

Research Article

Biogas as a Powerhouse of Renewable Energy: A Review

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ABSTRACT

This paper explores the potential of biogas as a renewable fuel. Biogas is a clean and sustainable energy source generated by the breakdown of organic material by certain bacteria under anaerobic conditions. It contains carbon dioxide, hydrogen, methane and can be produced from a wide range of waste materials, including sewage, manure, food, agricultural waste. Anaerobic digestion is the process used to produce biogas, which can then be used for heating, power generation, fuel, raw materials for further processing and production of sustainable chemicals such as hydrogen, CO₂, biofuels. With a plentiful supply of cost-efficient feedstocks and a broad range of applications, biogas is an attractive and sustainable energy resource. This paper outlines the applications of biogas in power generation and fuel production as potential pathways for its use in the transition towards a more sustainable energy system. The paper also discusses the expanding biogas-based power generation over the past decade and the feasibility and productivity of biogas as an energy resource.

Keywords: Biogas, Renewable Fuel, Power Generation, Green Energy, Anaerobic Digestion, Future Prospects

Introduction

Carbon dioxide and methane are the two primary components of biogas. It is possible that trace quantities of hydrogen sulphide and siloxanes are present. Many gases, such as methane, hydrogen, carbon monoxide, can be burned or oxidised with oxygen. As a result of this energy discharge, biogas has the potential to be used as a fuel; it can be used for anything that requires heat, including cookery. It is also possible to run a motor on the gas, which will convert the gas's energy into both heat and electricity. Diesel engines, petrol or oil engines, turbines, microturbines and Stirling engines are all viable options for converting biogas into usable energy.¹⁻⁹

According to a statement issued by the Punjab provincial government, the Bhutan Kalan community in the Sangrur

district is presently producing compressed biogas for sale. It has an estimated daily production capacity of 33.23 tonnes,^{10,11} making it the largest compressed biogas facility in Asia. In addition, it has been reported that the Punjab Energy Development Agency, a state organisation tasked with promoting and expanding renewable energy projects, has allocated 42 additional CBG units, each of which is capable of producing 492,58 tonnes of compressed biogas per day.¹²⁻¹³ This would be in addition to the already available units. In the past, the burning of vegetation in Punjab was a source of concern due to the air pollution and health issues it caused. Also a source of concern were agricultural residues and other organic materials. These biogas facilities use these residues and several other organic materials to produce compressed biogas.¹⁴⁻¹⁷



Several modest and medium-sized facilities in India produce compressed biogas or bio-CNG for automobiles. The largest compressed biogas facility in Asia is situated in Sangrur, Punjab, India. In 2014-2015, the estimated biogas production in our country is 20.757 billion cubic metres. This is equivalent to 6,600,000,000 domestic LPG cylinders. This represents 5% of the nation's current LPG consumption.¹⁸⁻¹⁹ Depending on the availability of various resources, the biogas potential in 2040 ranges from 310 to 655 billion m³/year, as determined by the analysis. In the scenario of high availability, the estimated biogas potential in 2040 accounts for approximately 36 percent of India's total primary energy supply in 2015. The state with the maximum production is Maharashtra with 3,578 million cubic meters, followed by Andhra Pradesh with 2,165 million cubic metres.²⁰⁻²¹

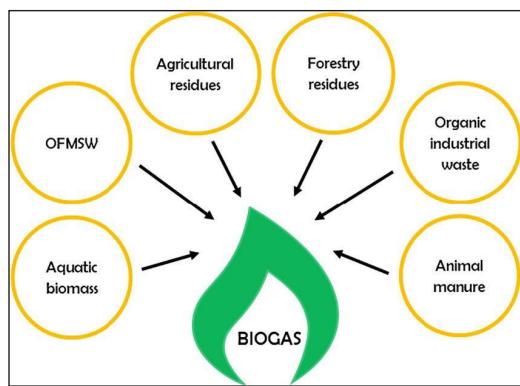


Figure 1. Sources of Biogass

Biogas Production Process

A variety of organic waste are converted into biogas. Because it is produced exclusively from local feedstocks, it is a renewable and environmentally friendly fuel that can be used for both transportation and industrial purposes. The organic nutrients recovered during production contribute further to the circular economy advantages of biogas production. Various varieties of basic materials can be utilised to produce biogas. Biogas is primarily produced by microorganisms that graze on organic matter. These bacteria decompose food to produce methane, which can be used locally as-is or converted into biogas with properties similar to those of natural gas to allow the biogas to be transported over greater distances. In addition, during the process, material containing organic nutrients is produced; this material can be utilised in numerous sectors, including agriculture. There are numerous stages involved in the production of biogas, which is accomplished with time-tested technology. To make biowaste suitable for anaerobic fermentation, it is broken down and slurred into smaller pieces. To facilitate processing, biowaste is slurred by saturating it with liquid. Due to the use of microorganisms in humid environments, biowaste is incinerated at approximately 37 °C. Large containers must

undergo approximately three weeks of anaerobic digestion to produce biogas. Carbon dioxide and other impurities are removed during the final phase of gas purification.²²⁻²⁷

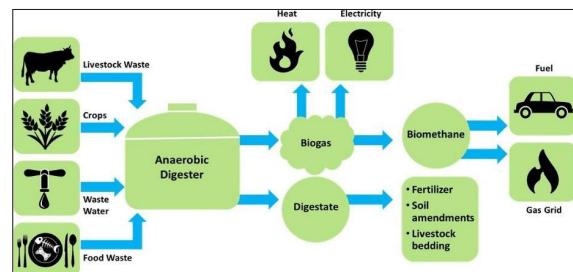


Figure 1. Sources of Biogass

Versatility and Sustainability of Biogas Energy

Biogas is a versatile energy source with a lot of uses and advantages. following are some key points about the versatility and sustainability of biogas energy:^{28,35}

- Biogas is a reliable, affordable, sustainable energy source
- It can be used for cooking, residential and public lighting, to power engines
- Biogas is pollution-free and environmentally friendly
- It is easy to produce, move, store, it enhances the cleanliness of the environment
- Biogas is a green technology that has favorable effects on the environment
- Biogas can be produced from municipal solid waste and accumulated animal waste from food production
- Biogas technology helps decrease insects, infections, odor associated with conventional manure heaps
- Methane production is decreased by the conversion of organic waste into biogas because carbon dioxide is produced instead of methane during effective combustion
- Biogas can be utilized as a raw material for the generation of hydrogen and transportation fuels as well as in fuel cells for direct conversion to electricity
- Biogas use can replace chemical fertilizers with enhanced bio-manure
- Biogas helps in sanitary issues as toilets may be connected directly to biogas plants
- Biogas results in a net decrease in greenhouse gas emissions as burning biogas releases carbon dioxide instead of methane
- Biogas technology provides job opportunities, biogas offers more financial and practical advantages to customers

Biogas-Powered Electricity: Leading the Charge for Green Energy in the Future

The use of biogas in various applications holds significant promise for the green revolution. These potential applications are explored in more detail below:³⁶⁻⁴⁴

- Biogas i3ctor. Farm waste such as manure, crop residue, other organic matter can be used to produce biogas through anaerobic digestion. This biogas can then be used to generate electricity, which can be used to power the farm or sold to the local grid
- Biogas can also be used to produce electricity in small-scale applications such as in rural areas where there is no access to the grid. In these cases, biogas can be used to power small-scale generators, which can be used to power appliances such as air conditioners

Biogas has emerged as a potential powerhouse of renewable energy in recent years. It is a versatile fuel that can be produced from various organic materials, including agricultural waste, food waste, sewage sludge, industrial waste. The process of biogas production not only generates energy but also helps in waste management by converting waste into a useful resource. A review of literature indicates that research and development are underway to further enhance the efficiency of biogas production and utilization. For instance, studies on the trends in coal fly ash utilization and developments in horizontal axis wind turbines have provided useful insights to improve the performance of biogas plants. However, it is also essential to address the environmental concerns associated with the disposal of e-waste, which is likely to increase with the growth of the biogas industry.⁴⁵⁻⁴⁹

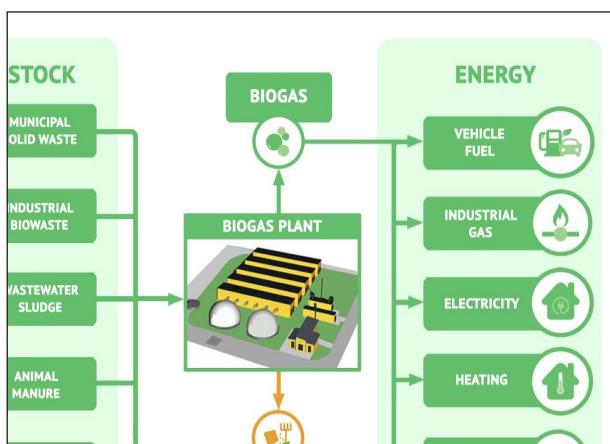


Figure 3. Energy derived from feedstock through biogas

Conclusion

Following conclusions can be drawn from above article discussion:

- Biogas is a renewable and ecologically beneficial fuel composed mostly of methane and carbon dioxide. It is produced by breaking down various organic waste materials through anaerobic digestion. Its versatility in heating and engine applications makes it a valuable and sustainable energy source
- Biogas has numerous environmental and economic

benefits, such as reducing pollution, creating job opportunities, producing organic nutrients that can be used in many fields like agriculture. India's leadership in compressed biogas technology represents a major stride in the quest to achieve sustainable energy and meet its energy demands

- Biogas-powered electricity is a clean and renewable energy source that has the potential to power a variety of appliances, including energy-intensive ones such as air conditioners. The production of biogas from organic matter, including wastewater, agricultural waste, other organic sources, can significantly reduce greenhouse gas emissions and provide a reliable energy source in rural areas
- The biogas industry has been expanding rapidly over the past decade and is set to become a powerhouse of renewable energy. The technology is constantly evolving to make biogas production more efficient, sustainable, cost-effective. It is a promising solution for mitigating climate change and achieving energy security
- The development of biogas technology is essential for a sustainable energy future. Its broad range of applications, including electricity generation and fuel production, make it an attractive and sustainable energy resource. Harnessing the potential of biogas will require a coordinated effort among stakeholders in the public and private sectors to promote the use of biogas and foster research and development

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