out mixed agricultural activities.

Representatives of all the surveyed enterprises that completed the questionnaire are men. 37.5% of the managers of the studied enterprises have basic higher education (technical school, college; bachelor) and 62.5% have full higher education. None of the questioned managers of the enterprises have a degree. According to the survey, 37.5% of the managers of the studied enterprises have experience in the agricultural sector up to 2 years, 12.5% - from 2 to 5 years, 25% - from 5 to 10 years, 25% over 10 years. At the same time, 37.5% of the managers of the enterprises surveyed have experience in managing the company for up to 2 years, 25% from 2 to 5 years and from 5 to 10 years, 12.5% for more than 10 years. 37.5% of the surveyed enterprises have an area of agricultural land up to 500 ha, 37.5% - from 500 ha to 5000 ha, 25% - more than 5000 ha. 37.5% of the surveyed enterprises have an average annual number of employees up to 10 people, 25% - from 10 to 50 people, 37.5% from 50 to 250 people. 25% of the surveyed enterprises spend on energy materials up to 15% of their costs, 75% of the surveyed enterprises share of these costs ranges from 15% to 25%. All surveyed enterprises generate plant wastes (Table 3).

Table 3. Types of plant waste at the studied enterprises

Type of waste	Share of enterprises producing this type of waste, %
Cereal and rapeseed straw	100
Corn waste (stems, cobs)	75
Sunflower waste (stems, baskets)	75
Sugar beet waste	12,5
Legumes waste	50
Garden pruning waste	12,5
Waste of berry crops	0

Source: developed by the authors

Thus, all the studied enterprises create waste from crop production of grain straw and rape. Also, 75% of all the studied enterprises produce corn waste (stalks, heads of cabbage) and sunflower waste (stalks, baskets). Half of the surveyed enterprises produce legumes and one out of every four enterprises produces sugar beet and garden pruning waste.

Also, 37.5% of the surveyed enterprises generate animal waste, the types of which are presented in Table 4.

Table 4. Types of animal waste at the surveyed enterprises

Types of waste	Part of enterprises creating particular type of waste, %
Cattle manure	25
Pig manure	25
Sheep manure	12,5
Goat manure	12,5
Manure of rabbits, nutria and other small animals	0
Bird droppings	37,5
Others	37,5

Source: developed by the authors

The data obtained as a result of the study on the production of livestock and crop waste by agricultural enterprises indicates their high level of involvement in the creation of these types of waste. 62.5% of managers of the surveyed enterprises report knowledge of the benefits of different types of biofuels. 75% of the managers of the surveyed enterprises know about the possibilities of agricultural enterprises in the production of biofuels.

At the same time, only 75% of the managers of the surveyed enterprises declare knowledge of the Law of Ukraine "On Alternative Fuels" (No. 1391-VI of 21.05.2009). Only 50% of the managers of the surveyed enterprises know about stimulating the use of renewable energy and alternative fuels in the form of tax exemption on profits from the sale of biofuels and profits from activities for the simultaneous production of electric and thermal energy and the production of thermal energy using biological species fuel. Only 25% of the managers of the studied enterprises reported having information on the possibility of obtaining loans on concessional terms for organizing the production of biofuels from international financial organizations.

It should be noted that 50% of the managers of the studied enterprises recognized universities as the most popular source of information on biofuels, 25% of the managers of the studied enterprises received information on biofuels from friends / colleagues, and 12.5% of the managers of the studied enterprises received information about biofuels from the media and websites, bioenergy associations and / or manufacturers of bioenergy equipment.

Table 5. The results of pairwise regression of awareness indicators in the field of biofuel production and the choice of a source of biofuel information

Biofuel Awareness Indicator	Correlation coefficient	The coefficient of elasticity	Strength of communication	Direction of communication
Knowledge of the Law of Ukraine "On alternative fuels"	0,386	0,283	Moderate	Direct
Knowledge of the "green" tariff	0,555	0,385	Noticeable	Direct
Knowledge about the possibility of exemption from import duties and VAT when importing biofuel production equipment	0,357	0,263	Moderate	Direct
Knowledge of the possibility of tax exemption	0,342	0,247	Moderate	Direct
Knowledge of biofuels and their benefits	0,357	0,263	Moderate	Direct
Knowledge of biofuel production opportunities for agricultural enterprises	0,482	0,353	Moderate	Direct
Knowledge of biofuel waste production opportunities for agricultural enterprises	0,482	0,353	Moderate	Direct
Knowledge about the possibility of obtaining credits on preferential terms for the organization of biofuel production from international financial institutions	0,64	0,424	Noticeable	Direct

Source: developed by the authors

The results described above allow us to characterize the state of awareness in the production and use of biofuels among the leaders of the studied agricultural enterprises.

To establish a relationship between the use of sources of information on biofuels and the awareness of heads of agricultural enterprises in the production and use of biofuels, a correlation analysis was carried out based on the pair regression equation using a graphical method, the results of which are presented in table 5.

The data in table 5 indicate the existence of a direct relationship between the source of information and knowledge in the production and use of biofuels in the studied agricultural enterprises. At the same time, there is a noticeable correlation between knowledge about the "green" tariff and knowledge about the possibility of obtaining credits on preferential terms for the organization of biofuel production from international financial institutions and sources of information on biofuels. It can be concluded that most of the representatives of the studied enterprises have knowledge of the "green" tariff and obtaining loans that were acquired at the university. The remaining information is obtained through communication with colleagues, through the media and through specialized sites.

The growth of high-intensity, unsustainable agriculture or short-term management of natural resources leads, among other consequences, to an increase in waste production in areas of highest concentration of production (Rechcigl and MacKinnon 1997).

According to the results of the survey, 87.5% of the studied agricultural enterprises use grain straw for plowing, 25% use grain straw for bedding, 12.5% use grain straw for bale and 12.5% - for the production of briquettes and pellets. The waste of sunflower and corn of the studied agricultural enterprises is used for plowing (75%), for the production of briquettes and pellets (25%), for burning in the fields (12.5%) and as litter (12.5%). 62.5% of the studied agricultural enterprises use legume waste for plowing, 12.5% use legume waste for burning in the fields, for bale and burning in boilers and for the production of briquettes and pellets. 37.5% of the studied agricultural enterprises use garden trimmings for burning locally and for burning in boilers, 12.5% - for the production of briquettes and pellets and for other purposes (without determining the method of use). 62.5% of the agricultural enterprises that produce animal by-products use manure for spreading in the fields, 37% - for storage in piles with subsequent use as fertilizer, 37% - for other purposes (without determining the method of use). In order to improve the quality of analysis, it is planned to specify the ways of using waste generated by agricultural enterprises in further studies.

Among the surveyed managers of the agricultural enterprises 57.1% reported their readiness to invest in innovations and 25% reported having a specialized innovation department or a person responsible for innovation.

None of managers of the surveyed agricultural enterprises reported the availability of intellectual property in biofuel production. This makes it impossible to study the relationship between the presence of intellectual property in the production of biofuels in the studied agricultural enterprises with other indicators of potential regarding the production and use of biofuels. This lack of research can be eliminated in further researches by expanding the statistical base and changing the selection of the surveyed agricultural enterprises.

The results described above allow characterizing existing potential of the studied agricultural enterprises for the production and use of biofuels.

To establish a connection between the willingness of the managers of the studied agricultural enterprises to invest in innovation and the potential for the production and use of biofuels by these enterprises, we carried out a correlation analysis based on the pair regression equation using the graphical method, the results of which are presented in table 6.

Table 6. The results of pairwise regression of potential indicators regarding the production and use of biofuels and willingness to invest in innovation

Indicator of Potential for Biofuel Production and Use	Correlation coefficient	The coefficient of elasticity	Strength of communication	Direction of communication
The number of ways to use cereal straw at the enterprise	0,677	0,639	Noticeable	Direct
Number of ways to use sunflower waste at the enterprise	0,81	0,769	High	Direct
Number of ways to use legumes waste at the enterprise	0,531	0,487	Noticeable	Direct
Number of ways to use garden scraps at the enterprise	0,531	0,487	Noticeable	Direct
The number of ways to use animal manure at the enterprise	0,307	0,121	Moderate	Direct

Source: developed by the authors

To correlate the availability of an innovative department in the surveyed agricultural enterprises and the potential for biofuel production and use of these enterprises, we performed a correlation analysis based on the pairwise regression equation using the graphical method, the results of which are presented in Table 7.

Table 7. The results of pairwise regression of potential indicators regarding the production and use of biofuels and the presence of an innovation department at the enterprise

Indicator of Potential for Biofuel Production and Use	Correlation coefficient	The coefficient of elasticity	Strength of communication	Direction of communication
The number of ways to use cereal straw at the enterprise	0,821	0,738	High	Direct
Number of ways to use sunflower waste at the enterprise	0,593	0,536	Noticeable	Direct
Number of ways to use legumes waste at the enterprise	0,6	0,524	Noticeable	Direct
Number of ways to use garden scraps at the enterprise	0,6	0,524	Noticeable	Direct
The number of ways to use animal manure at the enterprise	0,491	0,184	Moderate	Direct

Source: developed by the authors

The data in Table 6 indicate that there is a direct correlation between the willingness of agricultural managers to invest in innovation and indicators of the potential for biofuel production and use. However, the number of ways to use cereal straw, legume waste, garden trimmings, animal manure has a noticeable direct connection with the agricultural enterprise manager's willingness to invest in innovation. A high communication strength occurs between the readiness of the head of an agricultural enterprise to invest in innovations and the methods of using sunflower waste at the enterprise. There is also a clear direct correlation between indicators of potential for biofuel production and use and the presence of an innovation department in an agricultural enterprise. A high strength of communication was established between the presence of the innovation department at the agricultural enterprise and the methods of using grain straw at the enterprise. The obtained results require further research in the direction of a deeper determination of the types of activities of the enterprises under study and their grouping in the process of analysis by types of economic activity. This will allow us to establish more specific communications between innovative activities and ways of using the generated waste.

According to the results of the survey, none of the surveyed managers confirmed that biofuel production was introduced at his agricultural enterprise. Moreover, 50% of the studied agricultural enterprises carry out straw bales with their subsequent burning in boilers. Solid biofuels are produced in 12.5% of the studied agricultural enterprises. None of the surveyed agricultural enterprises carries out anaerobic digestion of biogas waste.

In order to establish a connection between the willingness of the managers of the studied agricultural enterprises to invest in innovations and their production and use of biofuels, we carried out a correlation analysis based on the pair regression equation using the graphical method, the results of which are presented in table 8.

Table 8. The results of pairwise regression of indicators of introduction the production and use of biofuel by agricultural enterprises and readiness to invest in innovations

Indicator of Potential for Biofuel Production and Use	Correlation coefficient	The coefficient of elasticity	Strength of communication	Direction of communication
Introduction of biofuel production	0,832	1	High	Direct
Introduction of straw bale technology followed by burning in boilers	0582	0,56	Noticeable	Direct
Introduction of the production of solid biofuels (pellets, briquettes)	0,715	0,799	High	Direct
Introduction of anaerobic digestion technology for biogas production	0,832	1	High	Direct

Source: developed by the authors

To indicate the presence of an innovation department in the studied agricultural enterprises and their production and use of biofuels, we performed a correlation analysis based on the pairwise regression equation using the graphical method, the results of which are presented in Table 9.

The data in Tables 8 and 9 indicate a strong direct connection between the willingness of the managers of the studied agricultural enterprises to invest in innovation and the actual presence of an innovation department or

a person responsible for innovation on the one hand and the introduction of production and use of biofuels by these enterprises on the other.

Table 9. The results of pairwise regression of indicators of production and use of biofuel by agricultural enterprises and the presence of an innovation department

Indicator of Potential for Biofuel Production and Use	Correlation coefficient	The coefficient of elasticity	Strength of communication	Direction of communication
Introduction of biofuel production	0,875	1	High	Direct
Introduction of straw bale technology followed by burning in boilers	0,869	0,796	High	Direct
Introduction of the production of solid biofuels (pellets, briquettes)	0,93	0,989	Very high	Direct
Introduction of anaerobic digestion technology for biogas production	0,875	1	High	Direct

Source: developed by the authors

According to the results of the study, it was found that 75% of the managers of the studied agricultural enterprises are ready to invest in the production of biofuels with guaranteed state support, 12.5% are not ready to invest in the production of biofuels and 12.5% are not ready to give a definite answer. 50% of the managers of the studied agricultural enterprises expressed their willingness to cooperate with state institutions (universities, research stations) on scientific and research support for the organization of biofuel production, and 50% expressed a clear rejection of such cooperation. 62.5% of the managers of the studied agricultural enterprises will not conclude business agreements with research institutes and / or universities for joint solution of the problems of production and use of biofuels; 12.5% are not ready to state the possibility of such cooperation explicitly, but 25% plan to conclude such agreements. 62.5% of the managers of the studied agricultural enterprises do not plan to invest in an upgrading the skills of the employees in the field of bioenergy, and 37.5% will nevertheless take certain measures to increase the level of knowledge and skills of employees in the field of bioenergy.

To correlate the willingness of the heads of the surveyed agricultural enterprises to invest in innovation and their willingness for consumption and production of biofuels, we performed a correlation analysis based on the pairwise regression equation using the graphical method, the results of which are presented in Table 10.

Table 10. Results of pairwise regression of agricultural enterprise willingness for consumption and production of biofuels and willingness to invest in innovation

Indicator of Potential for Biofuel Production and Use	Correlation coefficient	The coefficient of elasticity	Strength of communication	Direction of communication
Willingness to invest in biofuel production	0,68	0,742	Noticeable	Direct
Willingness to cooperate with government agencies on research support in the organization of biofuel production	0,235	0,188	Weak	Direct
Willingness for laying business contracts with research institutes and / or universities	0,531	0,487	Noticeable	Direct
Willingness to conclude licensing agreements with research institutes and / or universities	0,369	0,32	Moderate	Direct
Willingness to invest in advanced training for bioenergy workers	0,508	0,508	Noticeable	Direct

Source: developed by the authors

To correlate the presence of the innovative department in the studied agricultural enterprises and their readiness for biofuel production and use, we performed a correlation analysis based on the pairwise regression equation using the graphical method, the results of which are presented in Table 11.

The data in Tables 10 and 11 indicate that the willingness to invest in innovation by the managers of the surveyed agricultural enterprises is poorly correlated with their willingness for consumption and production of biofuels. At the same time, the already existing department of innovation or the person responsible for innovation activity in the investigated agricultural enterprises can also indicate the readiness of managers to invest in biofuel production, cooperation with state institutions on research support in the organization of biofuel production, to

conclude licensing agreements with research institutes and / or universities, to invest in the training of employees in the field of bioenergy.

Table 11. The results of pairwise regression of indicators of agricultural enterprise willingness for the production and use of biofuels and the presence of an innovation department

Indicator of Potential for Biofuel Production and Use	Correlation coefficient	The coefficient of elasticity	Strength of communication	Direction of communication
Willingness to invest in biofuel production	0,858	0,89	High	Direct
Willingness to cooperate with government agencies on research support in the organization of biofuel production	0,792	0,603	High	Direct
Willingness for laying business contracts with research institutes and / or universities	0,691	0,603	Noticeable	Direct
Willingness to conclude licensing agreements with research institutes and / or universities	0,881	0,725	High	Direct
Willingness to invest in advanced training for bioenergy workers	0,608	0,578	Noticeable	Direct

Source: developed by the authors

Table 12. Justification of the reliability of the hypotheses

Hypothesize	Question	Confirmation answers		Refutation answers		Signal responses		Status
1	22	2,3,4	75%	1	25%			+/-
2	18	2,3	37,5%; 25%			1	37,5%	+/-
	32	1	100%	2	-			
	38	1	37,5%	2	62,5%			
3	33	1-7	100%; 75%; 75%; 12,5%; 50%; 12,5%			8	-	+
	39	1-6	25%; 25%; 12,5%; 12,5%; 0; 37,5%			7	37,5%	
4	34	6	-			1-5	87,5%; 0; 25%; 12,5%; 12,5%; 0	-
	35	6	-			1-5	75%; 12,5%; 12,5%; 0; 25%	
	36	6	12,5%			1-5	62,5%; 12,5%; 0; 12,5%; 0	
	37	5	12,5%			1-4	37,5%; 37,5%; 12,5%; 0	
	40	3,4	0; 37,5%			1,2	62,5%; 37,5%	
5	27	2	37,5%	1	62,5%			-
	28	2	25%	1	75%			
	29	2	25%	1	75%			
6	30	3	12,5%			1,2,4-7	25%; 50%; 0; 0; 12,5%; 0	-
7	23	2	25%	1	75%			-
	24	2	12,5%	1	87,5%			
	25	2	37,5%	1	62,5%			
	26	2	50%	1	50%			
	31	2	75%	1	25%			

Source: developed by the authors

Hypothesis testing.

The analysis, which was made on the basis of the data in Table 1 and the answers received by the managers of the experimental group of agricultural enterprises, made it possible to substantiate the significance of the obtained results and the preconditions for establishing the reliability of the hypotheses (Table 12).

Hypothesis 1 is partially confirmed. 75% of the agricultural enterprises of the experimental group reported spending from 15% to 25% for the purchase of fuel and energy resources. Further research requires an accurate determination of the share of fuels and lubricants, electricity and natural gas in agricultural production costs.

Hypothesis 2 is partially confirmed. According to Tables 3 and 4, agricultural enterprises of the experimental group have significant potential for crop waste and livestock by-products for biofuel production. Further research requires an accurate determination of the area of farmland cultivated by agricultural enterprises.

Hypothesis 3 is confirmed. All agricultural enterprises of the experimental group reported the creation of various crop and livestock wastes as a result of the main activity.

Hypothesis 4 - disproved. The hypothesis regarding specification of the targeted use of waste generated in agricultural enterprises in the field of bioenergy is required to be clarified. Further research requires determining the sources of animal manure at agricultural enterprises (own production, purchase, etc.), as well as sampling with the inclusion of enterprises engaged in the production of livestock products to identify the most common by-products and uses of animal manure.

Hypothesis 5 is disproved. More than 60% of the managers of agricultural enterprises of the experimental group reported knowledge about the types of biofuels and their advantages over traditional fuels, 75% of managers have knowledge about the types of biofuels that can be created in the agricultural sector, as well as which of them can be produced by agricultural enterprises. Further research requires the establishment of the level of existing knowledge and the ability to apply them.

Hypothesis 6 is disproved. Universities (50% of answers) and colleagues (25% of answers) were recognized the main source of information on the possibilities of energy use of waste by managers of agricultural enterprises of the experimental group report. The media was recognized as the main source of knowledge about biofuels only by 12.5% of managers. It is planned to expand the geography of the questionnaire, create a representative sample and re-test the hypothesis in further studies.

Hypothesis 7 is disproved. The vast majority of managers of the experimental group of agricultural enterprises reported possession of information on legislative acts, support programs, "green" tariff, and 25% of surveyed managers also reported knowledge of the possibilities for using credit support of international financial organizations in the field of bioproduction. Further research requires the establishment of the level of existing knowledge and the ability to apply them.

5. Discussion

A variety of production characteristics of biofuels and sustainability factors underline the complexity of the industry, which is faced by both governments and agricultural enterprises. Some links in the field are not adequately covered due to the lack of relevant representative studies. The answers of the managers of the studied enterprises are contradictory regarding the fact that some enterprises actually produce biofuels, but they are not directly informed about this. This may be due to a poor understanding of the managers of the investigated enterprises the processes and technologies related to the production of biofuels. This issue requires further research.

Conclusion

Our experimental study of a group of agricultural enterprises in the Vinnitsa region, Ukraine partially revealed the general sense of potential, awareness and the current state of the use of agricultural waste to ensure the energy autonomy of agricultural enterprises.

It was confirmed that the expenses of agricultural enterprises on fuel and energy resources account for a significant part of the cost of production. There is a need to use the bioenergy potential of waste to ensure partial energy autonomy of agricultural enterprises.

Given the results shown in table 5, we consider it necessary to increase awareness in the production and use of biofuels in such directions:

- to deepen basic higher education (technical school, college; bachelor's degree) and complete higher education in the field of mastering biofuel disciplines by including them in the concepts of educational activities;
- to develop modern educational and methodological support that meets the requirements of the modern business environment to ensure an effective educational process;

- to increase the systematic implementation of the communication process between the heads of agricultural enterprises in the production and use of biofuels;
- to increase the level of information content of appeals distributed by the media in the field of production and use of biofuels and ensure their targeted influence on the heads of agricultural enterprises;
- to ensure systematic work in the field of creation and stable operation of Internet resources devoted to the production and use of biofuels and ensure their targeted impact on the heads of agricultural enterprises;
- to strengthen communications in value chains between the subject in the production and use of biofuels.

Given the results shown in tables 6 and 7, we consider it necessary for agricultural enterprises for ensuring their potential in the field of biofuel production to plan and implement the following activities:

- providing conditions and support in the development of the organizational structure of agricultural enterprises in the direction of creating innovation departments in the production and use of biofuels;
- providing incentives for investment by the heads of agricultural enterprises in the production and use of biofuels;
- special attention is required to ensure training, incentives, and comprehensive support for the creation of agricultural enterprises of intellectual property on the production of biofuels, especially in the use of cereal straw and sunflower waste.

Considering the results shown in table 9, we consider it necessary to take into account the following provisions for supporting and developing the production and use of biofuels by agricultural enterprises:

- the readiness of enterprise managers to invest in innovation can be considered as an important prerequisite for the production and use of biofuels. This requires additional research in determining: a) the definition of special terminology in communication; b) the establishment of the fact of the introduction of biofuel production at a particular enterprise; b) determination of potentially acceptable technologies for the production of biofuels and methods of its use for a particular enterprise;
- the presence at the agricultural enterprise of an innovation department or a person responsible for innovation can be considered as an important prerequisite for the production and use of biofuels;
- support and stimulation of the knowledge and technology transfer in value chains between their actors in the production and consumption of biofuels.
- considering the results shown in Table 10 and 11, we find it important to increase the level of readiness of agricultural companies for the production and use of biofuels based on waste plan and the implementation of the following measures:
 - when detection the readiness of the heads of agricultural enterprises to invest in innovations, to provide explanatory work on the possibilities of production and use of biofuels based on waste in terms of state support for bioproduction and cooperation with the value chain in this area;
 - when establishing the fact of the presence in the agricultural enterprise of an innovation department or a person responsible for innovation, to ensure conditions for realizing the existing potential for the production and use of biofuels.

Further studies plan to expand the geography of the survey, create a representative sample, refine the hypotheses, test them and establish correlations between different indicators of production potential and use of biofuels.

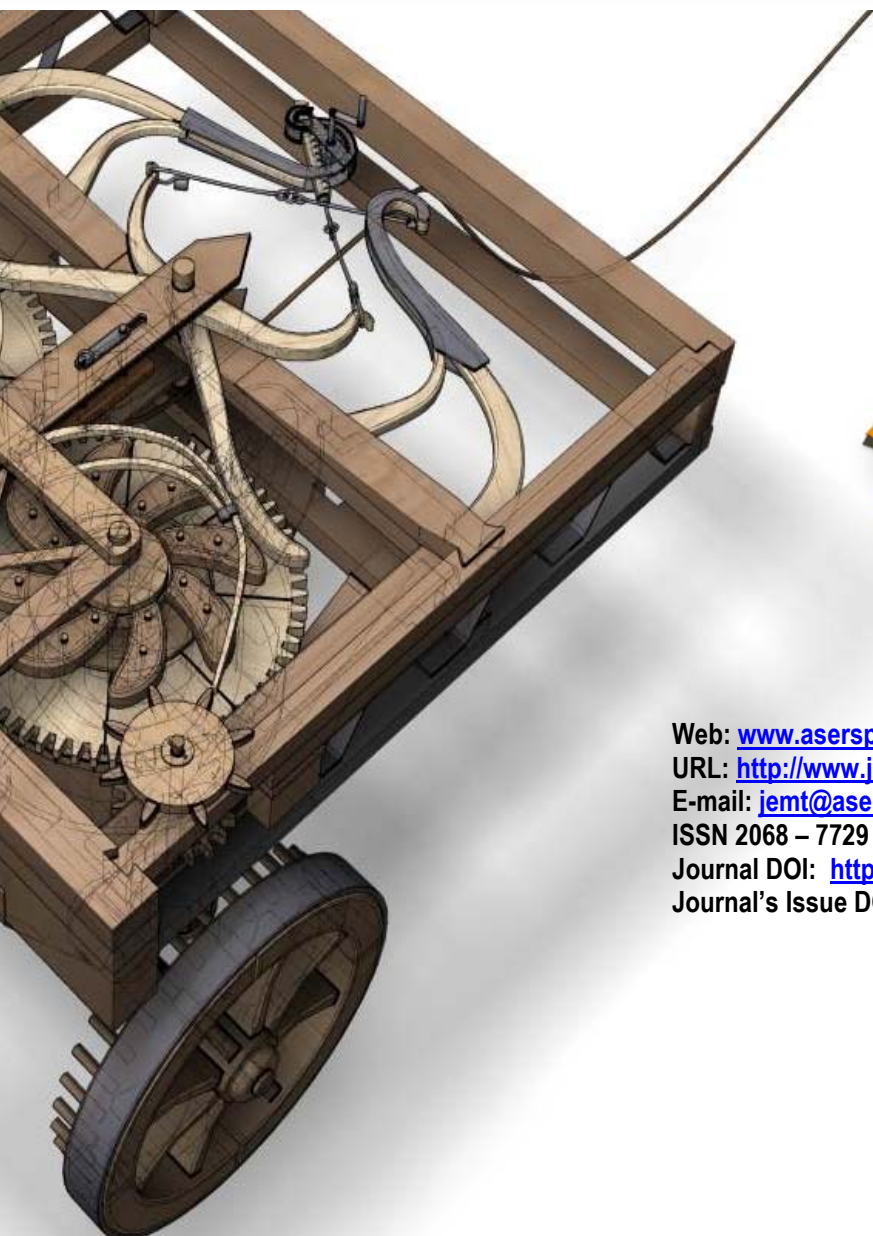
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