

Biogas Production and Utilization: A Review of Processes, Applications, Advantages and Limitations

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ABSTRACT

Biogas is a renewable and sustainable source of energy produced through the anaerobic digestion of organic materials. It primarily consists of methane along with carbon dioxide and trace gases. Growing concerns over global warming, greenhouse gas emissions, and depletion of fossil fuel reserves have intensified the need for alternative and environmentally friendly energy sources. Biogas technology offers a dual advantage of waste management and energy recovery, particularly in rural and developing regions. This review paper discusses the concept of biogas production, sources of feedstock, types of biogas digesters, applications, advantages, limitations, and future prospects of biogas technology based on existing literature.

Keywords: Biogas; Renewable energy, Methane; Anaerobic digestion, Sustainable development

INTRODUCTION

The increasing demand for energy and the adverse environmental impacts of fossil fuel consumption have encouraged the exploration of renewable energy alternatives (Gupta *et al.*, 2023). Biogas is one such alternative energy source produced through the anaerobic digestion of biodegradable organic matter such as animal dung, agricultural residues, food waste, and municipal waste (Alengebawy *et al.*, 2024). The major component of biogas is methane, which makes it suitable for use as a fuel for cooking, heating, electricity generation, and transportation (Jameel *et al.*, 2024).

Biogas technology not only provides clean energy

but also contributes to improved sanitation, waste management, reduction in deforestation, and mitigation of greenhouse gas emissions (Lapiso, 2025; Ravindran *et al.*, 2025). Owing to these benefits, biogas systems have gained importance, especially in rural areas of developing countries where access to conventional energy sources is limited (Pilarski *et al.*, 2025).

Biogas Production Process:

Biogas is produced through anaerobic digestion, a biological process in which microorganisms decompose organic matter in the absence of oxygen (Alengebawy *et al.*, 2024). This process occurs in four main stages: hydrolysis, acidogenesis, acetogenesis, and

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methanogenesis (DelaVega-Quintero *et al.*, 2025). The digestion process takes place in an airtight structure known as a biogas digester, where controlled conditions of temperature, moisture, and pH are maintained to ensure efficient gas production (Jameel *et al.*, 2024).

Common feedstocks for biogas production include cattle dung, poultry waste, crop residues, kitchen waste, sewage sludge, and organic municipal waste (Purwasih *et al.*, 2025). The by-product of this process, known as digestate or slurry, is rich in nutrients and can be used as an organic fertilizer, thereby supporting sustainable agricultural practices (Ravindran *et al.*, 2025).

Types of Biogas Digesters:

Various types of biogas digesters have been developed to suit different climatic, economic, and social conditions (Pilarski *et al.*, 2025). The commonly used small-scale digesters include:

Fixed-Dome Digester:

The fixed-dome digester consists of an underground masonry structure with a rigid gas-holding dome. It is durable, requires low maintenance, and is widely used in several developing countries due to its long service life and low operational costs (Jameel *et al.*, 2024).

Floating Drum Digester:

This type comprises an underground digester and a movable gas holder that floats on the slurry. The drum rises and falls depending on gas production, providing constant gas pressure. Floating drum plants are commonly used in India and are preferred where constant gas pressure is required (Pilarski *et al.*, 2025).

Balloon or Bag Digester:

The balloon digester is made of flexible plastic or rubber material. It is simple to construct and low-cost but has a shorter lifespan compared to masonry digesters. It is commonly used in some Latin American and African countries where low initial investment is a priority (Bórawski *et al.*, 2024).

Applications of Biogas:

Biogas has diverse applications across domestic, agricultural, and industrial sectors. It is primarily used for cooking and heating in households, especially in rural areas (Gupta *et al.*, 2023). In addition, biogas can be used to generate electricity through engine-generator

systems, power water pumps, operate small-scale machinery, and provide lighting (Bórawski *et al.*, 2024).

Compressed biogas can also be used as a substitute for compressed natural gas (CNG) in vehicles, contributing to reduced emissions from the transport sector (Ravindran *et al.*, 2025). The digestate obtained from biogas plants serves as an excellent organic fertilizer, improving soil fertility and crop productivity (Alengebawy *et al.*, 2024).

Advantages of Biogas Technology:

Biogas technology offers several environmental, economic, and social benefits. It enables effective utilization of organic waste and reduces environmental pollution (Lapiso, 2025). The use of biogas contributes to the reduction of greenhouse gas emissions and mitigation of climate change by capturing methane that would otherwise escape into the atmosphere (Jameel *et al.*, 2024).

Additionally, biogas reduces dependence on fossil fuels, improves sanitation and hygiene, generates employment opportunities, and produces nutrient-rich organic fertilizer that supports sustainable agriculture (Gupta *et al.*, 2023; Pilarski *et al.*, 2025).

Limitations and Challenges:

Despite its advantages, the adoption of biogas technology faces several challenges. High initial installation costs, lack of technical knowledge, inadequate maintenance, and limited awareness hinder widespread implementation (DelaVega-Quintero *et al.*, 2025). In some cases, leakage, improper construction, and unfavorable climatic conditions affect plant performance and gas yield (Pilarski *et al.*, 2025).

Social acceptance and consistent availability of feedstock also influence the success of biogas systems, particularly in small-scale and household-level applications (Lapiso, 2025).

Future Prospects:

With increasing emphasis on sustainable development and renewable energy, biogas technology has significant future potential (Ravindran *et al.*, 2025). Technological advancements in digester design, gas upgrading, and system integration, along with government support and policy incentives, can enhance the adoption of biogas systems (DelaVega-Quintero *et al.*, 2025).

Integrating biogas technology with waste

management and agricultural practices can further strengthen its role in sustainable energy generation and circular economy frameworks (Lapiso, 2025).

Conclusion:

Biogas represents a promising renewable energy source that addresses energy scarcity, waste management, and environmental protection simultaneously (Jameel et al., 2024). Its application can significantly contribute to sustainable development, particularly in rural and developing regions (Gupta et al., 2023). Continued research, technological improvements, and supportive policies are essential to overcome existing challenges and promote the large-scale adoption of biogas technology (Ravindran et al., 2025).

REFERENCES

- Alengebawy, A., Abdelkhalek, M.A., Qureshi, S.R. and Wang, M.Q. (2024). Anaerobic digestion of agricultural waste for biogas production: Mechanisms, sustainability, and circular bioeconomy perspectives. *Environmental Chemistry Letters*, **22**(2) : 987–1006. <https://doi.org/10.1007/s10311-024-01789-1>
- Bórawski, P., Beldycka-Bórawska, A., Jankowski, K. J., Dubis, B. and Dunn, J. W. (2024). Perspectives of electricity production from biogas in the European Union. *Energies*, **17**(5) : 1169. <https://doi.org/10.3390/en17051169>
- DelaVega-Quintero, J. C., López-Cortés, A., García-Depraect, O. and Gómez-Ramírez, J. (2025). Advances and challenges in anaerobic digestion for biogas production: Policy, technological, and microbial perspectives. *Processes*, **13**(11) : 3648. <https://doi.org/10.3390/pr13113648>
- Gupta, P., Singh, R.S. and Shukla, A. (2023). Biogas as a promising bioenergy source: A critical review focusing on sustainable development and utilization. *Energy Conversion and Management*, **278**, 116583. <https://doi.org/10.1016/j.enconman.2022.116583>
- Ijaola, A. O., Adeniyi, A. G. and Akinlabi, E. T. (2024). Biogas production, upgrading, and utilization: A comprehensive review. *Journal of Engineering and Applied Sciences*, **19**(1) : 1–15.
- Jameel, M. K., Al-Mansour, F. and Farooq, M. (2024). Biogas: Production, properties, applications, economic and future perspectives—A state-of-the-art review. *Renewable and Sustainable Energy Reviews*, **194**, 114120. <https://doi.org/10.1016/j.rser.2024.114120>
- Lapiso, T.T. (2025). Biogas as an instrument for circular economy and sustainable development: A systematic scoping review. *Sustainable Development*, **33**(1) : 1–15. <https://doi.org/10.1002/sd.70080>
- Pilarski, K., Adamski, M. and Dach, J. (2025). Biogas production in agriculture: Technological, environmental, and economic insights. *Energies*, **18**(21) 5844. <https://doi.org/10.3390/en18215844>
- Purwasih, R., Suryani, A. and Hidayat, M. (2025). Anaerobic digestion of fruit waste for biogas production: A bibliometric review (2005–2025). *Cleaner Engineering and Technology*, **15**, 100708. <https://doi.org/10.1016/j.clet.2025.100708>
- Ravindran, J. K., Nair, P. R. and Kumar, S. (2025). Current production routes and life cycle analysis of green fuels (biogas) for decarbonization. *Applied Energy*, **372**, 121023. <https://doi.org/10.1016/j.apenergy.2025.121023>
