ASEAN Journal of Science and Engineering 6(1) (2026) 35-48

ASEAN Journal of Science and Engineering

Journal homepage: http://ejournal.upi.edu/index.php/AJSE/

Economic Evaluation of Household Biogas Unit Production in Supporting Public Policy on Accelerating Renewable Energy Development

Neng Virly Apriliyani, R. Siti Pupu Fauziah, Rita Rahmawati, S. Sukarelawati, A. Agustini, Ali Alamsyah Kusumadinata*

Universitas Djuanda, Bogor, Indonesia

*Correspondence: E-mail: neng.virly.apriliyani@unida.ac.id

ABSTRACT

This study explores the economic feasibility and policy relevance of household biogas production as a means to accelerate the transition toward renewable energy and sustainable development. Using an engineering economics approach, the analysis includes cost structures, break-even analysis, return on investment, and capital recovery period. Data were drawn from case studies and market-based estimates of component and operational costs. The findings reveal that despite relatively high operational expenses, production efficiency and consistent market demand ensure long-term economic sustainability. Beyond financial performance, household biogas systems enhance local energy security, reduce environmental degradation, and create community-based employment opportunities. These outcomes provide a strong empirical foundation for evidence-based policymaking, particularly in promoting decentralized energy systems and cross-sector collaboration. The initiative directly supports key Sustainable Development Goals, including clean and affordable energy, inclusive economic growth, and climate action, positioning household biogas as both a profitable and socially impactful renewable energy solution.

ARTICLE INFO

Article History:
Submitted/Received 26 May 2025
First Revised 27 Jun 2025
Accepted 28 Aug 2025
First Available online 29 Aug 2025
Publication Date 01 Mar 2026

Keyword:
Economic analysis,
Household biogas,
Public policy,
Renewable energy,
Sustainable development.

1. INTRODUCTION

Biogas plays a vital role in the transition toward sustainable energy systems due to its dual function as a clean energy source and a waste management solution [1]. Derived from the anaerobic digestion of organic materials such as agricultural residues, animal manure, and household waste, biogas offers an environmentally friendly alternative to fossil fuels while simultaneously reducing greenhouse gas emissions. Its application at the household and community level enhances energy access, particularly in rural and off-grid areas, thereby promoting energy equity and security. In addition to its energy benefits, biogas production generates nutrient-rich digestate that can be used as organic fertilizer, supporting sustainable agriculture and reducing dependence on chemical inputs. The decentralized nature of biogas systems empowers communities, fosters local economic activity, and aligns with global commitments to the Sustainable Development Goals (SDGs), especially in relation to affordable energy, climate action, and sustainable production. Thus, biogas is a strategic component of integrated development and environmental resilience.

Based on numerous studies conducted across different countries, biogas production through anaerobic fermentation of organic waste (such as animal manure (cattle, buffalo, goats), household waste, agricultural residues, and black water) has been recognized as a renewable energy source with significant economic, environmental, and social benefits. Most studies consistently highlight the usefulness of biogas for cooking, lighting, water heating, and even small-scale electricity generation, thereby reducing dependence on fossil fuels and firewood [2-5]. In addition, many studies emphasize that biogas production yields digestate, an organic fertilizer by-product that benefits the agricultural sector [3, 6].

Despite these common findings, the focus and context of biogas technology implementation vary across regions. Some studies concentrate on technical and economic aspects. Some researchers [7, 8] assess the economic opportunities and integration of biogas into hybrid energy systems in remote areas. Others explore biogas within the framework of the circular economy and local energy security [9, 10], while another examines co-digestion technology through pilot-scale experiments in India's tropical climate [11]. Overall, although the scope and geographical settings of these studies differ, they collectively demonstrate that biogas holds strong potential as a clean and sustainable energy solution, particularly for rural communities and regions with limited energy access. Moreover, biogas development not only advances SDG 7 (Affordable and Clean Energy) but also contributes to SDG 13 (Climate Action) by reducing greenhouse gas emissions and to SDG 8 (Decent Work and Economic Growth) by generating added value from organic waste.

Building on previous research in economic technology analysis [12-16], this study aims to evaluate the economic aspects of household biogas unit production as a sustainable, renewable energy solution. By assessing the financial feasibility and economic impacts of household-level biogas adoption, this study provides an empirical foundation for developing more equitable and sustainable clean energy policies.

The findings directly contribute to SDG 7 (Affordable and Clean Energy) by offering efficient green energy alternatives, to SDG 8 (Decent Work and Economic Growth) by supporting local economic activities and creating new business opportunities in renewable energy, and to SDG 13 (Climate Action) by reducing carbon emissions through the use of low-emission energy sources. Through an evidence-based and multidisciplinary approach, this research also strengthens collaboration between community initiatives, public policy support, and global sustainability efforts.

DOI: https://doi.org/10.17509/ajse.v6i1.89792
p- ISSN 2776-6098 e- ISSN 2776-5938

The novelty of this research lies in its holistic approach, which integrates engineering-based economic analysis with public policy perspectives and the social dynamics of renewable energy development at the household level. Beyond financial considerations such as investment costs, economic efficiency, and return on capital, this study also explores how its findings can serve as a foundation for formulating evidence-based energy policies focused on community empowerment. By emphasizing the micro-scale (households), this research bridges the gap between the technical aspects of biogas technology and the need for locally grounded, responsive public policies. Ultimately, it provides strategic guidance to accelerate the achievement of clean and sustainable energy goals.

2. LITERATURE REVIEW

Techno-economic analysis is essential for evaluating the feasibility, efficiency, and sustainability of technological innovations by integrating technical performance metrics with economic viability. Many reports regarding techno-economic analysis have been well-documented (**Table 1**). It provides a comprehensive framework to assess not only how well a technology functions but also whether it is cost-effective, scalable, and suitable for long-term implementation. This approach is particularly crucial in sectors such as renewable energy, where investment decisions must balance engineering reliability with financial return, environmental impact, and social acceptability. By identifying cost drivers, estimating return on investment, and analyzing operational risks, techno-economic analysis helps stakeholders (including policymakers, investors, and engineers) make informed decisions and prioritize resources effectively. Moreover, it supports evidence-based policymaking by offering quantitative insights that bridge the gap between research innovation and practical application. In essence, techno-economic analysis is a key tool for transforming promising technologies into sustainable and impactful solutions aligned with broader development goals.

Table 1. Previous research on techno-economic analysis.

No	Title	Ref.
1	Particle board from rubber woods: Concept, technology, cost analysis, and application for teaching aids in science subjects in elementary schools	[17]
2	Social-economic evaluation of dye processing from indigofera tinctoria linn in the ammatoa kajang indigenous cultural community	[18]
3	Production of charcoal briquettes from coconut shell waste to improve community economy: Technology and cost analysis	[19]
4	Production of smart wheel educational props from mahogany waste: technology and cost analysis	[20]
5	Toward carbon-neutral power generation in Indonesia: A techno-economic assessment of renewable ammonia co-firing in combined cycle power plants	[21]
6	Techno-economic household-scale solar power plants in support of the policy of presidential regulation number 112 of 2022 concerning the acceleration of renewable energy development	[22]
7	Techno-economic evaluation of gold nanoparticles using banana peel (Musa Paradisiaca)	[23]
8	Techno-economic analysis of the business potential of recycling lithium-ion batteries using hydrometallurgical methods	[24]
9	Techno-economic feasibility and bibliometric literature review of integrated waste processing installations for sustainable plastic waste management	[25]
10	Production of wet organic waste ecoenzymes as an alternative solution for environmental conservation supporting sustainable development goals (SDGs): A techno-economic and bibliometric analysis	[26]

DOI: https://doi.org/10.17509/ajse.v6i1.89792
p- ISSN 2775-6793 e- ISSN 2775-6815

Table 1 (Continue). Previous research on techno-economic analysis.

No	Title	Ref.
11	Techno-economic analysis of production ecobrick from plastic waste to support sustainable development goals (SDGs)	[27]
12	Techno-economic analysis of sawdust-based trash cans and their contribution to Indonesia's green tourism policy and the Sustainable Development Goals (SDGs)	[28]
13	Computational bibliometric analysis on publication of techno-economic education	[29]
14	Techno-economic analysis for the production of LaNi5 particles	[30]
15	Techno-economic analysis of solar panel production from recycled plastic waste as a sustainable energy source for supporting digital learning in schools based on Sustainable Development Goals (SDGs) and science-technology integration	[31]
16	Techno-economic feasibility of educational board game production from agro-industrial waste in support of Sustainable Development Goals (SDGs) through science and technology integration	[32]
17	Resin-based brake pad from rice husk particles: From literature review of brake pad from agricultural waste to the techno-economic analysis	[33]
18	Techno-economic evaluation of biodiesel production from edible oil waste via supercritical methyl acetate transesterification	[34]

An economic evaluation of household biogas unit production, in the context of supporting public policy for accelerating renewable energy development, is a comprehensive analysis that examines both financial feasibility and broader economic impacts. This evaluation goes beyond calculating fixed costs, variable costs, break-even point (BEP), return on investment (ROI), and payback period; it also considers the influence of public policy, community participation, and local government support in promoting renewable energy adoption. By applying a multidisciplinary approach that combines engineering, economics, public administration, and the sociology of governance, the evaluation provides valuable insights for designing sustainable development strategies. These strategies are not only economically viable but also socially inclusive, aligning with the dynamics of local communities. Such evaluations are crucial for advancing renewable energy because they offer a strong evidence base for policymakers and communities to adopt biogas technology sustainably, particularly in rural and semi-urban areas. Moreover, they help identify both economic and social barriers that may hinder widespread adoption [35]. Ultimately, the findings can guide the formulation of effective clean energy policies that contribute to the achievement of the Sustainable Development Goals (SDGs), especially clean and affordable energy (SDG 7), inclusive economic growth (SDG 8), and climate action (SDG 13). The theoretical framework of this study is built upon a multidisciplinary approach that integrates concepts from economics, public policy, and the sociology of governance. The key theories underpinning the analysis are outlined below:

2.1. Engineering Economy Theory

Engineering economy applies microeconomic principles to evaluate design and engineering alternatives, where the economic units under consideration may include firms, households, or consumers who determine value through market interactions. Its primary role is to assess project feasibility, estimate value, and justify from an engineering perspective [36]. In this study, the principles of engineering economics were applied to evaluate the financial viability of household biogas unit production. Parameters such as fixed costs, variable costs, break-even point (BEP), return on investment (ROI), and payback period were employed to measure efficiency and profitability. To ensure a more comprehensive assessment of economic feasibility, additional methods such as Net Present Worth (NPW),

DOI: https://doi.org/10.17509/ajse.v6i1.89792
p- ISSN 2776-6098 e- ISSN 2776-5938

Net Present Cost (NPC), Net Present Revenue (NPR), Benefit-Cost (B/C) Ratio, and Internal Rate of Return (IRR) were utilized [4]. This theoretical perspective provided the foundation for analyzing the economic viability of household-scale biogas business models and supported the development of evidence-based strategies for renewable energy adoption at the community level.

2.2. Public Policy Theory

A public policy framework was applied to examine how the outcomes of economic evaluations can inform renewable energy policy formulation. Public policy is broadly defined as government actions or inactions aimed at addressing citizens' needs. However, such a definition is often too general for systematic analysis; therefore, more precise conceptualizations are necessary to facilitate interdisciplinary understanding [37]. To this end, the policy cycle framework—which includes problem formulation, agenda setting, policy design, implementation, and evaluation—was adopted as a lens for linking economic data with decision-making processes at both local and national levels. In the renewable energy (RE) sector, accelerating development has become a key national and international strategy for reducing dependence on fossil fuels and mitigating climate change. Biogas, as a biomass-based RE, offers dual benefits: energy diversification and waste management. Public awareness and government support—through regulatory frameworks, financial incentives, and program coordination—play a central role in promoting biogas adoption. In Indonesia, the commitment to RE is reflected in Law No. 30/2007 on Energy, which designates renewable energy development as a national priority (Article 24). This is further reinforced by Government Regulation No. 79/2014 on National Energy Policy, which sets ambitious RE targets, and Presidential Regulation No. 112/2022, which establishes mechanisms to address investment barriers and create favorable pricing schemes for RE developers. Nevertheless, the success of such policies depends heavily on alignment with local contexts. Decentralization enables local governments to adapt national policies to community-specific needs, although challenges in regional governance often hinder effective implementation [38].

From a social psychology perspective, Diffusion of Innovation Theory helps explain public adoption of biogas technology, influenced by factors such as compatibility with social norms, perceived complexity, and awareness of benefits. Government-led awareness campaigns and public engagement programs, therefore, play a critical role in facilitating adoption. Similarly, Social Capital Theory emphasizes how trust, networks, and reciprocity within communities shape their collective capacity to adopt and sustain biogas initiatives [39]. Empirical studies confirm that strong community involvement in planning and implementation fosters a sense of ownership and contributes to long-term project sustainability [40]. Participatory approaches, as highlighted by [41], also strengthen trust between government and communities.

2.3. Community Participation Theory

Community participation theory highlights the critical role of local community involvement in ensuring the success of development programs, including household biogas initiatives. Without meaningful participation and empowerment, achieving long-term development goals becomes highly challenging. While this study does not provide an exhaustive discussion of the definition of "community," the concept is inherently linked to development, participation, and empowerment.

DOI: https://doi.org/10.17509/ajse.v6i1.89792
p- ISSN 2775-6793 e- ISSN 2775-6815

Community participation can be understood as the active involvement of individuals or groups in collective activities that directly support development projects and contribute to sustainably improving the quality of life [42]. Within the context of household biogas programs, this theoretical perspective offers insights into the extent of local engagement, which is essential for establishing legitimacy, fostering a sense of ownership, and ensuring the long-term sustainability of renewable energy initiatives.

3. METHODS

This study adopted a quantitative framework to evaluate the economic feasibility of large-scale biogas production units. Data on initial investment and operational costs were obtained from current market prices of commercially available components and raw materials, ensuring that the cost estimates reflect present market conditions. The information was systematically collected from various e-commerce platforms and online product provider websites to capture up-to-date market dynamics.

Data analysis was carried out using Microsoft Excel, where mathematical calculations were applied to estimate key financial viability indicators. The primary evaluation parameters included Cumulative Net Present Value (CNPV), Gross Profit Margin (GPM), Payback Period (PBP), and Break-Even Point (BEP) [41, 43, 44]. Together, these indicators provided a comprehensive assessment of profitability potential and investment risks.

The process flow of biogas production is illustrated in **Figure 1**, which outlines seven main stages. The process begins with the collection of organic feedstocks, including food waste, animal manure, and agricultural residues.

At the cutting and mixing stage, solid waste is chopped into smaller pieces to enhance microbial activity during fermentation. The materials are then homogenized (often by mixing with water) to form a slurry suitable for anaerobic digestion under optimal fermentation conditions.

Anaerobic fermentation constitutes the core stage of the biogas production process. At this stage, the prepared slurry is fed into a closed reactor under strictly anaerobic conditions (absence of oxygen). Within this environment, a consortium of anaerobic microorganisms decomposes complex organic matter through a series of biochemical reactions, ultimately generating methane (CH_4) as the primary product. Methane, the principal component of biogas, accumulates in the upper section of the reactor, while the liquid residue (known as digestate) settles at the bottom.

Following fermentation, the gas and slurry are separated. The methane-rich biogas is extracted and distributed for direct household applications, such as cooking and lighting, thereby serving as a clean and renewable alternative to fossil fuels. Meanwhile, the digestate is removed from the digester and utilized as a high-quality organic fertilizer. This nutrient-rich by-product enhances soil fertility, promotes crop productivity, and reduces dependence on chemical fertilizers.

Household-scale biogas systems therefore provide multiple benefits: they deliver a reliable source of renewable energy, reduce reliance on conventional fuels, improve agricultural productivity, and support integrated waste management. Collectively, these advantages underscore the economic, ecological, and social relevance of biogas technology, positioning it as a strategic investment for accelerating renewable energy development and strengthening community-level sustainability.

DOI: https://doi.org/10.17509/ajse.v6i1.89792
p- ISSN 2776-6098 e- ISSN 2776-5938

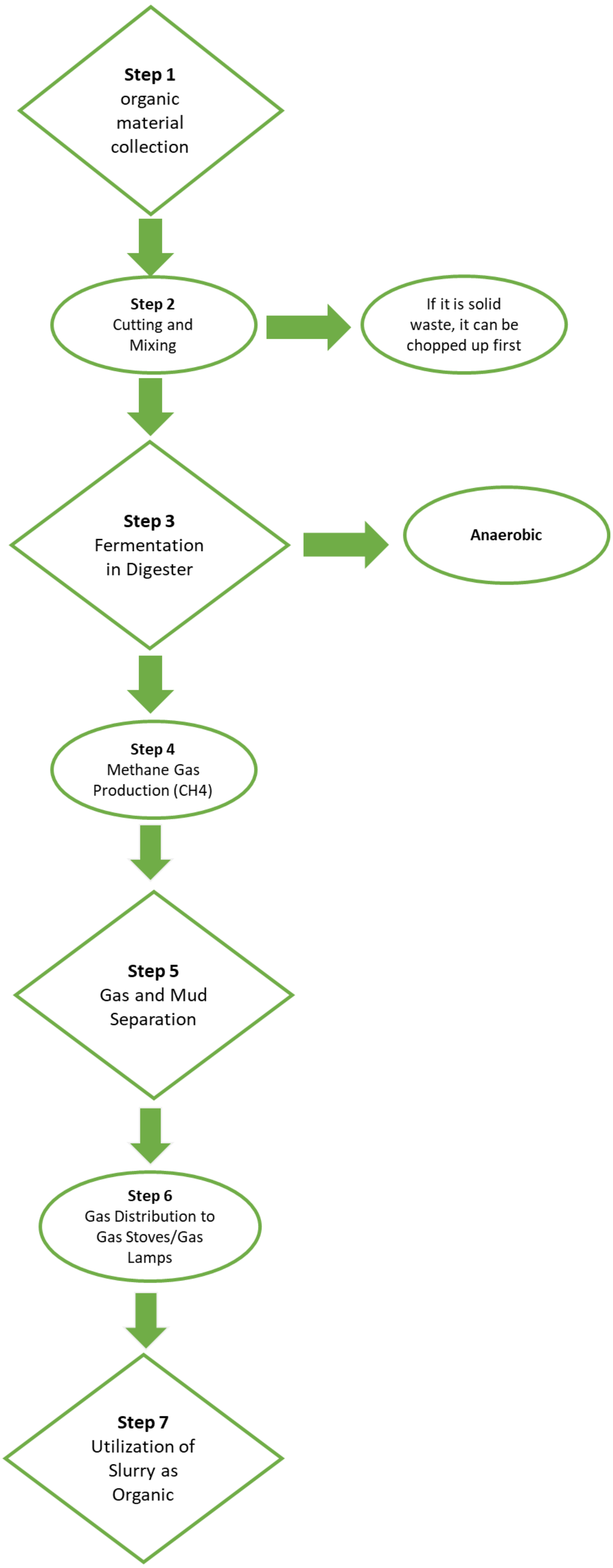

Figure 1. Biogas production process.

4. RESULTS AND DISCUSSION

A technical and economic analysis of household biogas unit production was conducted to assess the project's feasibility in terms of cost structure, revenue generation, and investment efficiency. The results of this analysis are summarized in **Table 2**. In terms of fixed costs, the total expenditure amounted to Rp. 128,291,113.50. These costs remain constant regardless of production volume and primarily consist of capital investment (Rp119,668,967.25) and depreciation (Rp. 8,622,146.25). Fixed costs represent the initial expenditures that are unaffected by fluctuations in production scale. In contrast, variable costs reached a significantly higher amount of Rp. 4,518,359,137,500.00. Unlike fixed costs, variable costs fluctuate with production output and are largely driven by raw material expenses (Rp. 2,754,000,000,000.00) and selling expenses (Rp. 1,764,000,000,000.00). Additional operational expenditures, including utilities, labor, and labor-related costs, further contributed to the overall production expense. This cost breakdown underscores the capital-intensive nature of household biogas unit production, with raw materials and selling expenses dominating the expenditure profile.

Table 2. Results of household biogas production cost.

No.	Analysis Component	Description	Value (Rp)
A	**Fixed Cost**		
1	Capital Related Cost	Initial capital cost	119,668,967.25
2	Depreciation	Asset depreciation	8,622,146.25
	Total Fixed Costs		**128,291,113.50**
B	**Variable Cost**		
1	Raw Materials	Raw material cost of production	2,754,000,000,000.00
2	Utilities	Operational costs (electricity, water)	337,500.00
3	Operational Labor (OL)	Operational labor salary	276,000,000.00
4	Labor Related Costs	Employee allowances/surcharges	82,800,000.00
5	Cost of Sales	Marketing and distribution costs	1,764,000,000,000.00
	Total Variable Cost		**4,518,359,137,500.00**

Table 2 highlights the project's strong potential in terms of revenue generation and profitability. The total projected sales amounted to Rp. 25,200,000,000,000.00, while the overall manufacturing costs were calculated at Rp. 4,518,478,806,467.25. Although the gross profit margin was relatively modest at 0.82%, the project remains financially attractive because of the substantial absolute profit realized per unit of sales, which reached Rp. 223,783.39. This result indicates that while percentage-based profitability is constrained by high variable costs, the combination of economies of scale and stable market demand can sustain long-term economic viability.

Table 2. Household biogas production income and profits.

No	Analysis Component	Description	Value (Rp)
1	Total Sales	Estimated revenue from the sale of biogas units	25.200.000.000.000,00
2	Manufacturing Cost	Total production cost (fixed + variable cost)	4.518.478.806.467,25
3	Profit	Net Profit	0,82
4	Profit Margin to Sales	Percentage of profit to total sales	223.783,39

Table 3 presents the BEP analysis. The BEP is achieved at a production volume of approximately 5,583 units, supported by fixed costs of Rp. 128,291,113.50 and variable costs

DOI: https://doi.org/10.17509/ajse.v6i1.89792
p- ISSN 2776-6098 e- ISSN 2776-5938

of Rp. 4,518,359,137,500.00. This indicates that the project can cover its total operational expenses at a relatively small production scale. In addition, the investment feasibility indicators demonstrate highly favorable outcomes. The return on investment (ROI) was calculated at 239,865.12%, while the payback period is remarkably short, at only 3.42 days. These results underscore the project's exceptional financial efficiency and confirm its overall economic viability. Although the gross profit margin is relatively modest at 0.82%, the absolute profit per unit remains substantial at Rp. 223,783.39. Taken together, the findings suggest that despite the considerable variable costs, the project offers strong revenue potential, rapid capital recovery, and excellent prospects for long-term profitability.

Table 3. Break-even point of household biogas production.

No	Analysis Component	Description	Value (Rp)
1	BEP	Break-even point	5.582,83
2	Fixed Cost at BEP	Fixed costs at break-even	128.291.113,50
3	Variable Cost at BEP	Variable cost at break-even	4.518.359.137.500,00
4	Revenue at BEP	Revenue at the break-even point	25.200.000.000.000,00
5	ROI (Return on Investment)	Return on investment	239.865,12 %
6	Payback Period (Return on Investment Time)	Time period to return the initial investment	3,42 hari

Overall, the technical and economic analysis confirms that household biogas unit production represents a highly profitable investment opportunity as well as a sustainable renewable energy solution. The combination of relatively affordable start-up costs, substantial revenue potential, and an exceptionally short payback period positions this project as a strategic initiative to accelerate renewable energy adoption at the community level. **Figure 2** illustrates the business development trajectory based on the CNPV calculation. The CNPV/TIC (Net Present Value to Total Initial Cost) ratio shows a dynamic trend over time. In the first year, the value remains negative, reflecting that the initial investment has not yet been recovered. However, the project quickly reaches its breakeven point within just 1–2 years. Beyond this stage, the CNPV/TIC ratio demonstrates consistent growth, indicating sustained profitability. By the 20th year, the value exceeds 20 times the total initial cost, highlighting the project's substantial long-term profit potential. Taken together, these results provide strong evidence that the project ensures high economic viability, rapid return on investment, and long-term financial sustainability.

The renewable energy policy outlined in Law No. 30/2007 on Energy provides a crucial foundation for this study. Specifically, Article 1, paragraph 7 defines renewable energy as energy derived from naturally replenishable resources, while Article 4 mandates the state to regulate new and renewable energy resources for the public good. These legal provisions directly inform the findings of this study, which offer an empirical basis for policymakers to formulate strategies that accelerate the adoption of community-based renewable energy. The economic analysis highlights the significant savings and long-term benefits associated with household biogas, presenting a compelling case for stronger government support through incentives, subsidies, and microfinance schemes. Accordingly, this study recommends policy updates that prioritize decentralized approaches and foster greater collaboration among government agencies, the private sector, and local communities in advancing renewable energy development. Beyond economic considerations, the findings demonstrate notable social impacts. Household biogas adoption promotes environmental sustainability by reducing reliance on fossil fuels and firewood, both of which have adverse

DOI: https://doi.org/10.17509/ajse.v6i1.89792
p- ISSN 2775-6793 e- ISSN 2775-6815

effects on human health and the environment [45]. It also enhances energy security [46], reduces household expenditures, and encourages sustainable lifestyles. More broadly, biogas utilization contributes to improved quality of life in rural areas [47] and supports community-level energy self-sufficiency [48].

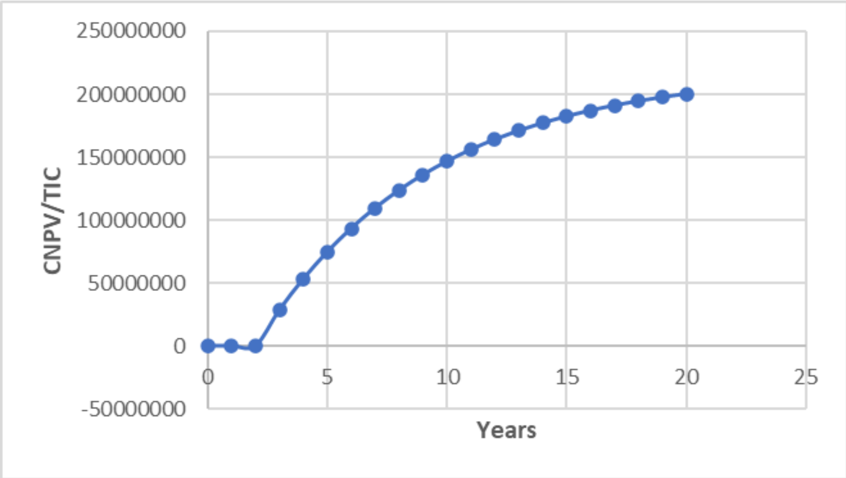

Figure 2. Trend of increase in CNPV/TIC (Net Present Value/Total Initial Cost) over a Period of 20 Years.

5. CONCLUSION

This study confirms that household biogas production is a financially viable and socially beneficial solution for advancing renewable energy adoption. Through a techno-economic approach, it demonstrates strong investment potential, operational efficiency, and rapid capital recovery. Despite high operational costs, consistent market demand and supportive public policies enhance its sustainability. Beyond economic benefits, biogas contributes to environmental protection, local energy independence, and community empowerment. These findings offer valuable insights for policymakers, investors, and development practitioners aiming to promote clean energy transitions. Therefore, household biogas is not only a profitable venture but also a strategic instrument for achieving the SDGs.

6. Acknowledgement

We thank the Chancellor and Rector of Universitas Djuanda and Djuanda Reborn for fully supporting this study.

7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

7. REFERENCES

[1] Mukti, R.N., Salsabilla, A., Muamar, A.S., Prima, E.C., and Hana M.N. (2021). Biogas effectiveness test from household waste (vegetable waste) with cow dung starter and EM4. *Indonesian Journal of Multidiciplinary Research, 1*(1), 73-78.

DOI: https://doi.org/10.17509/ajse.v6i1.89792
p- ISSN 2776-6098 e- ISSN 2776-5938

[2] Awan, F. N., Mawaddah, N., Munandar, A., Taher, T., and Fajar, M. (2024). Utilization of animal manure for biogas production: Renewable energy solutions for livestock houses. *IOP Conference Series: Earth and Environmental Science, 1414*(1), 1–5.

[3] Fendel, V., Kranert, M., Maurer, C., Garcés-Sánchez, G., Huang, J., and Ramakrishna, G. (2022). Fendel, V., Kranert, M., Maurer, C., Garcés-Sánchez, G., Huang, J., and Ramakrishna, G. (2022). Stakeholder assessment on closing nutrient cycles through co-recycling of biodegradable household kitchen waste and black water between rural and urban areas in south India. *Recycling*, *7*(4), 1-16.

[4] Elizabeth, R. (2021). Pemakaian biogas: Hemat biaya bahan bakar dan tambahan pendapatan rumahtangga mendukung ketahanan energi. *Risalah Kebijakan Pertanian dan Lingkunga*n, *8*(3), 151–175.

[5] Luo, B., Khan, A. A., Ali, M. A. S., and Yu, J. (2021). An evaluation of influencing factors and public attitudes for the adoption of biogas system in rural communities to overcome energy crisis: A case study of Pakistan. *Science of the Total Environment*, *778*(146208), 1–10.

[6] Gadirli, G., Pilarska, A. A., Dach, J., Pilarski, K., Kolasa-Więcek, A., and Borowiak, K. (2024). Fundamentals, operation and global prospects for the development of biogas plants—A Review. *Energies*, *17*(3), 1-26.

[7] Chebotareva, G. S., and Dvinayninov, A. A. (2023). Economic feasibility of gasification scenarios in remote areas (the case of Sverdlovsk region, Russia). *R-Economy*, *9*(1), 5–18.

[8] Sharma, K. K., Gupta, A., Kumar, R., Chohan, J. S., Sharma, S., Singh, J., Khalilpoor, N., Issakhov, A., Chattopadhyaya, S., and Dwivedi, S. P. (2021). Economic evaluation of a hybrid renewable energy system (HRES) using hybrid optimization model for electric renewable (HOMER) software-a case study of rural India. *International Journal of Low-Carbon Technologies*, *16*(3), 814–821.

[9] Li, M., Pysmenna, U., Petrovets, S., Sotnyk, I., and Kurbatova, T. (2024). Managing the development of decentralized energy systems with photovoltaic and biogas household prosumers. *Energy Reports*, *12*, 4466–4474.

[10] Wiprächtiger, M., Haupt, M., Froemelt, A., Klotz, M., Beretta, C., Osterwalder, D., Burg, V., and Hellweg, S. (2023). Combining industrial ecology tools to assess potential greenhouse gas reductions of a circular economy: Method development and application to Switzerland. *Journal of Industrial Ecology*, *27*(1), 254–271.

[11] Kesharwani, N., and Bajpai, S. (2021). Pilot scale anaerobic co-digestion at tropical ambient temperature of India: Digester performance and techno-economic assessment. *Bioresource Technology Reports*, *15*, 100715.

[12] Rahmawati, R., Roestamy, M., Martin, A. Y., Fauziah, R. S. P., Salbiah, E., Wahyudin, C., Ramdani, F. T., and Harini, S. (2025). Aromatic art paper: Concept, technology, cost analysis, and application in economic businesses for tourist village communities development. *Journal of Engineering Science and Technology*, *20*(1), 17–24.

[13] Ramdani, F. T., Awa, A., Wahyudin, C., Apriliani, A., Ilyanawati, R. Y. A., Rahmawati, R., Sastrawan, B., and Yama, A. (2025). Production of organic fertilizer from cooking oil waste to support sustainable development goals (SDGs): Technology and cost analysis. *Journal of Engineering Science and Technology*, *20*(1), 65–72.

DOI: https://doi.org/10.17509/ajse.v6i1.89792
p- ISSN 2775-6793 e- ISSN 2775-6815

[14] Wahyudin, C., Apriliyani, N. V., Hasbiyah, D., Pratidina, G., Rahmawati, R., Purnamasari, I., Syahrudin, D., and Pamuncak, M. B. (2025). Production of cassava into plastic bags with a collaborative governance perspective to support sustainable development goals (SDGs): Technology and cost analysis. *Journal of Engineering Science and Technology*, *20*(1), 49–56.

[15] Sastrawan, B., Susanti, S., Madya, F., Wulandari, F. R., Maruapey, M. H., Hernawan, D., Ramdani, F. T., and Surur, M. (2025). Organic compost fertilizer from livestock bone waste: Technology and cost analysis. *Journal of Engineering Science and Technology*, *20*(1), 161–168.

[16] Warizal, W., Anwar, S., Awa, A., Mubarokah, S. L., Kusuma, I. C., Aziz, I. A., Hambani, S., and Pangestu, R. A. (2025). Production of roster from plastic waste to support sustainable development goals (SDGs): Technology and cost analysis. *Journal of Engineering Science and Technology*, *20*(1), 33–40.

[17] Adri, H. T., Fauziah, R. S. P., Sesrita, A., Indra, S., Monaya, N., Suherman, I., and Pengestu, R. A. (2025). Particle board from rubber woods: Concept, technology, cost analysis, and application for teaching aids in science subjects in elementary schools. *Journal of Engineering Science and Technology*, *20*(1), 177-184.

[18] Purnomo, A. M., Monaya, N., Suherman, I., Qulyubi, A. T., Amalia, N., Sihotang, S., and Fanani, M. Z. (2025). Social-economic evaluation of dye processing from Indigofera tinctoria Linn in the Ammatoa Kajang indigenous cultural community. *Journal of Engineering Science and Technology*, *20*(2), 206-213.

[19] Aziz, I. A., Hasbi, S., Munawar, W., Kurnia, T., Ibnu, A. R., Anwar, S., Lathifah, Z. H., and Apriyana, M. (2025). Production of charcoal briquettes from coconut shell waste to improve community economy: Technology and cost analysis. *Journal of Engineering Science and Technology*, *19*(6), 121-128.

[20] Ramdhani, M. R., Fauziah, R. S. P., Rusli, R. K., Kholik, A., Indra, S., Warizal, W., Munawar, W., and Ibnu, A. R. (2024). Production of smart wheel educational props from mahogany waste: Technology and cost analysis. *Journal of Engineering Science and Technology*, *19*(6), 105-112.

[21] Hussein, S., Syafi'i, S., and Muthia, R. (2025). Toward carbon-neutral power generation in Indonesia: A techno-economic assessment of renewable ammonia co-firing in combined cycle power plants. *Indonesian Journal of Science and Technology*, *10*(3), 529-550.

[22] Ramdani, F.T., Roestamy, M., Rahmawati, R., Ilyanawati, R.Y.A., and Sudarsa, A.S. (2026). Techno-economic household-scale solar power plants in support of the policy of presidential regulation number 112 of 2022 concerning the acceleration of renewable energy development. *Indonesian Journal of Science and Technology*, *11*(2), 205-216.

[23] Maratussolihah, P., Rahmadianti, S., Tyas, K.P., Girsang, G.C.S., Nandiyanto, A.B.D., and Bilad, M.R. (2022). Techno-economic evaluation of gold nanoparticles using banana peel (Musa Paradisiaca). *ASEAN Journal for Science and Engineering in Materials*, *1*(1), 1-12.

DOI: https://doi.org/10.17509/ajse.v6i1.89792
p- ISSN 2776-6098 e- ISSN 2776-5938

[24] Rachmadhani, D.R., and Priyono, B. (2024). Techno-economic analysis of the business potential of recycling lithium-ion batteries using hydrometallurgical methods. *ASEAN Journal for Science and Engineering in Materials*, *3*(2), 117-132.

[25] Samsuri, S., Anwar, S., Harini, S., Kartini, T., Monaya, N., Warizal, W., and Setiawan, A.B. (2025). Techno-economic feasibility and bibliometric literature review of integrated waste processing installations for sustainable plastic waste management. *ASEAN Journal for Science and Engineering in Materials*, *4*(2), 225-244.

[26] Sesrita, A., Adri, H.T., Suherman, I., Rasmitadila, R., and Fanani, M.Z. (2025). Production of wet organic waste ecoenzymes as an alternative solution for environmental conservation supporting sustainable development goals (SDGs): A techno-economic and bibliometric analysis. *ASEAN Journal for Science and Engineering in Materials*, *4*(2), 245-266.

[27] Syahrudin, D., Roestamy, M., Fauziah, R.S.P., Rahmawati, R., Pratidina, G., Purnamasari, I., Muhtar, S., and Salbiah, E. (2026). Techno-economic analysis of production ecobrick from plastic waste to support sustainable development goals (SDGs). *ASEAN Journal for Science and Engineering in Materials*, *5*(1), 9-16.

[28] Apriliani, A., Waahyudin, C., Ramdani, F.T., Martin, A.Y., Syahrudin, D., Hernawan, D., and Salbiah, E. (2026). Techno-economic analysis of sawdust-based trash cans and their contribution to Indonesia's green tourism policy and the Sustainable Development Goals (SDGs). *ASEAN Journal for Science and Engineering in Materials*, *5*(1), 17-36.

[29] Ragahita, R., and Nandiyanto, A.B.D. (2022). Computational bibliometric analysis on publication of techno-economic education. *Indonesian Journal of Multidiciplinary Research*, *2*(1), 213-220.

[30] Nandiyanto, A. B. D., Maulana, M. I., Raharjo, J., Sunarya, Y., and Minghat, A. D. (2020). Techno-economic analysis for the production of LaNi5 particles. *Communications in Science and Technology*, *5*(2), 70–84.

[31] Indra, S., Subagyo, A., Dyarini, and Nandiyanto, A. B. D. (2025). Techno-economic analysis of solar panel production from recycled plastic waste as a sustainable energy source for supporting digital learning in schools based on Sustainable Development Goals (SDGs) and science-technology integration. *Journal of Engineering Science and Technology*, *20*(4), 1149–1158.

[32] Mukmin, M. N., Sukoharsono, E. G., Rusydi, M. K., Prihatiningtias, Y. W., and Nandiyanto, A. B. D. (2025). Techno-economic feasibility of educational board game production from agro-industrial waste in support of Sustainable Development Goals (SDGs) through science and technology integration. *Journal of Engineering Science and Technology*, *20*(4), 1111–1120.

[33] Nandiyanto, A. B. D., Al Husaeni, D. F., Ragadhita, R., and Kurniawan, T. (2021). Resin-based brake pad from rice husk particles: From literature review of brake pad from agricultural waste to the techno-economic analysis. *Automotive Experiences*, *4*(3), 131–149.

[34] Nandiyanto, A. B. D., Soegoto, E. S., Maulana, S. A., Setiawan, A. W. F., Almay, F. S., Hadinata, M. R., Ragadhita, R., and Luckyardi, S. (2022). Techno-economic evaluation of biodiesel production from edible oil waste via supercritical methyl acetate transesterification. *Nigerian Journal of Technological Development*, *19*(4), 332–341.

DOI: https://doi.org/10.17509/ajse.v6i1.89792
p- ISSN 2775-6793 e- ISSN 2775-6815

[35] Surendra, K. C., Takara, D., Hashimoto, A. G., and Khanal, S. K. (2014). Biogas as a sustainable energy source for developing countries: Opportunities and challenges. *Renewable and Sustainable Energy Reviews*, *31*, 846–859.

[36] Elmardi Suleiman, D. O. M., and Muki Nafea, N. M. (2021). A review study of economics analysis in engineering projects. *International Journal of Engineering Applied Sciences and Technology*, *6*(4), 1–9.

[37] Anyebe, P. A. A. (2018). An Overview of approaches to the study of public policy. *International Journal of Political Science*, *4*(1), 8–17.

[38] Supriadi, A., and Hadi, S. (2019). Desentralisasi kebijakan energi terbarukan dan dampaknya pada partisipasi masyarakat. *Jurnal Administrasi Publik*, *5*(1), 40–55.

[39] Sukmawati, R., and Budi, S. (2022). Peran modal sosial dalam keberlanjutan program biogas komunal di desa Y. *Jurnal Sosiologi Pedesaan*, *7*(2), 160–175.

[40] Fitri, N., and Raharjo, B. (2018). Community engagement in rural renewable energy projects: A case study in Indonesia. *Journal of Sustainable Development Studies*, *11*(3), 88–102.

[41] Chen, E. F., Li, G., and Wang, H. (2018). Economic feasibility assessment of renewable energy projects: A comprehensive guide. *Renewable and Sustainable Energy Reviews*, *92*, 123–135.

[42] Samah, A. A., and Aref, F. (2011). The theoretical and conceptual framework and application of community empowerment and participation in processes of community development in Malaysia. *Journal of American Science*, *7*(2), 186–195.

[43] Nandiyanto, A. B. D. (2018). Cost analysis and economic evaluation for the fabrication of activated carbon and silica particles from rice straw waste. *Journal of Engineering Science and Technology*, *13*(6), 1523–1539.

[44] Ragadhita, R., Bayu, A., Nandiyanto, D., Maulana, A. C., Oktiani, R., Sukmafitri, A., Machmud, A., and Surachman, E. (2019). Techo-economic analysis for the production of titanium dioxide nanoparticle produced by liquid-phase synthesis method. *Journal of Engineering Science and Technology*, *14(*3), 1639–1652.

[45] Mustikawati, I. (2019). Manfaat biogas sebagai bahan bakar alternatif bagi rumah tangga. *Majalah Ilmiah Pelita Ilmu*, *2*(2), 27–34.

[46] Adellea, A. J. (2022). Implementasi Kebijakan energi baru dan energi terbarukan dalam rangka ketahanan energi nasional. *Indonesian State Law Review*, *5*(1), 43–51.

[47] Wulandar, C. I., Aliyudin, and Dewi, R. (2021). Pemberdayaan masyarakat melalui program keaksaraan. *Tamkin: Jurnal Pengembangan Masyarakat Islam*, *6*(1), 1–20.

[48] Wijayanti, O. E. (2017). Analisis kinerja program: Dampak pelaksanaan program desa mandiri energi (DME) berbasis biogas dalam peningkatan keberdayaan masyarakat pengguna biogas di desa Purworejo Kecamatan Sanankulon Kabupaten Blitar. *Kebijakan dan Manajemen Publik*, *5*(1), 128-134.

DOI: https://doi.org/10.17509/ajse.v6i1.89792
p- ISSN 2776-6098 e- ISSN 2776-5938