Bioenergy Installed Capacity Projected to Reach 15.5 GW by FY32

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CareEdge ANALYTICS & ADVISORY
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Synopsis

Bioenergy contributes 11.6 GW to India's renewable energy mix as of March 2025, dominated by bagasse cogeneration, supported by biomass and waste-to-energy segments. This capacity has steadily expanded over the last five years, with the addition of around 868 MW of BM Power/Cogeneration and 693 MW of WtE nationwide, signalling sustained government support.

National initiatives such as the National Bioenergy Programme, the Waste-to-Energy Programme Guidelines, the Biomass Co-firing Policy, and the Biofuel Blending Targets are accelerating biomass cogeneration and pelletisation. These schemes provide targeted financial support, technology standards and stable offtake mechanisms that are strengthening project viability and driving steady growth in solid biomass-based bioenergy across the country.

Key growth drivers include abundant agricultural residue, rising demand for clean fuels, rural economic benefits, decentralised power generation and environmental gains such as reduced stubble burning and improved waste management. India's large surplus of agricultural biomass estimated at 230 MMT annually, further strengthens the country's long-term bioenergy potential.

Major challenges remain in biomass supply chains, seasonality, logistics, storage constraints and high aggregation costs, along with the difficulty of matching falling tariffs of solar and wind. There is a need for organised supply networks, digital logistics platforms and multi-supplier contracting to address these persistent operational bottlenecks.

Policy enablers such as financial assistance, support for biomass aggregation machinery, and improved RPO/RCO frameworks aim to reduce risks, strengthen bankability, and boost investor confidence. New policies also encourage long-term biomass procurement and renewable consumption mandates, creating stable demand signals for developers.

Going forward, India's bioenergy potential, particularly in biomass-based power, pelletisation, cogeneration and waste-to-energy, is expected to expand steadily, supported by stronger supply chains and continued policy backing for biomass utilisation and co-firing in thermal power plants, which are projected to further accelerate India's bioenergy expansion through 2030.

Overview

Bioenergy is a renewable form of energy obtained from recently living organic materials, collectively known as biomass. This biomass, such as agricultural residues, forestry waste and organic municipal waste, stores carbon that plants absorb from the atmosphere through photosynthesis. When used for energy production, the carbon is released during combustion but is subsequently reabsorbed by new biomass growth, creating a balanced carbon cycle. This makes modern bioenergy a near-zero emissions energy source. Bioenergy can be utilised to generate electricity, produce heat, create transportation fuels and develop various bio-based products, contributing to both energy security and environmental sustainability.

Feedstock

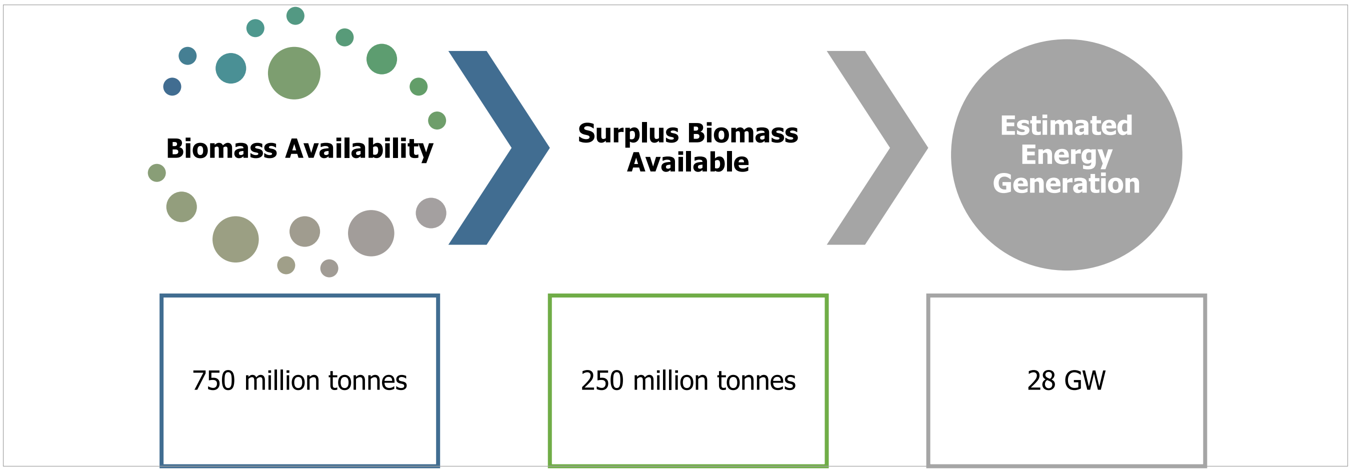
Feedstock refers to organic, biodegradable materials that are converted into usable forms of energy, such as electricity, heat, or biogas. These feedstocks originate from various sources, including agriculture, forestry and specially cultivated energy crops. In renewable energy systems, biomass feedstock such as algae, plant materials, and animal waste is commonly used to generate biofuels and energy. The type and quality of feedstock used directly impact the efficiency, environmental benefits, and economic feasibility of the WtE (Waste-to-Energy) process.

Agricultural residue is one of the most widely available sources of feedstock, especially in rural and farming regions. This residue includes materials such as paddy straw, wheat straw, corn stover, sugarcane bagasse, cotton stalks and animal manure, which remain after harvesting or as a by-product of farming. They can be processed through combustion, gasification, or anaerobic digestion to produce energy. Utilising these materials not only provides a renewable energy source but also reduces the harmful practice of open field burning.

Biomass Availability in India

As per Ministry of New and Renewable Energy (MNRE), in FY24, almost 750 million tonnes of agricultural waste was produced in India. Wheat waste contributes almost 25% followed by rice waste 24% and rest is contributed by other crop wastes. Since wheat straw is also used as animal fodder, rice straw and husk can be used in WtE generation. The surplus biomass availability is estimated at around 250 million tonnes in FY24, which can generate energy of 28 GW.

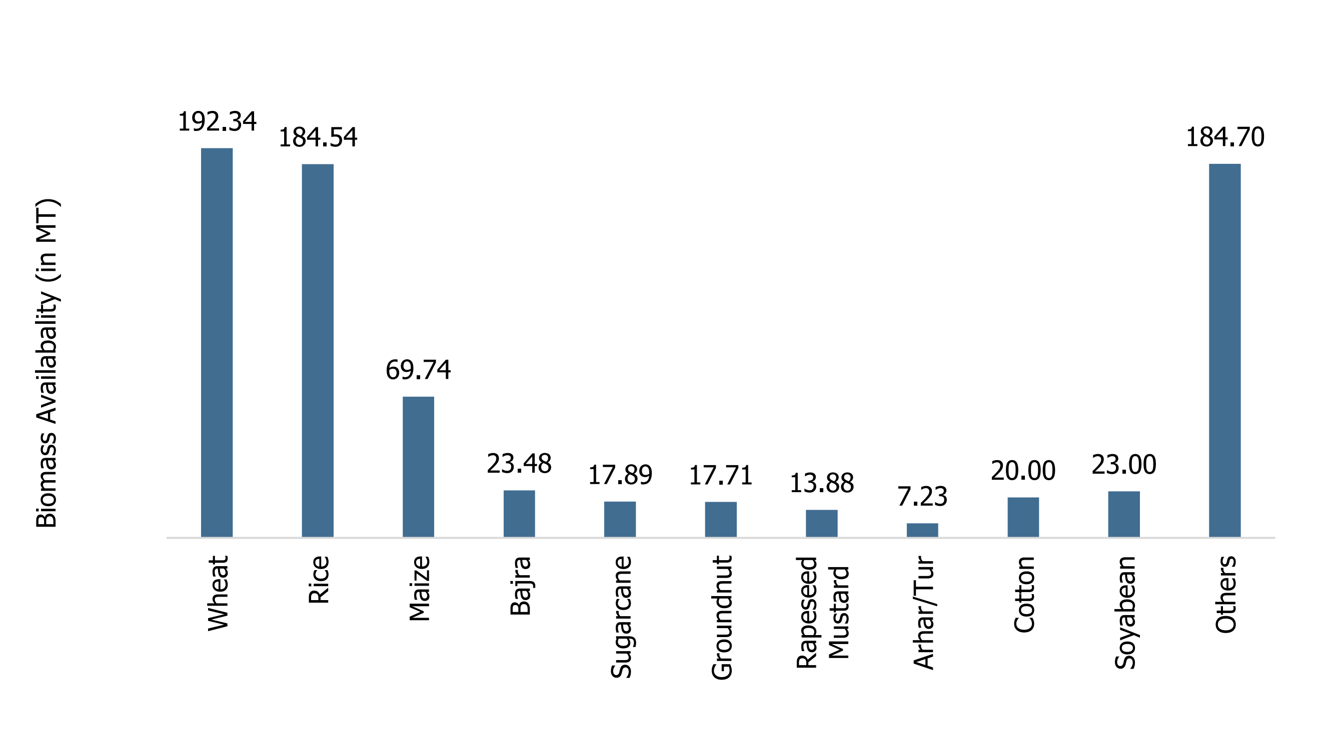
Biomass Scenario in FY24



Source: Ministry of New and Renewable Energy (MNRE)

The biomass availability is estimated to increase by almost 27% to reach 948 million tonnes in FY25 whereas the surplus biomass availability is estimated to increase by 18% to reach 295 million tonnes. The bioenergy generation is estimated to increase from 28MW to 35 MW in FY25.

Chart 1: Crop-wise Biomass Availability in India (FY24)



Source: Ministry of New and Renewable Energy (MNRE)

The 'Others' category, with a total of 184.7 MT, comprises biomass from banana, barley, coriander, cowpea (lobia), dry chillies, garlic, ginger, gram, guar seed, jowar, jute, linseed, masoor, mesta, moong (green gram), moth, onion, other kharif pulses, other oil seeds, peas & beans (pulses), potato, ragi, sesamum, small millets, sunflower, sweet potato, tobacco, turmeric and urad. Strengthening the supply chain for these residues could enhance bioenergy output and improve waste management efficiency, contributing to a diversified and resilient bioenergy sector.

Benefits of Energy Generation from Paddy Straw

Reduces Harmful Gas Emissions

Open burning of paddy straw significantly contributes to air pollution in northern India, especially during winter, releasing harmful pollutants like carbon monoxide and methane. Using paddy straw for energy generation offers a cleaner alternative and helps reduce these emissions.

Reduces Carbon Footprint

Replacing fossil fuels like coal and diesel with energy from paddy straw can significantly reduce carbon emissions in thermal and industrial uses. This cleaner option supports India's climate goals and promotes long-term environmental sustainability.

Preserves Soil Fertility

Open burning of paddy straw destroys vital soil nutrients, organic matter, moisture, and beneficial microbes. In contrast, utilising crop residues as biomass helps protect soil fertility and supports better crop yields over time.

Minimises the Need for Landfills

India produces about 750 million tonnes of crop residues each year, much of it paddy straw. Converting this waste into energy reduces landfill pressure, supports sustainable waste management, and helps maintain ecological balance.

Supports Decentralised Power Generation

Biomass energy from paddy straw can power small, decentralised plants in rural areas, providing reliable electricity to villages and farms while reducing dependence on centralised grids and improving rural energy security.

Offers Round-the-Clock Energy Supply

Unlike solar and wind, which depend on weather, biomass energy provides a stable and continuous power supply. This reliability makes it suitable for grid integration and for industries needing uninterrupted energy.

Provides an Additional Income Source for Farmers

Farmers can earn extra income by selling paddy straw to biomass plants instead of burning it, turning agricultural waste into a valuable resource while promoting sustainable practices and supporting farmer livelihoods.

Rural Employment

Collecting, baling, transporting, and processing paddy straw for energy creates rural jobs across the value chain, supporting livelihoods and promoting inclusive economic development.

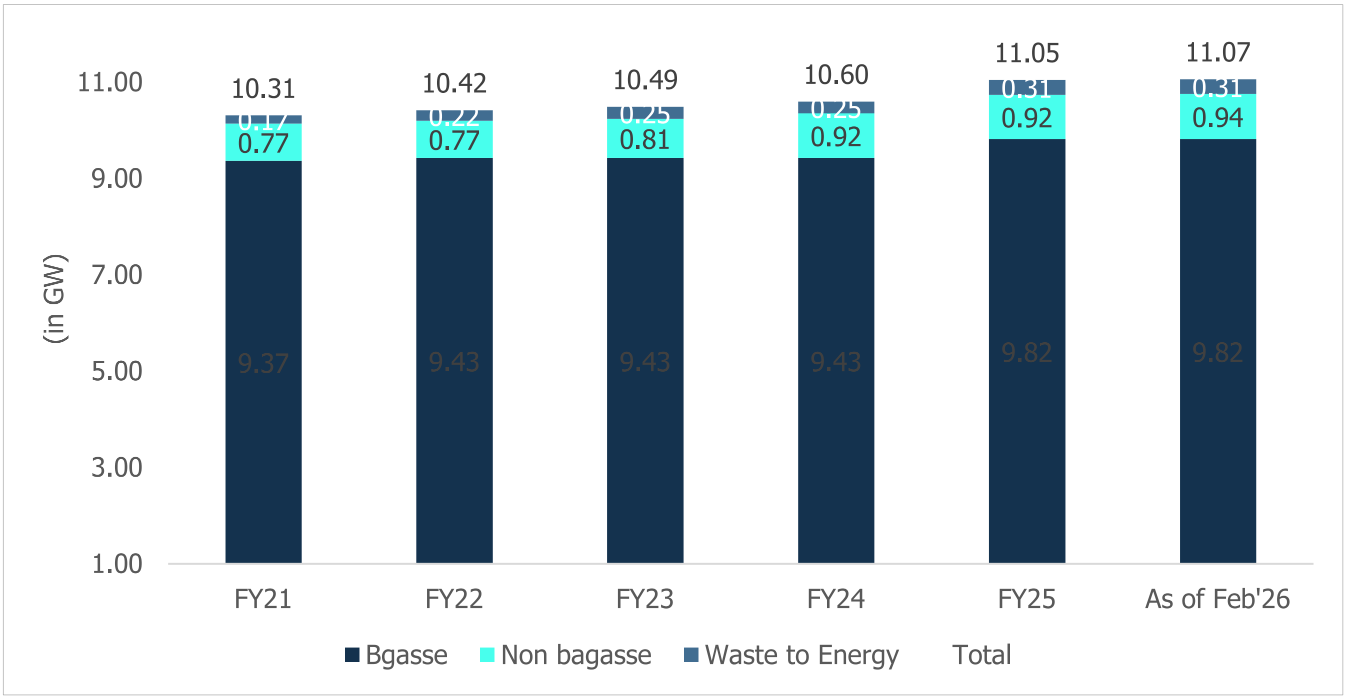
Strengthens Local Economies

Energy from paddy straw can power agro-processing units, cold storages, irrigation, and small rural industries. Reliable electricity boosts productivity, supports local businesses, and helps strengthen rural economies.

Consistent Growth Seen in Bioenergy Installed Capacity

The installed capacity of bioenergy sources in India has shown consistent growth from FY21 to FY25, along with Waste-to-Energy (WtE).

Chart 2: Installed Capacity of Bioenergy



Source: Ministry of New & Renewable Energy (MNRE)

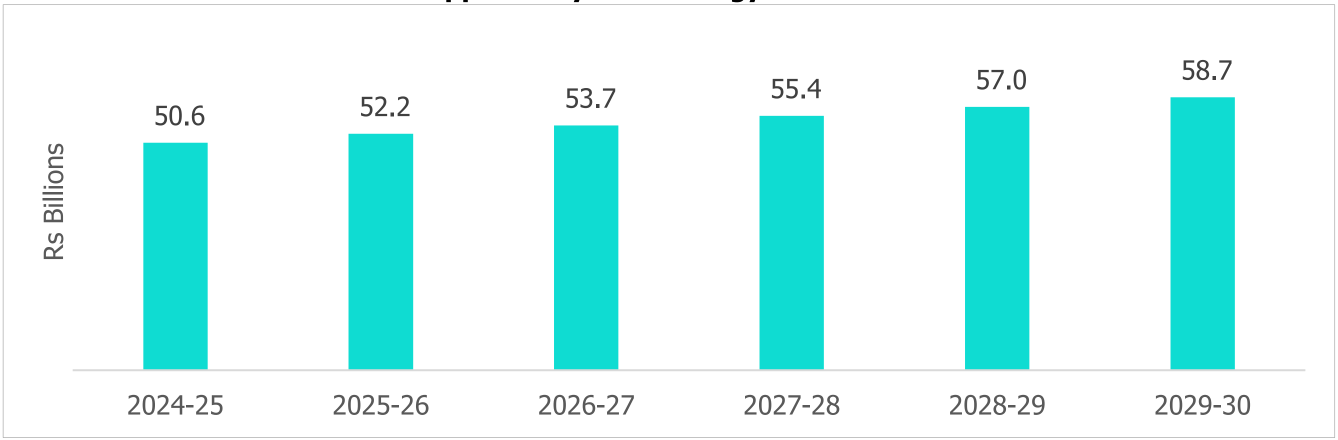
The total installed bioenergy capacity expanded from 10.53 GW in FY21 to 11.58 GW in FY25, reflecting a Compound Annual Growth Rate (CAGR) of 2.24%. Biomass Power/Bagasse Cogeneration grew from 9.37 GW to 9.82 GW and continues to be the main source of bioenergy. Biomass Cogeneration (Non-Bagasse) also experienced a gradual increase from 0.77 GW to 0.92 GW, demonstrating diversification in biomass feedstock usage. Waste to Energy (WtE), however, showed the highest growth rate, increasing from 0.17 GW to 0.31 GW, nearly doubling its capacity. This increase in WtE capacity suggests a stronger policy push to convert waste into a viable energy source, reduce reliance on landfills, and enhance sustainable urban waste processing. The installed capacity numbers indicate an active transition in India's renewable energy strategy, with traditional bioenergy showing stable growth while WtE is emerging as a key component.

These trends underscore India's commitment to expanding its bioenergy sector while diversifying renewable energy solutions. The consistent increase in biomass-based energy highlights the sector's stability, while the rapid rise of WtE signals growing government support and technological advancements in waste-to-energy conversion. The CAGR of 2.24% suggests steady sectoral growth, with WtE playing an increasingly important role in meeting energy and sustainability targets.

Investments Planned for Bioenergy

The investment opportunity in bioenergy projects will continuously increase and reach its peak in FY30. Year-wise fund requirement to achieve the targeted installed capacity is given below.

Chart 3: Year-wise Investment Opportunity in Bioenergy-based Power Plants



Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

Cost and Returns Benchmarking of WtE Projects

Capital Cost

Normative capital cost in India typically includes land cost, pre-development expenses, all capital work including plant and machinery, civil work, erection, commissioning, financing cost, interest during construction and evacuation infrastructure up to an interconnection point. This varies based on source of energy and technology, which can be witnessed from the table below:

Normative Capital Costs for WtE Projects and Other Sources of Power

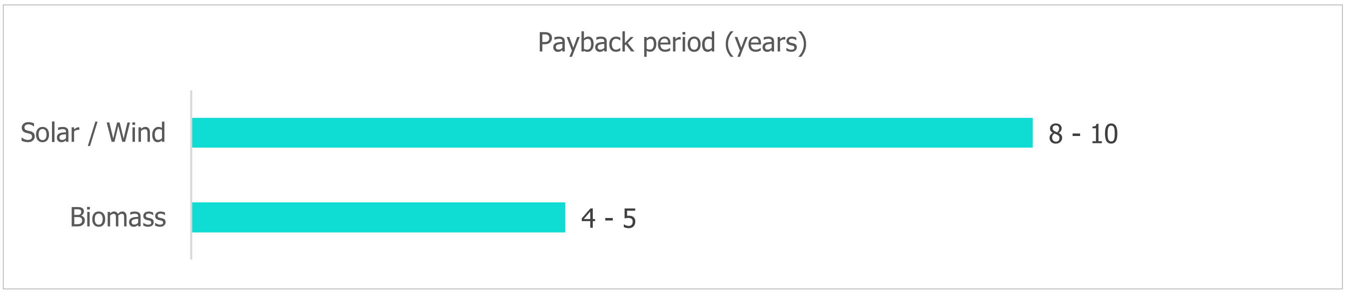
Normative Capital Cost	Value (Rs Crore / MW)
Biomass Projects Based on Rankine Cycle	
Biomass project with rice straw and juliflora (plantation)	6.97 - 7.44
Biomass project other than rice straw and juliflora (plantation)	6.38 - 6.85
Solar	**4.0 - 4.5**
Wind (onshore)	**7.5 - 8.5**

Source: Central Electricity Regulatory Commission (CERC), Central Electricity Authority (CEA), CareEdge Research

Normative capital costs for renewable energy projects in India indicate that Solar PV is generally the least expensive per megawatt, followed by Wind. In contrast, Waste-to-Energy (WtE) projects have the highest capital intensity due to the complex waste-processing infrastructure required.

Return Analysis

Though Waste-to-Energy (WtE) projects have the highest capital costs and tariffs compared to other renewable projects, their payback periods are shorter than those of solar/wind projects. On an illustrative basis, based on our assessment of a 10 MW Biomass, Solar, and Wind projects, the payback periods estimated for such projects are as follows:



Source: Central Electricity Regulatory Commission (CERC), CareEdge Research

Conclusion

India produces more than 700 million tonnes of agricultural residue annually, with estimates indicating that a substantial share remains under-utilised or is disposed of through open-field burning, particularly in northern Indian states. This practice contributes significantly to air pollution, greenhouse gas emissions, and declining soil quality, while simultaneously representing a lost economic opportunity.

"Reframing agricultural residue from 'waste' to a strategic national bioenergy resource can unlock significant socio-economic and environmental gains, especially considering that India generates over 230 million tonnes of such residues annually, much of which remains under-utilised" says Tanvi Shah, Senior Director at Care Analytics and Advisory Private Limited.

"Realising Waste to Energy potential requires a coordinated and systems-based policy approach integrating agricultural supply chains, energy markets, environmental regulation, and financial incentives. With India projected to generate ~300 million tonnes of agricultural residue annually, a data-driven biomass mapping framework and strong institutional alignment will be critical to unlocking this opportunity" says Nitu Singh, Associate Director at Care Analytics and Advisory Private Limited.

Overall, Waste-to-Energy technologies offer multiple benefits - effective waste management, renewable energy generation, environmental protection and employment generation, making them an essential component of India's pathway towards a sustainable and low-carbon future.

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