Recovery of Ukraine's Economy: Construction of Biogas Plants[1]

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Abstract. *The paper is devoted to the topical issue of the recovery of Ukraine's economy after military operations. In particular, the expediency of building biogas plants as one of the critical tools for achieving this goal is investigated. In addition, converting waste into energy and heat is essential for effective waste management. This allows for better adaptation to global changes, balancing economic, environmental and social goals. The paper assesses the resource potential for biogas production and determines such a solution's economic, social, and ecological advantages. Business planning and financing of projects for constructing biogas plants in the Sumy region of Ukraine were considered, and state support*

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for this industry was proposed based on the obtained calculations. The paper describes the construction of a biogas production enterprise considering modern scientific and methodological approaches. The main aspects that determine the strategic and tactical aspects of planning and implementing the construction of a biogas plant are considered. An analysis of the most important criteria and indicators that should be considered when planning and executing the construction of a biogas plant is given. An analysis and comparative assessment of other sources of heat and energy in the context of military conflict were carried out. The potential advantages and limitations of using biogas plants and their crucial role in the reconstruction of Ukraine during the martial law and post-war period are highlighted. Based on the work results, conclusions were drawn that constructing a biogas plant in the Sumy region is feasible. Indicators were analysed, and a strategy was created to use the business plan successfully. It is worth considering the possibilities of a broader scale in biogas production in other regions of Ukraine and attracting exports to other countries. The research results can be used to develop an effective state policy on renewable energy and promote the sustainable development of the territories of Ukraine.

Keywords: *recovery, construction, energy, financial indicators, biogas, raw materials, waste, organic resources.*

JEL Classification: *L74, O13, Q53*

1 Introduction

The growing volume of waste and its detrimental environmental impact pose significant challenges to traditional waste management systems. These challenges jeopardise financial stability and hinder the ability of countries to achieve sustainable development. As global trends increasingly focus on converting waste into energy and heat, there is a pressing need to adapt waste management strategies to address economic, environmental, and social goals effectively. The inability to integrate modern waste-to-energy technologies and practices threatens to exacerbate ecological degradation and constrain economic growth. Therefore, understanding these global trends and developing strategies for their implementation is crucial for fostering a sustainable and competitive economy while addressing waste management's immediate and long-term challenges.

*Analysis of recent research and publications***.** Recent research and publications underscore the pressing need for innovative approaches to waste management, considering escalating environmental and economic concerns. Studies have increasingly focused on the potential of waste-to-energy technologies as a sustainable solution to the growing waste problem.

Studies by Ruiz et al. (Ruiz, San Miguel, Corona, Gaitero, Domínguez, 2018) and Govender et al. (Govender, Thopil, Inglesi-Lotz, 2019) highlight the significant capital investment required for biogas plants, which can be a barrier to entry.

The potential for electricity or heat sales revenue is critical in determining economic viability. Papers by Taleghani & Kia (Taleghani, Kia, 2005) and Akbulut (Akbulut, 2012) explore the economic benefits of biogas power generation.

The cost and availability of feedstock can significantly impact the profitability of biogas plants. Studies by Igliński et al. (Igliński, Buczkowski, Iglińska, etc., 2012) and Adeoti et al. (Adeoti, Ilori, Oyebisi, Adekoya, 2000) examine the role of feedstock in economy.

Biogas plants can contribute to reducing greenhouse gas emissions by capturing and utilising methane, a potent greenhouse gas. Studies by Mukumba et al. (Mukumba, Makaka, Mamphweli, Misi, 2013) and Obileke et al. (Obileke, Makaka, Nwokolo, Meyer, Mukumba, 2022) discuss the environmental benefits of biogas production.

The land requirements for biogas plants can vary depending on the scale of operation and the type of feedstock used. Studies by Mæng et al. (Mæng, Lund, Hvelplund, 1999) and Kurbatova (Kurbatova, 2018) explore the implications of biogas plants.

Overall, these studies reflect a growing consensus on the need for transitioning to more sustainable waste management systems and provide valuable insights into the benefits and challenges of implementing waste-to-energy technologies.

Despite the growing body of research on waste-to-energy technologies, several aspects still need to be addressed. These include the economic impacts of biogas plant implementation in different regional contexts, the long-term sustainability of biogas production, and the integration of these technologies within existing waste management frameworks. Additionally, there is a lack of comprehensive studies on the socio-economic benefits of biogas plants, such as job creation and local economic development. The variability in waste composition and its effect on biogas production efficiency still needs to be explored. These gaps hinder the growth of robust, region-specific strategies for optimising waste-to-energy systems and maximising their potential benefits.

The aim of the paper. The research aim is to explore biogas plants' economic feasibility and sustainability in regional contexts, explicitly focusing on the Sumy region.

2 The primary research material

The analysis of needs is a primary step in the planning and implementation of constructing a biogas production facility. This stage requires a detailed market study and determination of potential demand for biogas and other products. It is important to consider current and projected consumer needs to ensure the efficient operation of the facility in the future.

A detailed needs analysis allows for identifying key market segments, identifying competitive advantages, and understanding the main factors affecting demand. This helps develop a marketing and sales strategy to meet customer needs and maximise profitability.

Having conducted a needs analysis for the Sumy region, the following results were obtained:

1. Energy Infrastructure: The Sumy region is an important regional centre with significant energy potential. The Sumy region with the Poltava and Kharkiv regions, is part of the northern power grid. The total capacity of the region's power system is approximately 3398 MW, while the average electricity consumption is up to 2000 MW. This indicates the potential for implementing additional energy sources, such as biogas production facilities.

2. Potential Biogas Consumers: The region hosts many industrial enterprises, agricultural institutions, heating networks, and municipal services. Over 300 industrial enterprises in the region currently produce about 20% of Ukraine's industrial output, including food products, building materials, light industry, and chemicals. The use of biogas in these sectors can become a practical energy source, reducing the reliance on traditional fuels and contributing to emission reductions.

3. Socio-Ecological Aspects: Reducing greenhouse gas emissions and improving air quality are essential objectives for the Sumy region. The air pollution levels in the region exceed the standards for harmful emissions. Biogas can help mitigate this negative impact and improve environmental quality in the region.

As a result, these aspects indicate the potential for successful implementation of biogas projects in the Sumy region, which will meet the needs and interests of the area, as well as contribute to economic and environmental development.

Both national and international standards, legislative requirements, and regulatory acts determine the standardisation and regulation in constructing biogas plants. Establishing unified standards is a critically important step to ensure the quality and safety of a biogas production facility. The regulation of this activity helps prevent potential negative consequences for the environment and public health.

Ukraine has its own system of standardisation and regulation in biogas plant construction. National legislation and regulatory acts set requirements for such facilities' design, construction, operation, and maintenance. Ukrainian standards consider international standards and norms and specific conditions and requirements unique to the country.

In the Sumy region, the same standards and requirements that govern the construction and operation of biogas plants throughout the country apply. Regional legislation and regulatory acts define the procedures for obtaining construction permits, environmental monitoring and land use requirements, and facility safety and technical standards.

Collaboration among local government authorities, state agencies, the public, and the business community is crucial for effectively implementing standards and regulatory requirements in the region's construction and operation of biogas plants. Therefore, when constructing and initially planning the development of a biogas plant and coordinating its construction, all decisions should be made based on the relevant laws and regulatory acts. They include the Constitution of Ukraine (Constitution of Ukraine, 1996), the Civil Code of Ukraine (Civil Code of Ukraine, 2003), the Land Code of Ukraine (Land Code of Ukraine, 2002), the Water Code of Ukraine (Water Code of Ukraine, 1995), the Forest Code of Ukraine (Forest Code of Ukraine, 1994), the Urban Planning Code of Ukraine (Urban Development Code of Ukraine, 2011), the Construction Code of Ukraine (Building Code of Ukraine, 2011), the Law of Ukraine "On Environmental Protection" (Law of Ukraine on Environmental Protection, 1991), the Law of Ukraine "On Waste" (Law of Ukraine on Waste, 1998), the Law of Ukraine "On Alternative Energy Sources" (Law of Ukraine on Alternative Energy Sources, 2003), the Law of Ukraine "On Energy Efficiency of Buildings and Structures" (Law of Ukraine on Energy Efficiency of Buildings and Structures, 2017), the Cabinet of Ministers of Ukraine Resolution "On Approving the Energy Policy Strategy of Ukraine until 2035" (Resolution of the Cabinet of Ministers of Ukraine), and others.

Given the list of legislation and regulatory acts that govern the construction and operation of biogas plants in Ukraine, well-defined legal parameters and requirements frame this process. The regulatory framework is designed to ensure safety, environmental sustainability, and efficient resource use in biogas production. This supports the stable development of the sector and contributes to achieving strategic goals in energy efficiency and environmental protection. However, it is also crucial to consider national norms, local specifics, and regulatory requirements for successfully implementing projects in the Sumy region.

Another crucial component of the organisational and technical aspects is developing a comprehensive approach to the environmental assessment of biogas production. This comprehensive approach involves analysing the environmental impact of all production components, including greenhouse gas emissions, resource use, energy efficiency, and potential soil and water pollution risks. A more detailed description of each element can be found in Table 1.

In today's world, biogas production is becoming increasingly relevant in the search for environmentally friendly and sustainably profitable energy sources. However, to successfully implement a biogas production project, it is crucial to have a clear strategic plan. This plan helps identify critical steps for the development of the enterprise, including market analysis, identification of potential competitors, and highlighting product advantages. Such an approach gives the company a clear understanding of achieving its goals and an effective development strategy.

The initiation of constructing profitable biogas plants requires significant financial investments, often beyond the reach of small businesses without additional resources. However, there are effective financing strategies include seeking investors, applying for government programs, or utilising personal funds. Securing financial support from the government or investors requires careful planning and economic forecasting to demonstrate potential profit and project payback periods. Overall, it is noted that obtaining funding from investors has a higher likelihood of success, especially during economic instability and wartime, when the government focuses on supporting existing enterprises. Therefore, we focus on potential investor capital in exploring various funding options.

However, securing sufficient funding for the project is only the first step toward success. It is also crucial to consider other aspects that, when analysed further, will contribute to achieving the desired income and expenses for the biogas enterprise. A clear strategic plan is essential to ensure the successful implementation of a biogas production facility. This plan helps identify the critical steps for the development of the enterprise, including market analysis, identification of potential competitors, and highlighting the product's advantages. Such an approach gives the company a clear understanding of achieving its goals and an effective development strategy.

A vital component of the funding acquisition process is the development of a business plan, which encompasses various aspects: documentation preparation, finding a location for the construction of the biogas plant while adhering to all necessary conditions, sourcing raw materials, acquiring equipment, forming a workforce, developing sales channels, forecasting profit from processing, as well as creating a marketing plan and calculating the profitability of the enterprise. Therefore, we examine the business plan elements in this work to understand better how to organise a business focused on biogas activities.

A central business plan component is selecting a production facility, which must be considered from both technical and economic perspectives. A well-

Table 1 Comprehensive Approach to Environmental Assessment of Biogas Production and Biogas Plant Construction

Greenhouse Gas Emissions	To analyse CO_2 and methane emissions, it is necessary to measure the number of gases released during the biogas production process and its use as an energy source. This data can be collected through systematic monitoring of production processes.
Water Resource Usage	To analyse water usage, it is necessary to measure the volumes of water used in the process of converting organic materials into biogas at biogas plants. Additionally, water consumption for the cleaning and disposal of waste should be considered. This data can be obtained from production reports and systematic record-keeping.
Impact on Soils and Biodiversity	To assess the impact of constructing and operating biogas plants on soils and biodiversity, a detailed analysis of the effects on biological diversity and soil condition is necessary. This data can be obtained through field studies and expert assessments

Source: (Dziadikevich, others, 2016)

chosen facility can significantly impact production efficiency and reduce costs. For instance, an optimally located facility can provide convenient access to raw materials and markets, thereby reducing transportation costs and optimising logistical processes.

Depending on the available budget, the investor can choose between renting or purchasing a facility for the biogas plant. Since this business sector is relatively new to Ukraine, purchasing large properties may be risky due to the substantial investment required for equipment. A facility with no more than 500 square meters would be sufficient to accommodate production zones, storage, equipment rooms, staff and management areas, and other necessary spaces. Considering safety regulations, such plants are often located outside urban areas, which can be advantageous for lower rental costs and favourable conditions for collaboration with local authorities. An ideal location might be near a landfill, agricultural farm, or factory, which would minimise raw material transportation costs. Access to a water source is also crucial. It is important to note that such facilities cannot be built on land designated for agricultural purposes, which may limit available site options. Considering all these factors, you can construct the facility, ensuring compliance with all sanitary and fire safety regulations. Renting the facility and adjacent land may cost approximately $2,500 per month, provided additional expenses for repairs and equipment are not required (Bezugla, 2014).

Documentation is essential to the business plan, ensuring structure and systematisation throughout all project stages. This includes preparing technical documentation, licensing permits, and other necessary documents for the establishment and operation of the enterprise. Documentation also allows for monitoring task completion and timely resolution of potential issues. Preparing and agreeing on the required documents is critical for all business sectors, including product processing. It is essential to obtain all necessary licenses. It permits regulatory bodies, mainly if the enterprise deals with waste, animal by-products, or hazardous substances that could harm the environment. It is advisable to consult with specialists in this field, as attempting to handle documentation independently may lead to rejection, resulting in a waste of time and money. Obtaining all necessary licenses can take four to eight months (What exactly is solid household waste (SWW)?). Following this, project documentation must be prepared detailing the technological operations. With this description, the entrepreneur can obtain approvals from various agencies, such as the fire department, water authority, and municipal services. Regular inspections are conducted to ensure compliance with environmental regulations. However, even with all licenses in place, there is no 100% guarantee that production will not be halted due to potential issues related to sanitation, fire safety, or other factors that may arise.

The selection of equipment is of great importance in biogas production, as it affects the quality and productivity of the process. This includes choosing technologies and equipment that meet the efficiency and environmental sustainability requirements. Advanced and reliable biogas production technologies are already available on the global market. The technical issues that small biogas plants faced two decades ago have been resolved. Millions of biogas installations are now operational worldwide. While using gas for direct combustion in household stoves or gas lamps is common, generating electricity from biogas remains relatively rare in most developing countries. Despite this, various desulfurisation methods are successfully applied, and the available internal combustion engines designed to run on biogas have proven their reliability and durability. Moreover, there is ample know-how for designing and constructing reliable biogas power plants.

Germany is a leader in biogas plant production for electricity generation. Additionally, countries such as China, Thailand, other Asian countries, and Brazil have access to the necessary technologies and components (Why Does Sweden Buy Garbage? Global Experience in Landfill Management). In Africa, biogas-powered electricity production is still mainly limited to pilot projects, although Kenya is a centre for development and expertise in this field. For the effective and reliable construction of biogas power plants, some key components still need to be imported from industrialised countries.

The choice of equipment for a biogas business depends on financial capabilities and the specifics of the industry. Additional equipment might be necessary for processing different types of waste or producing supplementary products. If you opt for a basic set of equipment for one or several types of products and do not consider additional costs, the average price of setting up a mini waste processing facility would be approximately $150,000 (Equipment for Biogas Production).

Staff Selection. Equipment at the facility must be under constant supervision, so assembling a team of employees is essential. The production process differs from retail in that the equipment must operate continuously, and the facility functions around the clock. Even for a small production facility operating a single shift, 10–15 workers are required, including a shift supervisor, an equipment maintenance specialist, and an electrician. For procurement of raw materials, product sales, documentation, accounting, and other administrative tasks, 3–5 office staff members are needed. Depending on location, the enterprise's payroll fund will be approximately $30,000 per month (Waste Processing Plants, Waste Sorting Plants).

Distribution Channels. In the wartime realities of Ukraine, distribution channels for biogas gain particular importance due to the instability of traditional markets and logistics networks. Let's examine the main potential distribution channels for biogas under these conditions:

1) Energy Companies and Local Heat Supply Enterprises. Biogas can be used to generate electricity and heat. In wartime, when there is an increasing shortage of traditional fuels, energy companies may be interested in purchasing biogas to ensure a stable supply of electricity and heat to the population.

2) Industrial Enterprises. Some industrial enterprises, especially those involved in food processing or agriculture, may use biogas as an energy source for their needs. This allows them to reduce their dependence on traditional energy resources, which may be unavailable or expensive.

3) Agricultural Farms and Operations. Large farming operations with high energy consumption can utilise biogas for their energy needs. Additionally, they can use the byproducts from biogas processing as fertilisers.

4) Local Communities and Municipal Institutions. Biogas can become a crucial energy source for heating, lighting, and other needs in rural or remote areas with limited gas supply. Municipalities may invest in infrastructure for the production and use of biogas.

5) Military Bases and Field Hospitals. Military facilities and medical establishments near combat zones can use biogas to meet their energy needs, providing greater autonomy and independence from traditional fuel supplies.

6) Transport Companies. Biogas can be used as fuel for transportation, particularly for public transport or freight services. In wartime, this can be strategically important for maintaining mobility and ensuring the delivery of essential goods.

7) Biogas Supply for Generators. In power outages, using biogas to fuel generators can be critically important for maintaining the operations of various institutions and businesses.

These sales channels help sustain the situation in Ukraine and preserve their value for the future. After the war and the reopening of borders, biogas will become relevant in the market as an eco-friendly fuel that will be cheaper and more advantageous to purchase. Such an environmentally friendly and cost-effective processing result will always be in demand.

Marketing Strategy. The waste processing market is not yet highly competitive, so significant advertising spending is unnecessary. However, to ensure strong market positions in the future, inform potential clients about the results of your work, and maintain stable long-term relationships, the following promotional activities are recommended:

– publishing articles about the company's activities in specialised journals and on relevant websites;

– production and distribution of informational brochures and leaflets;

– created and distributed branded promotional items for potential clients.

Considering this, a proposed monthly advertising budget is about $10,000 (Accounting for Production Costs and Finished Goods).

When implementing any project, especially one as large and complex as establishing a biogas plant, it is crucial to understand the costs involved at various stages. Identifying costs is the first step in the planning and management process. It allows for an accurate assessment of the financial effort required to complete the project successfully. Any underestimation of costs can lead to economic problems and delays, so it is essential to thoroughly examine all potential aspects and components of expenses.

Additionally, risk assessment plays a crucial role in project planning. Identifying potential threats and unforeseen circumstances in advance allows for preventive measures and effective management. This may include developing alternative strategies, securing contracts with insurance companies, or altering work processes. Risk assessment can ensure greater control and stability throughout all project stages.

Finally, developing a financial strategy is crucial to any project's success. It involves creating a plan for expenses, resource allocation, and managing revenues and costs throughout the project's lifecycle. A well-designed financial strategy allows for effective use of financial resources, minimises risks, and ensures financial stability during project execution.

Determining the costs of establishing a biogas plant plays a critical role in the planning and execution of the project. This process helps clarify the financial efforts required to implement the business initiative successfully (Accounting for Production Costs and Finished Goods).

The main costs for establishing a biogas plant include land acquisition, design and engineering, construction, installation, and procurement. Additionally, costs for transportation, documentation, marketing, and other aspects may arise during project implementation. An essential part of the analysis is assessing the financial indicators' stability and effectiveness, which will help determine whether the project is profitable and economically viable. A more detailed list of cost types and their estimates is presented in Table 2.

Risk assessment is also a crucial component of project planning. Identifying potential threats and risks in advance allows for developing management strategies and helps minimise their negative impact on the project.

Risks can include fluctuations in material costs, technical difficulties, delays, changes in legislation, and other unforeseen circumstances. Table 2 identifies potential risks associated with various expenses that may arise during the facility's design, construction, or operation. All risks and their descriptions are detailed in Table 3.

Conducting these analyses has allowed for the early identification of potential issues and risks that may arise during the implementation of the project, as well as understanding which types of expenses need to be anticipated. Determining the costs provided insight into the resources, funds, and efforts required for the successful execution of the project. Risk assessment helps identify problems and threats that could impact the project and develop strategies for managing them. This approach helps reduce the likelihood of delays and budget overruns, which is crucial for completing the project.

Finally, developing a financial strategy outlines the plan for managing financial resources throughout the project's entire lifecycle. It includes budget allocation, revenue and expense management, and financial control mechanisms. A well-developed financial strategy ensures the stability of the project's finances, preserves resources and minimises financial risks. According to Tables 2 and 3, the principles of the financial strategy have been derived, enabling the achievement of the highest profitability for the business with the lowest costs in the future:

– allocating sufficient funds to cover all construction-related expenses and establishing a contingency fund for unforeseen costs;

– careful planning of monthly expenses and monitoring them to ensure the financial stability of the enterprise;

– monitoring the costs of raw materials, supplies, and energy, as well as maintaining reserves to cover unexpected increases in expenses;

– entering into maintenance contracts with reliable suppliers and establishing a fund to cover potential repair costs;

– establishing a contingency fund for unforeseen expenses or emergencies, which can ensure the financial stability of the enterprise;

– exploring opportunities for expanding funding sources and attracting investments to ensure the stable development of the enterprise;

– ongoing analysis of market conditions and the competitive environment to respond promptly to changes and minimise risks.

Table 2 List of Variable and Fixed Costs (USD)

Types of Costs	**One-Time Costs**	**Fixed Costs for Construction**	**Fixed Costs**	**Variable Costs**
Land Acquisition	50 000	-	-	-
Design and Engineering	20 000	-	-	-
Construction	100 000	-	-	-
Equipment Installation	30 000	-	-	-
Equipment Purchase	150 000	-	-	-
Transportation Costs	10 000	-	10 000/year	-
Documentation and Licensing	15 000	-	-	-
Advertising and Marketing	10 000	-	10 000/year	-
Office Equipment and Furniture	5 000	-	-	-
Working Capital	-	-	20 000/year	-
Staff Salaries	-	-	360 000/year	-
Raw Materials and Supplies	-	-	-	Depending on volume
Energy Consumption	-	-	-	Depending on volume
Maintenance	-	-	5 000/year	-
Contingency Fund	-	-	-	-
Total	$390,000	-	$75,000/year	Depending on volume

Table 3 Risk Assessment for Establishing a Biogas Production Facility

Risk Type	Risk Description
Land Acquisition	There is a risk of changes in real estate prices, as well as potential legal and regulatory obstacles during the purchase
Design and Engineering	Risk of technical errors in design that could lead to construction delays or increased costs.
Construction	Possibility of delays in construction due to weather conditions, unforeseen technical problems, or changes in legislative requirements
Equipment Installation	Risk of technical problems during installation that could result in additional costs or delays in startup
Equipment Purchase	Risk of price changes for equipment, as well as the risk of selecting inappropriate equipment that does not meet the facility's needs
Transportation Costs	Risk of increased transportation costs for materials and equipment due to fuel price changes or unforeseen circumstances.
Documentation and Licenses	Possibility of delays in obtaining necessary documents and licenses due to bureaucratic processes or unforeseen circumstances
Advertising and Marketing	Risk of ineffective use of advertising resources and the potential for low response rates from the target audience
Office Equipment and Furniture	Risk of changes in prices for office equipment and furniture, as well as the risk of selecting unsuitable equipment for office needs
Working Capital and Employee Salaries	Risk of insufficient working capital to cover current expenses and the possibility of changes in salary levels, which could lead to employee dissatisfaction and turnover
Raw Materials and Supplies, Energy Consumption	Risk of price changes for raw materials and supplies, as well as fluctuations in energy costs, which could impact overall production costs
Maintenance	Possibility of increased maintenance costs due to technical issues or unforeseen expenses.

Source: (Serpeninova, Denisenko, 2013)

Adhering to this strategy will help reduce financial risks and ensure more sustainable economic growth and higher profitability from the project.

Profit and profitability calculations are crucial for understanding the viability of any business, including planning a biogas plant (Pandas, Federka, 2020). They form the basis for assessing the economic feasibility of the project and its attractiveness to investors, allowing one to determine how successful the enterprise may be and how quickly it can recoup the invested capital.

Given the complexity of implementing environmental technologies and the constant changes in the energy market, considering these indicators becomes necessary in the business plan development process. They will help to substantiate or adjust potential risks and benefits, assess profitability, and determine optimal financial management strategies (Vovk, Kovalchuk, Komissarenko, Dzhulai, 2020). This analysis will clearly understand the project's profitability and help decide whether it is worth investing in creating a biogas plant in the given context.

To calculate the profit, let's assume that the planned biogas plant will process 65 tons of organic waste daily. This waste may include household organic garbage, wastewater from treatment facilities, and organic waste from agricultural enterprises or production. This figure can be obtained by examining the fill levels of waste bins near residential buildings and other businesses that will provide the raw materials (Kurachkina, 2020).

To approximately calculate the profit from a biogas plant that produces heat and electricity for sale, several key factors need to be considered: the volume of processed feedstock, the yield of biogas, the efficiency of converting biogas into energy, and costs and revenues.

Data for the calculation

The volume of processed feedstock: 65 tons of organic waste per day.

Biogas yield: 100 m^3 of biogas per ton of feedstock.

Energy equivalent of biogas: 1 m^3 = 6 kWh of energy.

Efficiency of the energy plant: 35% (electricity), 50% (heat).

Working days in a year: 365 days.

Calculation of Biogas and Energy Output

1. Daily Biogas Output:

$$65 \text{ tons / day} \times 100\,м^3 \text{ / tons} = 6\,500\,m^3 \text{ / day.}$$

2. Daily Energy Output:

$$6\,500\,m^3 \text{ / day} \times 6 \text{ kWh / } м^3 = 39\,000 \text{ kWh /day.}$$

3. Daily Electricity Output (considering 35% efficiency):

39 000 kWh / day × 0,35 = 13 650 kWh / day.

4. Daily Heat Energy Output (considering 50% efficiency):

39 000 kWh / day × 0,50 = 19 500 kWh / day.

Annual Energy Output

Annual Electricity Output:

13 650 kWh / day ×365 = 4 982 250 kWh /year.

Annual Heat Energy Output:

19 500 kWh / day ×365 = 7 117 500 kWh / year.

Revenue from Energy Sales

Assuming that electricity is sold for 0,10 USD / kWh and heat for 0,05 USD / kWh, the annual revenue from electricity sales (Waste Utilization):

4 982 250 kWh / year ×0,10 USD / kWh = 498 225 USD / year.

Annual Revenue from Heat Energy Sales:

7 117 500 kWh / year × 0,05 USD / kWh = 355 875 USD / year.

Total Annual Revenue:

498 225 USD / year +355 875 USD / year = 854 100 USD / year.

Using the previously provided data on costs in Table 2, let's calculate the total fixed costs.

Total Fixed Costs per Year:

10 000 + 10 000 + 20 000 + 360 000 + 5 000 = 405 000 USD / year.

Based on the collected information about costs and revenues, the annual profit is created:

854 100 USD / year – 405 000 USD / year = 449 100 USD / year.

When constructing a biogas plant that processes 65 tons of organic waste daily and produces electricity and heat, the expected annual profit will be approximately 449,100 USD. This considers the current costs and revenue from energy sales. The project's success will also depend on effective management, cost reduction, potential additional sources of income, and possible plant expansions within the region and city.

The profitability formula has been used to determine if the project is profitable:

$$ROI = \left(\frac{Net\ Profit}{Total\ Investment} \right) \times 100\% - 100\% .$$

Substituting all the values, we obtained the following result:

ROI = ($449 100 / $390 000) × 100% – 100% = 15,15%.

Despite the profitability indicator being lower than what might be attractive to investors in Ukraine due to the relatively modest return compared to the invested capital, it is essential to recognise that the project is profitable. Moreover, prices and volumes gathered from various sources may fluctuate over time and in response to the situation in the country. Similarly, factors such as the plant size, the number of staff, and the equipment quality can also impact profitability. However, this project holds promise from an environmental perspective. It shows a positive profitability indicator, which can be considered economically viable for investment and profit generation. Moreover, it represents a resource replenished daily and could benefit humanity.

3 Conclusions

In the context of ongoing changes in the energy world and the need to transition to more sustainable and eco-friendly energy production methods, biogas is becoming increasingly relevant and viable as an alternative fuel source, particularly in Ukraine. Its use helps reduce dependence on imported energy and positively impacts the country's economy.

Biogas plants could be critical in Ukraine's transition to a sustainable energy future. They will help reduce greenhouse gas emissions and contribute to environmental conservation. Additionally, the development of the biogas sector will create new jobs, attract investments, and promote technological progress.

The economic feasibility study of building a biogas plant in Sumy Oblast highlights its potential as a promising infrastructure project aimed at energy production and manufacturing valuable products. A thorough analysis of financial metrics, including profit, profitability, costs, and other critical indicators, has led to the conclusion that the implementation of this project is economically viable. The calculations demonstrate that constructing a biogas plant could be a practical investment solution to foster regional development. Given the current situation in Ukraine, where the country is under military aggression, significant concerns arise regarding recovery and future growth. After the war ends, there will be a pressing need to rebuild the economy, and environmental considerations will play a crucial role. Planning for creating an ecological society could be a key focus for the country's recovery.

Adopting the right strategy and focusing on the ecological industry, particularly constructing a biogas plant in Sumy Oblast, reflects Ukraine's transition to a balanced and environmentally safe energy system. This step significantly addresses modern society's energy, environmental, and economic challenges. Focusing on the biogas industry is a strategic choice and an essential step towards creating a sustainable future for future generations and preserving the environment for the coming generations.

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