Biomining as an Effective Mechanism for Utilizing the Bioenergy Potential of Processing Enterprises in the Agricultural Sector

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Abstract

The article offers a comprehensive overview of global bioenergy, especially biofuel production, and its potential, including different feedstock sources, technological pathways, financing, and trade. The impact on food production, the environment, and land requirements is also discussed. It concludes that increased use of biofuels is inevitable and that international cooperation, regulations, certification mechanisms, and sustainability criteria should be established to address land use and mitigate the environmental impacts of biofuel production. The result of replacing traditional animal feeds with biofuel by-products on the land use of feedstocks is also considered.

Keywords

Bioenergy, economy, agriculture, renewable energy, cryptocurrency, biomining, generating bitcoins, finance.

1. Introduction

Rising prices and the environmental impact of fossil fuels have driven biofuel production to unprecedented levels over the past 15 years. Given the growing need for land for biofuel production, assessing the impact that large-scale biofuel production can have on food and the environment is of considerable importance [1–4].

Agriculture is facing some major interrelated challenges in ensuring food security at a time of increasing pressure from population growth, changing consumption patterns, food preferences, and post-harvest losses. At the same time, there are growing opportunities and demands for the use of biomass to provide additional renewable energy, heat and fuel, pharmaceuticals, and green chemical feedstocks. Biomass from cellulosic bioenergy crops is expected to play a significant role in future energy systems. However, the global potential of bioenergy is limited because all land is multifunctional, land is also needed for food, feed, wood, and fiber production, as well as for nature conservation and climate protection [5–8].

Analysis of recent research and publications. Domestic and foreign scientists are studying the issues of the impact of bioenergy on food, energy, and the environment. In particular, it is worth noting the works of P. Lamers, K. Hamelink, M. Junginger [9], R. Ivanukh, S. Dusanovsky, and E. Bilan [10].

2. Research Results

Natural capitalism can help overcome the deficits of work and hope, security and satisfaction by reversing the interconnected losses of resources, money, and people. Firms that reduce their non-productive tons, liters, and kilowatt-hours can provide more and better jobs for more people. Countries that shift taxation from income to work and from depletion and pollution will need less tax revenue to compensate both families and nature [10, p. 2–4].

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Therefore, the following definition arises, when studying the processing enterprises of the agro-industrial complex, which have biological material—production waste, it can be used properly, considering the term “Bioenergy”.

For a deeper disclosure of the content of the studied concept, it is important to define the categories of “bioenergy” and “potential”. Researchers in different fields of science interpret the term “bioenergy” in different ways. Thus, in the ecological sense, bioenergy is understood as the use of biomass energy (organic matter produced by photosynthesis) [11].

M. V. Dubinina proposes to consider bioenergy as a new sector of the economy that links the solution to the problems of obtaining fuel from biomass and environmental protection [12, p.32].

In the technical sense, bioenergy is considered a branch of energy based on the production of energy sources from biomass through its technical processing.

Bioenergy is the use of energy from biomass (organic matter produced by photosynthesis). “Green fuel” is sometimes referred to as a plant-based fuel, the raw material for which is biomass. However, the more people talk about bioenergy, the more often the term “biofuels” is understood as liquid biofuels (biodiesel, bioethanol, and methanol) and forget about solid and gaseous biofuels, such as biogas, synthesis gas, pyrolysis liquids, agricultural and household waste, and wood residues. It is energy plants grown for energy or fuel that will compete with gas and diesel shortly. They include food plants (wheat and sugar cane) and non-food plants (energy willow, poplar and perennial grasses, rapeseed, soybeans, sunflower, corn, flax, etc.).

Biomass as an energy source can be used in the process of direct combustion of wood, straw, and sapropel (organic bottom sediments), as well as in processed form as liquid (rapeseed oil esters, alcohols) or gaseous (biogas) fuel. The conversion of biomass into energy carriers can take place through physical, chemical, and biological methods; the latter is the most promising.

It can be argued that bioenergy is a choice that has a global perspective for the further successful development of civilization. Overcoming current and preventing future environmental crises is not possible without the use of the latest eco-biotechnologies for wastewater treatment, biosorption of heavy metals from wastewater, neutralization of hazardous gas emissions, oxygen enrichment, use of promising means of solid and liquid industrial waste disposal, biodegradation of pesticides and insecticides, increasing the efficiency of biological remediation of contaminated soils, replacement of several agrochemicals with biotechnological products, etc.

At the moment, while decisions are being made in Ukraine and around the world on strategies for using bioenergy from agricultural waste, there is a need for a quick response, so we will consider generating electricity from waste processing and further using electricity for cryptocurrency mining, and for this purpose, we will get acquainted and learn what cryptocurrencies are.

Bitcoin is a peer-to-peer digital decentralized cryptocurrency created by a person under the pseudonym Satoshi Nakamoto. It is the first digital decentralized currency. Several developers and organizations have researched the importance of digital cryptocurrency and the blockchain concept. It is believed that Bitcoin is one of the safe and convenient payment methods that can be used in the coming days. The basis of Bitcoin mining is the concept of blockchain, which is considered one of the brilliant inventions of this century. A blockchain is a set of blocks that are interconnected in such a way that the hash of the previous block is contained in the current block. Any change in the information in any blocks in the blockchain will lead to an error in the entire blockchain. Bitcoins are generated through a process called mining, where miners solve a complex mathematical puzzle. Miners compete with each other to mine bitcoins as quickly as possible and receive a reward [13].

Bitcoin mining requires very high computing power. Since miners solve complex mathematical puzzles using hardware, they must be fast to be the first to solve a block. A miner who successfully solves a block receives a bitcoin. Mining can be done by a single person or a pool when a bunch of miners join a network to mine a single block. Single mining also called solo mining, is challenging because the complexity of mining bitcoins is increasing every day. Pool mining is another option for those with fewer mining resources.

Bitcoin (also known as BTC) is a cryptocurrency created by Satoshi Nakamoto and released in 2009 [14]. Satoshi Nakamoto is not the real name of the creator of Bitcoin; instead, it is a pseudonym. Bitcoin is a distributed, decentralized, peer-to-peer virtual cryptocurrency. Because Bitcoin is a virtual cryptocurrency, it does not have any shape or size like the currencies we use today and is stored in Bitcoin wallets created to store virtual currencies. Bitcoins can be transferred to each other using a bitcoin address. Since its inception, it has grown in both popularity and use. There are three different ways to get bitcoins. One way is to buy them on an exchange, which is a process of converting local currency into bitcoin. Another way is to get it from Bitcoin ATMs, which are installed in several places around the world, and another is to mine them. The main protocol underlying Bitcoin is the blockchain, which is a truly innovative invention of this century. Bitcoin is created through a process called mining [14]. People who mine Bitcoin are called miners. The Bitcoin network is managed and protected by miners. Bitcoins can be used as a substitute for physical money in terms of buying and selling goods. It can be bought, sold, and even exchanged for other physical currencies.

Since the introduction of Bitcoin in 2009, it has attracted the attention of many sectors, mainly focused on business, industry, and academia. With a market capitalization of $88,604,642,423 and over 300,712 total confirmed transactions per day (March 2019), Bitcoin is considered the most successful cryptocurrency to date.

With the advent of Bitcoin and the technology behind it come huge opportunities that are being explored by different people in different sectors, such as consumers, developers, marketers, etc. Many organizations have started working on mining Bitcoin, which serves as a virtual currency as a replacement for fiat currencies. Several countries, including the United States, Japan, China, and Australia, have started using Bitcoin as a payment method in restaurants and shops [15]. The method of generating new bitcoins is known as bitcoin mining. Since the number of bitcoins is limited (21 million), the number of bitcoins left for mining is decreasing every day. At the moment, approximately 17.7 million bitcoins have been mined and 3.5 million bitcoins remain to be mined. The motivation to learn more about Bitcoin and the technical aspect of Bitcoin generation is evolving from the ever-growing interest of people in Bitcoin and its implementation in various sectors.

Bitcoin mining is the process of generating bitcoins by solving a complex mathematical puzzle using hardware. Individuals refer to miners as the Bitcoin secure network. Bitcoin mining requires hardware. Over time, miners use different types of hardware to mine Bitcoin blocks. Initially, bitcoin mining was done with a CPU, and within a year, the hardware changed to GPUs, FPGAs, and ASICs.

Having studied the two concepts of bioenergy and mining, we introduced a new concept, namely “biomining”, i.e. by processing the outputs of enterprises and obtaining biogas, which is burned to produce electricity, which we use for equipment adapted for mining.

Biomining is the process of generating bitcoins by solving a complex mathematical puzzle with the help of hardware powered by clean energy using biomass, i.e. organic matter produced by photosynthesis (Fig. 1).

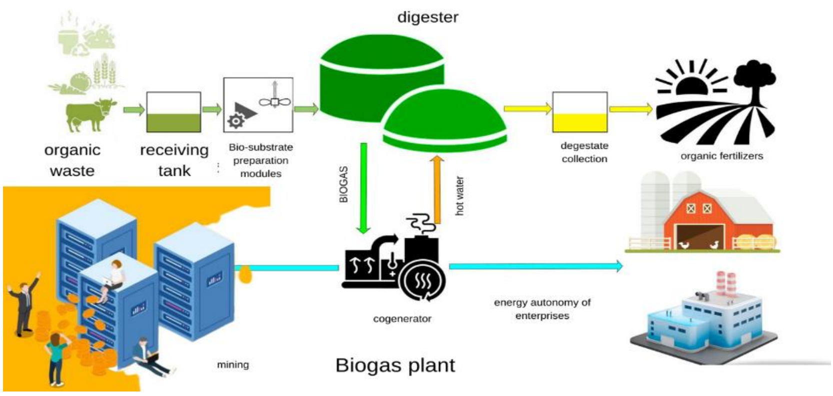

Figure 1: Biomining is the process of generating bitcoins by solving a complex mathematical puzzle

The main conclusion is that the concept of “biomining” is used and described for the first time. The main task in the study of this topic, most scientists proceeded from the paradigm of using subsidies from the state at the expense of the green tariff, reducing CO_2 emissions from waste processing, and selling improved fertilizers, our study proves that with the proper use of modern technologies and the correct use of the available resource, it is possible to become a center for the extraction of cryptocurrencies through biomining and increase the country's GDP by selling crypto coins on exchanges.

Based on a study of 20 companies that use biogas processed from waste from processing plants to generate electricity, 303.6 million kW of electricity was produced in 2021 alone, which was sold to the grid and received about €36 million in subsidies from the state for €0.12 per kWh. Using the generated electricity, it was possible to realize Bitcoin cryptocurrency mining, based on the capacities of enterprises, the number of assists required for Bitcoin mining is more than 10 thousand units, and the result obtained from mining during 2021 would be as follows:

Based on a study of 20 enterprises that use biogas processed from waste from processing plants to generate electricity, a significant amount of electricity was produced in 2021. According to the study, a total of 303.6 million kW of electricity was produced from biogas and sold to the grid. These companies also received about €36 million in subsidies from the state for €0.12 per kWh.

The electricity produced was used for various purposes, including mining the cryptocurrency Bitcoin. Based on the capacity of the enterprises, bitcoin mining could be realized using more than 10 thousand devices. This is a significant amount of computing power required for Bitcoin mining.

The result obtained from mining during 2021 will depend on various factors, such as the complexity of mining, the price of bitcoin, and the cost of electricity. However, assuming a constant level of difficulty, it is possible to calculate the approximate number of bitcoins that could be mined using the electricity generated. Based on the current price of bitcoin and the estimated cost of electricity, the revenue from bitcoin mining would be approximately 93 million euros.

This is a significant amount of income that can be generated using electricity produced from biogas. In addition, this revenue can be used to offset the costs of implementing a biomining system, which can be a significant investment for businesses. This provides additional economic benefits for enterprises, making biomining an attractive technology for utilizing bioenergy potential.

Thus, the study emphasizes the potential of biomining as an effective mechanism for utilizing the bioenergy potential of processing enterprises in the agricultural sector. The use of electricity generated from biogas for Bitcoin mining is an innovative application of this technology that can bring significant income to enterprises. Although there are challenges to be overcome, the potential benefits of biomining make it worth further exploration.

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- At a Bitcoin price of 40.2 thousand euros as of January 2022—received more than 119 million euros from mining.
- At a bitcoin price of 20.1 thousand euros as of May 2022, we received more than 59 million euros from mining.

If these operations are taxed at 5% and 1.5% tax rates, the first option will amount to 7.7 million euros, and the second option will amount to 3.8 million euros, respectively, of state budget revenues. Thus, based on our dissertation research, we have developed an effective mechanism for utilizing the bioenergy potential of processing enterprises, which results in a weakening of the receipt of budget funds under the green tariff, and vice versa, additional revenues to the state budget. This mechanism can be used for producers of solar energy, and wind energy, as well as the construction of new biogas plants, resulting in the end product of electricity that will be used for cryptocurrency mining.

Let's consider a correlation model between sales to the general grid under the green tariff and cryptocurrency mining—number of mining nodes—bitcoin value.

Developing a correlation model between investment and various variables related to the biomining industry can provide insight into the potential benefits of this technology for businesses. In this study, we examine the correlation between investment and five variables related to biomining technology, including the green tariff, cryptocurrency production at different bitcoin prices, electricity production, and the number of ASICs (Table 1).

Table 1. Summary data for correlation and regression analysis of the influence of factor variables X1, X2, X3, X4, X5

	Investments (Y)	Green tariff (X1)	Cryptocurrency mining at BTC price = 20.1 thousand euros May 2022 (X2)	Cryptocurrency mining at BTC price = 40.2 thousand euros January 2022 (X3)	Generated electricity million kW 2021 (X4)	Number of Asics million (X5)
Teofipol Energy Company LLC	40,00	10,02	16,40	32,79	83,5	0,00297365
Vinnytsia Poultry Farm LLC	27,00	6,85	11,21	22,43	57,1	0,00203348
Korsun Eco Energy LLC	18,00	4,55	7,44	14,88	37,9	0,00134972
PJSC Oril leader	15,00	3,86	6,32	12,65	32,2	0,00114672
Gorodische Pustovarivske LLC	12,90	3,25	5,32	10,64	27,1	0,0009651
LLC Agrofirma im Chkalova	12,30	3,10	5,07	10,13	25,8	0,0009188
LLC Józefo-Nikolaivska bioenergy	11,00	2,77	4,54	9,07	23,1	0,00082265
Clear Energy Odesa LLC	8,00	2,03	3,32	6,64	16,9	0,00060185
LNK LLC	7,80	1,98	3,24	6,48	16,5	0,00058761
Clear Energy LLC	6,30	1,58	2,59	5,18	13,2	0,00047009
Clear Energy Kherson LLC	5,10	1,28	2,10	4,20	10,7	0,00038105
Biogas Ukraine LLC	4,00	1,02	1,67	3,34	8,5	0,00030271
Komertsbudplast LLC	3,70	0,95	1,55	3,10	7,9	0,00028134
Clear Energy Kremenchuk LLC	2,80	0,72	1,18	2,36	6	0,00021368
Lancast LLC	2,20	0,58	0,94	1,89	4,8	0,00017094
Energo Sich LLC	2,05	0,52	0,84	1,69	4,3	0,00015313
Clear Energy Chernihiv LLC	2,00	0,50	0,82	1,65	4,2	0,00014957
Tis Eco LLC	3,50	0,50	0,82	1,65	4,2	0,00014957
AEO Energy LLC	2,90	0,43	0,71	1,41	3,6	0,00012821
PJSC Ecoprod	5,40	0,43	0,71	1,41	3,6	0,00012821
Total	144,2	36,4	59,6	119,2	303,6	0,01081197
Teofipol Energy Company LLC	40,00	10,02	16,40	32,79	83,5	0,00297365

The first variable under consideration is the green tariff, which is the price at which companies can sell electricity generated from biogas to the grid. The second and third variables are cryptocurrency mining at different bitcoin prices, such as 20.1 thousand euros in May 2022 and 40.2 thousand euros in January 2022. The fourth variable is electricity production in millions of kW in 2021, which is the amount of electricity generated by enterprises using biomining technology. The fifth variable is the number of ASICs in millions, representing the amount of computing power used for cryptocurrency mining.

To develop the correlation model, data were collected from several businesses that use biomining technology, including investment in the technology, green tariff, cryptocurrency mining data, electricity production, and the number of ASICs. A correlation analysis was conducted to determine the strength and direction of the relationship between these variables.

The results of the correlation analysis showed a positive correlation between investment and the green tariff. This indicates that as the green tariff increases, the amount of investment in biomining technology increases. This can be explained by the fact that a higher feed-in tariff provides greater revenue potential for enterprises.

In addition, there is a positive correlation between investment and cryptocurrency production at different bitcoin prices. This indicates that as the value of Bitcoin increases, so does the amount of investment in biomining technology. This can be explained by the fact that a higher Bitcoin price provides greater revenue potential for businesses.

In addition, there is a positive correlation between investment and electricity production. This indicates that as the amount of electricity produced by companies using biomining technology increases, the amount of investment in this technology also increases. This can be explained by the fact that more electricity production provides greater revenue potential for enterprises.

Finally, there is a positive correlation between investment and the number of ASICs. This indicates that as the amount of computing power used for cryptocurrency mining increases, the amount of investment in biomining technology increases. This can be explained by the fact that more ASICs provide more revenue potential for enterprises.

A regression model is an important tool in statistical data analysis that allows you to find out the relationship between a dependent variable and one or more independent variables. In this model, the dependent variable is considered to be the result of a function of the independent variables (Tables 2–4).

In this context, the multiple coefficients of determination R-squared allow us to determine how well the model fits the data. This coefficient can be in the range from 0 to 1, where a value of 1 indicates a perfect fit of the model to the data. In this case, the R-squared with a value of 0.9916499 indicates the high adequacy of the regression model.

In addition, the normalized R-squared indicates that the model fits the data when there is more than one independent variable. The value of 0.991186005 indicates the high quality of the model, which depends on the correspondence of the independent variables to the real data.

The standard error reflects the accuracy of the model, which can be estimated using the standard errors of the regression. This value of 0.90495824 can be used to find a confidence interval and to compare different regression models.

The number of observations (20) is also important to determine the accuracy and fit of the model to the data. To summarize, a regression model is a powerful tool for analyzing the relationship between variables and can be used to predict future values of a dependent variable based on known values of independent variables. The results obtained from a regression model can be used to develop management and decision-making strategies.

In a regression model, two types of variables are usually used: dependent and independent. A dependent variable is a quantity that is to be predicted or estimated, while independent variables are quantities that can influence the dependent variable.

The most common form of the regression model is linear regression, where the dependent variable is assumed to be a linear function of the independent variables. In this case, the values of the regression model parameters are determined by the least squares method, which involves finding the parameters that minimize the sum of the squared deviations between the observed and predicted values of the dependent variable.

Table 2

Regression statistics indicators

Regression statistics	
Multiple R	0,995816198
R-square	0,9916499
Normalized R-squared	0,991186005
Standard error	0,90495824
Observations	20
Multiple R	0,995816198

Table 3
Correlation coefficients

	Ratios	Standard error	t-statistic	P-value	The bottom 95%	The top 95%	Bottom 95.0%.	The top 95.0%
Y-section	0,5130045	0,282054131	1,818815763	0,08561758	-0,079569241	1,10557824	-0,079569241	1,10557824
Variable X 1	3,871363036	0,083732549	46,23486445	3,67399E-20	3,695447479	4,047278593	3,695447479	4,047278593
Variable X 2	2,365734675	0,051167765	46,23486445	3,67399E-20	2,25823519	2,47323416	2,25823519	2,47323416
Variable X 3	1,182867338	0,025583882	46,23486445	3,67399E-20	1,129117595	1,23661708	1,129117595	1,23661708
Variable X 4	0,464563564	0,010047906	46,23486445	3,67399E-20	0,443453697	0,485673431	0,443453697	0,485673431
Variable X 5	13044,94489	282,1451959	46,23486445	3,67399E-20	12452,17983	13637,70995	12452,17983	13637,70995

Table 4
Indicators characterizing the reliability of the regression model

	df	*SS*	*MS*	*F*	*The value of F*
Regression	1	1750,637611	1750,637611	2137,66269	3,67399E-20
Balance	18	14,74108948	0,818949415		
Total	19	1765,3787			

Analysis of variance is a statistical analysis method that allows you to evaluate the influence of factors on a variable by comparing the mean values. The table below shows the results of an analysis of variance for a model consisting of regression and residuals.

The results of the analysis of variance showed that the regression model has one degree of freedom and a Sum of Squares (SS) value of 1750.637611. The residual model has 18 degrees of freedom and an SS value of 14.74108948. The total SS for the model is 1765.3787, which is the sum of the SS for the regression and the residuals.

The F-statistic was used to assess the statistical significance of the regression. The F-value is 2137.66269, which is the result of dividing the regression Mean Square (MS) by the residuals MS. The F-statistic value is very small (3.67399E-20), which indicates that the regression model is statistically significant, i.e., there is a statistically significant effect of the regression factor on the dependent variable.

3. Conclusions

The role of renewables continues to be the fastest-growing energy source in the global energy mix. Shortly, global renewable electricity production will surpass natural gas production. Increasing population density, combined with changing habits in developing countries towards high-quality food, is projected to increase demand for food production by 60% by 2050. The need to increase agricultural productivity and efficiency in developing countries is now widely recognized. More sustainable food production requires crops that make better use of limited resources, including land, water, and fertilizers. The comparison between high-input agriculture, which cannot be sustained, and agroecology is not helpful at all, as it is no longer the point of the discussion. The point is whether existing knowledge of agroecological practices can achieve these yield growth rates, and if not, whether investments in research and innovation that focus on this stream of practices rather than intensification can help achieve them.

Globally, advanced biofuel capacity is expected to expand only slowly, although the first commercial plants in the United States and Europe have recently come online. While the United States should remain the largest producer, technical and economic challenges associated with blending more than 10% ethanol into the gasoline base create uncertainty about the outlook. In Brazil, more optimistic sugarcane harvesting conditions and new government support measures should help further growth, although the ethanol sector still faces financial difficulties. High feedstock prices and low margins continue to challenge biofuel producers in Europe.

In conclusion, the correlation model developed in this study provides insight into the relationship between investment and various variables related to the biomining industry. The results show that there is a strong positive correlation between these variables, which emphasizes the potential benefits of biomining technology for businesses. Further research is needed to confirm these findings and develop more accurate predictive models.

However, it is worth noting that a regression model may not be sufficient to describe all the dependencies between variables and may underestimate the effects of a large number of independent variables or an incorrect choice of variables included in the model. However, by using variance analysis and other methods, it is possible to improve the accuracy of the regression model and provide more accurate results.

Thus, the analysis of variance allowed us to estimate the statistical significance of the regression model and proved that the regression factor has a statistically significant effect on the dependent variable.

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