



A comprehensive analysis of biomass energy in India for agricultural and domestic use

A Prakash^{a#} and K Lal^b

Summary

Biomass is an abundant and renewable resource in India, with vast potential for use in energy production, agricultural applications, and waste management. The country has made significant strides in developing and utilizing biomass resources for various purposes in recent years. One of the primary uses of biomass in India is for energy production. Biomass fuels, such as wood chips, agricultural residues, and municipal waste, are used in rural areas for cooking and heating. Additionally, the government has implemented policies and initiatives to promote the use of biomass for electricity generation. Biomass-based power plants have been established nationwide, with a total installed capacity of over 9,000 MW. Biomass is also used in agricultural applications in India. The country is a major producer of sugarcane, and bagasse, a byproduct of sugarcane processing, is commonly used as a feedstock for producing biofuels and biogas. Additionally, farmers are increasingly using biomass-based fertilizers and pesticides to improve soil health and reduce chemical inputs. Regarding waste management, biomass is a valuable resource for converting organic waste into useful products. Anaerobic digestion and composting are popular methods for treating organic waste, with the resulting biogas and compost being used for energy generation and agricultural applications, respectively. Overall, biomass is an essential resource for India, providing energy, supporting agriculture, and promoting sustainable waste management practices. With continued investment and innovation, biomass has the potential to play an even more significant role in the country's energy and agricultural sectors in the coming year.

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Introduction

India has 1210 crore people, or 17.5% of the world's population, making it the second-most densely inhabited nation (Provisional Population Totals: India 2015), the second-largest economy in the world is that of India. India's enormous and continuous economic expansion over the years has greatly strained its energy resources (UNESCO Publishing 2014). The Indian government wants to produce electricity from renewable energy sources (solar, wind, biomass, etc.), which are available as a free or low-cost method to meet the country's energy needs. To achieve energy security, a nation should use renewable energy sources (Vishal Maurya et al. 2015). India is now the third-largest domestic gas user in the world, following China and the United States, and the fourth-largest consumer of LPG overall at about 90% (Chandra A. & Secretary-Marketing, 2010). India should establish an efficient system that produces energy from biomass to meet its demands if it is to compete with the future's enormous need for energy resources. Biomass results from green plants using photosynthesis to turn

sunlight into plant material. It comprises both land-based and aquatic vegetation as well as all organic waste. Biomass resources may be considered as organic materials in which chemical bonds store solar energy. The chemical energy that has been stored in those molecules is released by breaking the bonds between nearby carbon, hydrogen, and oxygen molecules throughout digestion, combustion, or decomposition. Biomass has always been a valuable energy source for both humans and the environment, and currently, 10–14% of the energy that is delivered to our nation originates from it (McKendry 2002). India now has an estimated 500 million metric tons of biomass available yearly. Figure 1 shows LPG consumption in India till 2022.

As per information provided by the Ministry, the annual availability of biomass is projected to be between 120 and 150 million metric tons, which amounts to an estimated 18000 MW of potential (Karnataka Renewable Energy Development Ltd. Report, 2015). India consumes 450 kg per car annually compared to a worldwide average of 1428 kg (Chandra A. & Secretary-Marketing 2010). Around 450–500 million tons of biomass are produced annually in India. Nowadays, 32% of the main energy used in the nation comes from biomass. The anticipated range of biomass electricity in India is between 18000 and 20,000 MW. A maximum of 50,000 MW is the scope of biomass. The present percentage of biofuels in the total amount of fuel consumed is

¹Department of Renewable Energy Engineering, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, U.P., India

²Department of Farm Machinery and Power Engineering, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, U.P., India

*Corresponding author: Amol Prakash, E-mail: amolprakash001@gmail.com

incredibly low and is just 5% ethanol in gasoline, which the government has mandated in 10 states. Currently, biodiesel is not available on the Indian fuel market, but

the government intends to utilise it to meet 20% of the nation's diesel needs by the year 2021 (India Biomass Energy Report, 2015).

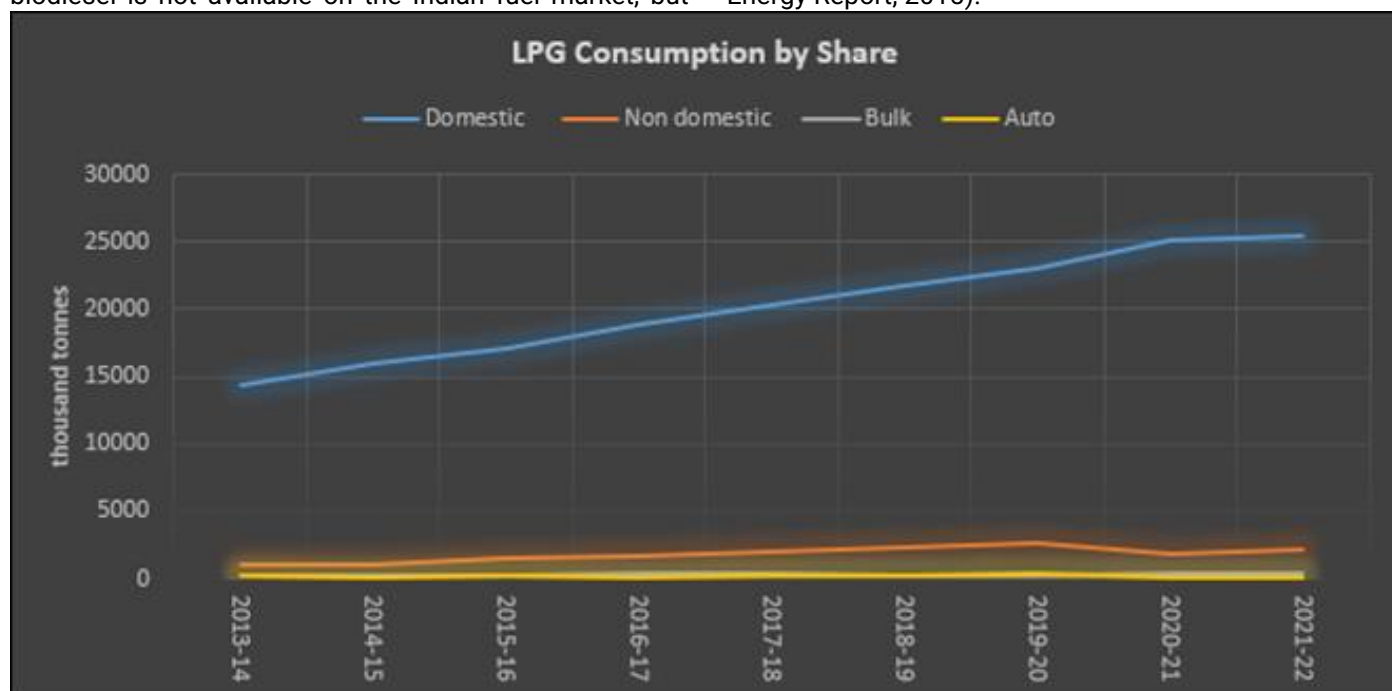


Figure 1. LPG consumption in India by share (Akhilesh Sati et al. 2022)

Major conversion technique of biomass resources

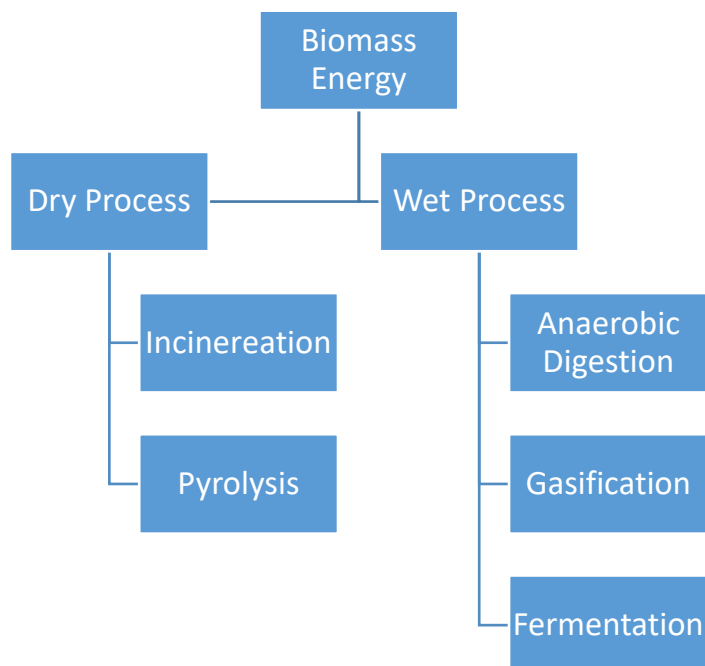


Figure 2. Conversion techniques of biomass resources

Combustion

Burning is the most effective method of obtaining energy from biomass, and direct combustion technology is both economically more advantageous and commercially viable. Systems for combustion come in a variety of sizes and designs. Other systems employ agricultural waste or leftovers like straw, hay, husk, tree stumps, municipal garbage, and scrap tyres as fuel sources. In certain systems, the heat released when garbage is burned is used to generate electricity, heat water, and conduct industrial processes. The fundamental problem with these systems is their extremely poor efficiency. With such systems, most of the heat is lost and not

utilized for cooking or any other activity. Building stoves out of mud and leftover iron is might improve such systems in underdeveloped nations (Rawat Kishan et al. 2016).

Pyrolysis

Hay, husk, dry wood, straw, and wood chips may all be smouldered to provide a wide variety of energy sources. From ancient times, this method has been used to create charcoal. The substance is ground or mixed before being added to a reactor and heated in a vacuum flask. The process of pyrolysis may also be carried out in the absence of oxygen (gasification), water (steam gasification), or hydrogen (hydrogenation). Methane,

which is the most efficient fuel for high-efficiency gas turbines used to generate power, can also be pyrolyzed (Rawat Kishan et al. 2016).

Anaerobic digestion

Creating biogas without oxygen allows green plants, moist sewage, sludge, or animal waste to break down in a sealed tank. Wood chips, straw, hay, and husk are also possible, but digestion takes longer. One kilogram of organic material should produce 450–500 litres of biogas. A useful fertilizer or manure can be made from the leftovers of decomposition (Rawat Kishan et al. 2016).

Fermentation

The fermentation of sugar solution with wild yeast produces ethanol. Feedstock like fruit and sugar beet juice in crushed form by pulping or boiling cellulose and vegetable starches, as well as by acid-treating cellulose, sugar can be produced. After 30 hours of fermentation, the solution contains 6–10% alcohol, which may be eliminated by distillation and extracted as fuel (Rawat Kishan et al. 2016). Yeast can be introduced to sugar after it has undergone fermentation. As a result, alcohol produced during fermentation has very high energy reserves and may be utilized as fuel for automobiles. Brazil has implemented this practical method with success.

Energy demand in India

Figure 3 shows India's total Primary energy demand from 2000 to 2020. As of 2022, India has a population of over

1.3 billion people, making it the world's second-most populous country. With rapid economic growth and a growing population, the country's energy demand has been on the rise, which is expected to continue in the coming years. According to a report published by the International Energy Agency (IEA) in 2021, India's energy demand is projected to grow by 4.6% per year through 2040, which is the fastest among all major economies. The report states that the primary energy demand in India is expected to double by 2040, with coal and oil remaining the dominant fuels in the country's energy mix. The report also highlights that India's energy consumption patterns are expected to evolve, with the share of coal in the country's energy mix declining and the share of renewables increasing. The government of India has set a target to achieve 450 GW of renewable energy capacity by 2030, which includes 280 GW of solar power and 140 GW of wind power (IEA report 2021). In addition, the report also emphasizes the importance of energy efficiency in India, which has a significant potential for reducing energy demand. The government of India has launched various initiatives to promote energy efficiency in different sectors, including buildings, industry, and transport. However, the report also points out some challenges India faces in meeting its energy demand. These include the need for significant investment in energy infrastructure, improving energy access in rural areas, and addressing of air pollution, a significant health concern in many cities.

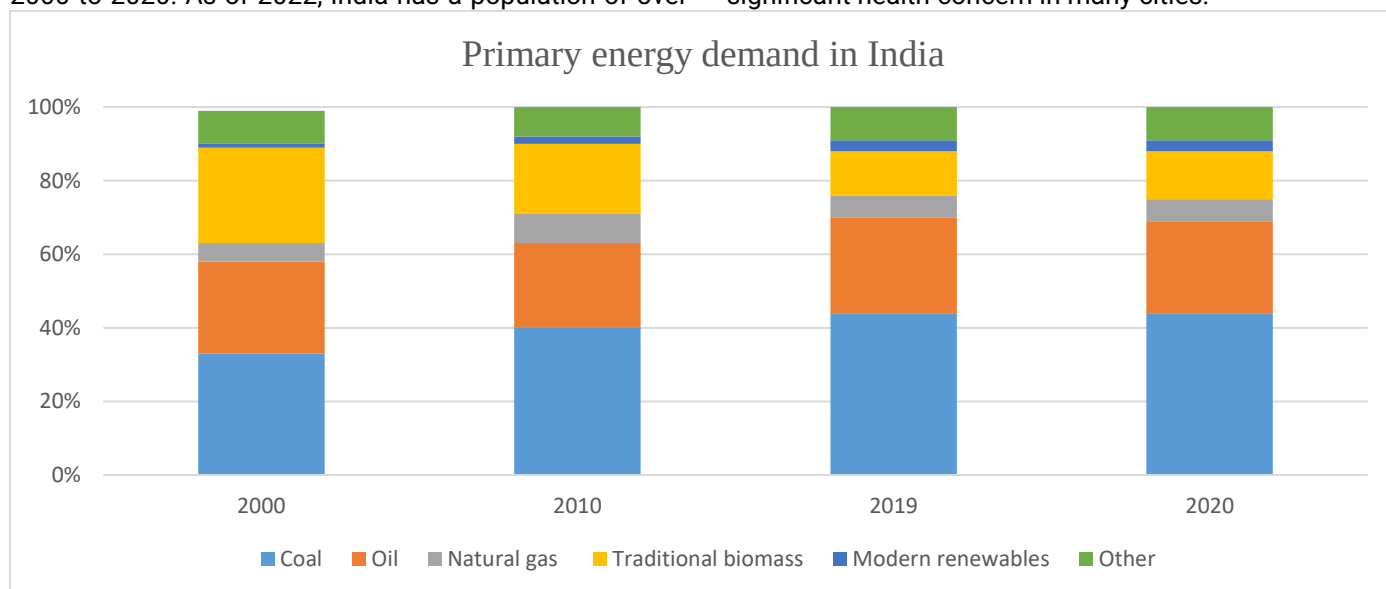


Figure 3. Total Primary energy demand in India from 2000 to 2020 (India Energy Outlook 2021)

Central financial assistance and fiscal incentives

CFA for Briquette/Pellet manufacturing and Biomass (non-bagasse) based projects (Valid upto 31 March 2026)

Table 1. Biomass Projects and Capital Subsidy (Ministry of New and renewable energy, 2023)

Project type	Capital subsidy
Briquette / Pellet Manufacturing plants	Rs. 9 Lakh per MTPH (metric ton/hour) manufacturing capacity (maximum CFA of Rs 45 Lakhs per plant)
Biomass (Non-bagasse) cogeneration projects	Rs. 40 Lakhs/MW (on Installed Capacity) (maximum CFA of Rs. 5 Crores per project)

State-wise installed capacity of Biomass energy

As per the Ministry of New and Renewable Energy report, there is a vast increase in the power grid instalment in

every sector of renewable energy sources. Table 2 shows a state-wise installed capacity of Biomass energy in India till 31st March 2023.

Table 2. State-wise installed capacity of Biomass energy in India (Ministry of New and renewable energy, 2023)

S. No.	State/UTs	BM Power/Bagasse Cogeneration (MW)	BM Power Cogeneration Non-bagasse (MW)
1.	Andhra Pradesh	378.10	1015.57
2.	Bihar	112.50	12.20
3.	Gujarat	65.30	12
4.	Haryana	151.40	89.26
5.	Karnataka	1867.10	20.20
6.	Madhya Pradesh	92.50	14.85
7.	Maharashtra	2568.00	16.40
8.	Punjab	299.50	196.65
9.	Rajasthan	119.25	2.00
10.	Tamil Nadu	969.10	43.55
11.	Telangana	158.10	2.00
12.	Uttar Pradesh	1957.50	160.76
13.	Uttarakhand	72.72	57.50
14.	West Bengal	300.00	38.62
15.	Odisha	50.40	8.82
16.	Chhattisgarh	272.09	2.50

Conclusion

India's biomass energy sector has tremendous potential to contribute to the country's energy security and rural development goals. While the country has made significant progress in developing the sector over the past few decades, much remains to be done to fully harness the potential of this renewable resource. Several challenges, such as inefficient conversion technologies, limited availability of feedstock, and lack of access to financing and market incentives, continue to hamper the sector's growth. However, with sustained policy support and investment, the country can overcome these challenges and emerge as a global leader in biomass energy production. Moreover, the recent push towards cleaner energy sources and the growing interest in circular economy models are expected to further boost India's biomass energy demand. As such, the sector is poised to play an increasingly important role in the country's transition towards a sustainable and low-carbon economy.

Declaration of interests

The authors have no conflict of interest to declare.

Data Sharing

All relevant data are within the manuscript.

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