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GREENING INDIA'S THERMAL SECTOR: BAGASSE BRIQUETTES AS A CLEAN FUEL SOLUTION

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ABSTRACT
This research paper explores the establishment of a sugarcane bagasse-based briquette manufacturing plant as a strategic initiative to address India's clean energy transition, mitigate climate change, and manage agro-industrial waste effectively. With India's commitment to sourcing 50% of electricity from renewables by 2030 and achieving net-zero emissions by 2070, the use of biomass briquettes as a coal substitute offers an environmentally sustainable and economically viable solution. This paper analyses the technical, economic, and environmental feasibility of utilizing bagasse from sugar mills . It presents a comprehensive review of market trends, policy support, raw material availability, technology, manpower, and financial models to demonstrate how such a project aligns with India's low-carbon growth trajectory.

Keywords: *Bagasse, Biomass Briquetting, Renewable Energy, Agro-Waste, Climate Change Mitigation, Sustainable Development, Circular Economy, Sugar Mills, PPP Model.*

1. INTRODUCTION
India is undergoing a significant energy transformation driven by rapid industrialization and growing environmental concerns. With an ambitious commitment to clean energy, the country seeks sustainable alternatives to fossil fuels. Biomass briquetting, particularly using sugarcane bagasse, presents an efficient solution for generating eco-friendly solid fuel known as white coal. This paper proposes a bagasse-based briquette manufacturing plant leveraging surplus by-products of sugar mills across country. By converting bagasse into briquettes using binder- less technology, the initiative supports waste-to-energy conversion, enhances sugar mill revenue, and contributes to climate goals.

2. LITERATURE REVIEW
Previous studies have established the environmental benefits of biomass briquetting. Kumar et al. (2020) highlighted the potential of sugarcane bagasse in reducing GHG emissions. The IEA Bioenergy Task 32 noted improved combustion efficiency in thermal plants using biomass briquettes. India's National Bio-Energy Mission and MoEFCC guidelines (2023) further reinforce regulatory backing for biomass co-firing. However, implementation challenges such as off-season availability, technological adaptation, and rural financing .

3. OBJECTIVES OF THE STUDY
- To propose a commercially viable model for bagasse-based briquette production
- To analyse technical, financial, and operational feasibility.
- To evaluate the market demand and supply potential.
- To align the project with India's climate and rural development objectives.

4. METHODOLOGY
This study uses a mixed-method approach, combining primary data and secondary data from government reports and industry databases. Financial analysis is based on standard DPR formats, while technical and market analyses draw on operational benchmarks and national policies.

5. MARKET ANALYSIS AND DEMAND FORECAST
India's biomass pellet sector is witnessing a rapidly expanding demand driven by environmental mandates and a shift towards sustainable energy practices. Currently, the **estimated daily demand for biomass pellets stands at approximately 95,000 tons/day**, primarily fuelled by the country's coal-based thermal power plants. However, the **present production capacity is significantly lower, ranging between 8,000 to 10,000 tons/day**, creating a massive supply-demand gap of nearly 85,000 tons/day. This gap not only underlines the urgent need for enhanced production infrastructure but also **presents a lucrative business opportunity** for new entrants and investors in the biomass sector.

Policy Push: Government Mandates & Compulsory Utilization
To support India's commitment to reducing its carbon footprint, the **Ministry of Environment, Forest & Climate Change (MoEFCC)** issued a directive (Notification dated 11th July 2023) mandating **5% biomass blending in all coal-based thermal power plants**. This mandate is part of the Government of India's wider

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initiative to reduce reliance on fossil fuels and enhance the utilization of agricultural residues and other biomass resources. The obligation will further **increase to 7% from FY 2025-26**, accelerating the pace of biomass adoption.

Adoption by Thermal Power Sector

India hosts over **208 thermal power plants**, out of which more than **60 have already implemented co-firing of biomass pellets**, showcasing a growing shift in operational norms and technology integration. This also reflects the readiness of infrastructure to absorb higher levels of biomass usage, provided supply meets the rising demand.

Industry Expansion and Key Market Players

The industry is already witnessing a growing base of buyers, including major power producers and government undertakings. Key stakeholders currently sourcing biomass pellets include:

- **NTPC**
- **Adani Power**
- **NPL – L&T**
- **TSPL Vedanta Punjab**
- **NABHA Power Plant**
- **UP-RVUNL**

These large-scale buyers represent a stable and expanding market for biomass suppliers, with long-term procurement potential under regulatory backing.

Sectoral Diversification: Industries Shifting to Biomass

Beyond power generation, multiple industries are transitioning to biomass pellets due to their **cost-effectiveness and environmental benefits**. The key sectors driving this diversification include:

- **Thermal Power Plants**: Subject to compulsory biomass blending as per MoEFCC regulations.
- **Paper Industry and Other Coal-Consuming Industries**: Embracing biomass as a cleaner, more economical alternative to coal.
- **Hotels and Commercial Facilities**: Utilizing biomass for heating and energy efficiency to reduce operational costs and meet sustainability goals.

6. PROJECT IMPLEMENTATION MODELS

To effectively establish and operate bagasse-based briquetting plants, four distinct project implementation models are proposed. Each model is designed to suit different institutional capacities, investment appetites, and operational preferences of cooperative sugar mills and private players.

6.1. In-House Mill Operation

In this model, the sugar mill takes full ownership of the briquetting unit. It invests in infrastructure, manages day-to-day operations, and markets the briquettes. This approach ensures maximum value capture and control over the supply chain. It is ideal for financially strong mills with the technical expertise and willingness to engage directly in renewable energy ventures.

6.2. Integrated Value Chain Model

This innovative model goes beyond briquetting by integrating it with complementary agro- industrial processes such as bio-CNG production, composting, and ethanol distillation. It encourages a circular economy approach, maximizing resource utilization and creating multiple income streams. It is best suited for regions with high biomass availability and potential for industrial clustering.

7. RAW MATERIAL AVAILABILITY

India's robust sugarcane processing industry provides a strong and sustainable foundation for establishing bagasse-based briquette plants. The country processes **over 300 million tons of sugarcane annually**, resulting in the generation of an estimated **90–100 million tons of**

bagasse as a by-product. With approximately **30–33% of the cane weight converted into bagasse** during the crushing process, this biomass residue offers an abundant and renewable source of raw material for briquette manufacturing.

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Bagasse is primarily produced during the crushing season, which typically spans **from November to April** each year. While a significant portion of bagasse is consumed in captive cogeneration units within sugar mills, a substantial surplus remains available for commercial use, especially in states with high cane production like **Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, and Haryana**.

The widespread and concentrated availability of bagasse provides an ideal opportunity for setting up briquette plants near sugar mill clusters. **Such proximity not only ensures consistent raw material supply but also reduces transportation costs**, making the project financially viable and operationally efficient.

To ensure **year-round plant operations**, seasonal bagasse availability can be supplemented through:

- **Strategic storage systems**, enabling preservation of bagasse during off-season months.
- **Blending with other agro-residues**, such as mustard husk, cotton stalk, wheat straw, and paddy straw, all of which are widely available across agricultural regions.

Given India's growing emphasis on **renewable energy, sustainable fuel alternatives, and industrial decarbonization**, a bagasse-based briquette plant offers a viable solution to meet both environmental and commercial objectives. It supports thermal power plants, industrial boilers, and commercial heating systems while contributing to circular economy and waste-to- energy initiatives.

8. TECHNICAL ASPECTS

The briquetting process involves converting loose, moisture-laden bagasse into dense, high- calorific fuel briquettes. The first step is drying the raw bagasse to reduce moisture content below 15%, either using sun drying or mechanical dryers. The dried material is then fed into a briquetting press, which compresses it under high pressure into uniform briquette shapes.

These briquettes have an energy content ranging between 3500–4200 kcal/kg, making them suitable substitutes for coal and lignite in various industrial applications. Essential machinery includes dryers, presses, feeders, and conveyors. The total capital cost of setting up a plant ranges from ₹50 to ₹150 lakh, depending on the scale, automation level, and machinery type used excluding land cost.

9. MANPOWER AND OPERATIONAL DETAILS

A standard 2-tonne per hour (TPH) briquetting plant requires minimal manpower due to partial automation. Operating in two shifts per day, the plant needs at least four personnel: one skilled operator to manage equipment and three semi-skilled workers for feeding, bagging, and loading tasks. A supervisor may also be employed for monitoring, quality control, and coordination.

The total annual salary expenditure for such a setup is **approximately ₹23.2 lakh.** This lean operational structure makes the plant labour-efficient and suitable for rural industrialization.

10. FINANCIAL VIABILITY

A financially viable model has been **developed for a 2 TPH briquetting plant running 300 day**s a year. At full capacity, the plant would **consume around 14,769.2 tonnes of bagasse** annually and **produce approximately 9,600 tonnes of briquettes, given a yield of 650 kg per** tonne.

The capital investment required is between ₹50 and ₹95 lakh, while operational costs include raw material procurement, labor, electricity, and maintenance. The model demonstrates a competitive internal rate of return (IRR) and a break-even period of 2 to 4 monthss, making it highly attractive for both public and private investors.

11. ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACT

Establishing a bagasse-based briquetting plant offers significant **environmental and socio- economic advantages**, contributing meaningfully to India's green growth agenda.

From an environmental perspective, **replacing fossil fuels like coal with biomass briquettes**

drastically reduces greenhouse gas (GHG) emissions. Studies indicate that **replacing just 1**

tonne of coal with bagasse briquettes can prevent up to 2.5 tonnes of CO_2 emissions, making this technology a powerful tool for decarbonization. Furthermore, the briquetting process supports **zero-waste operations** in sugar mills by utilizing bagasse—an agricultural by-product that would otherwise go underutilized or discarded.

Economically and socially, the briquetting industry stimulates **rural employment** and economic activity. It creates **direct jobs in biomass collection, drying, briquette production, storage, and logistics**, while also

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generating **indirect employment** in equipment maintenance, local services, and marketing. These decentralized job opportunities are particularly beneficial in rural and semi-urban regions, helping reduce migration to urban centers.

Moreover, bagasse briquetting aligns strongly with India's **Sustainable Development Goals (SDGs)**, especially:

- **SDG 7** – Affordable and Clean Energy
- **SDG 8** – Decent Work and Economic Growth
- **SDG 12** – Responsible Consumption and Production
- **SDG 13** – Climate Action

In essence, the technology supports a **circular economy**, promotes energy self-sufficiency in rural industries, and contributes to national environmental and economic objectives.

12. CLIMATE CHANGE MITIGATION POTENTIAL

Briquetting this biomass converts waste into a **clean-burning fuel** that can replace coal and diesel in industrial boilers, thermal plants, and commercial heating systems. This transition aids India's commitment under the **Paris Agreement** to reduce the emissions intensity of its GDP by 33–35% by 2030 (compared to 2005 levels).

Additionally, the process:

- Enhances **carbon sequestration potential** by avoiding open-field burning.
- Boosts **rural renewable energy ecosystems**.
- Encourages **agro-industrial synergy**, making farms and sugar mills part of the green energy supply chain.

This climate-friendly solution also drives **inclusive rural development**, encouraging **micro- entrepreneurship** and improving farmer income through biomass residue monetization. The result is a low-cost, scalable model that complements both national and international climate action targets.

13. CHALLENGES AND SOLUTIONS

Despite its high potential, the bagasse briquetting industry must overcome several **technical, logistical, financial, and market-related challenges** to scale successfully. Below are the key issues and their respective solutions:

1. Moisture Content in Bagasse

- **Challenge**: Freshly produced bagasse contains high moisture (45–55%), which affects briquette combustion quality and storage life.
- **Solution**: Introduce **sun drying yards**, **mechanical dryers**, or use waste heat from nearby industrial processes to reduce moisture content to the ideal level (~10–15%).

2. Seasonal and Irregular Raw Material Supply

- **Challenge**: Sugarcane crushing (and hence bagasse production) is seasonal, leading to raw material shortages during the off-season.
- **Solution**: Ensure consistent feedstock through:
  - **Long-term supply agreements** with sugar mills.
  - **Blending bagasse with other biomass residues** like mustard husk, cotton stalk, and wheat straw.
  - **Storage and preservation strategies** for bagasse.

3. Limited Market Awareness and Demand Volatility

- **Challenge**: Many industries remain unaware of the benefits of briquettes, and the market suffers from inconsistent demand.
- **Solution**:
  - Promote the product through **industrial exhibitions**, **digital platforms**, and local awareness campaigns.
  - Develop **branding and quality certification standards** to build market trust.

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- Partner with **industrial consumers** and negotiate **bulk procurement contracts**.

4. Financial Barriers

- **Challenge**: High upfront costs for briquetting machinery and drying systems can deter small entrepreneurs.
- **Solution**:
  - Leverage **subsidies and soft loans** through schemes by **NABARD**, **MSME Ministry**, and **State Renewable Energy Departments**.
  - Tap into **CSR funds**, **green energy finance programs**, and **carbon credit mechanisms**.

Addressing these challenges with strategic interventions can significantly improve the viability, scalability, and profitability of bagasse-based briquette plants.

14. POLICY AND INSTITUTIONAL SUPPORT

The Indian government, through various central and state schemes, offers robust policy and institutional support for promoting biomass briquetting units. These incentives significantly reduce the capital and operational burden, making such ventures financially viable and attractive.

14.1.Interest Subvention under Agriculture Infrastructure Fund

Under this scheme, a **3% interest subvention** is available on loans up to ₹2 Crores for a period of **7 years**. Importantly, **no collateral is required** for loans up to ₹2 Crores, thereby easing access to credit for small and medium-scale entrepreneurs. The scheme remains valid till **2032– 33**, providing a long-term support framework for new projects in the agri-infrastructure space.

14.2.MNRE Scheme (Ministry of New and Renewable Energy)

The MNRE offers **Central Financial Assistance (CFA)** for establishing biomass briquette and pellet plants. The assistance is calculated at **₹9 lakh per MTPH (Metric Ton per Hour)** of manufacturing capacity, subject to a **maximum subsidy of ₹45 lakh per plant**. This direct capital support plays a critical role in reducing the initial project cost.

14.3.State-Specific MSME Incentives

Several state governments offer incentives to promote industrial growth under MSME policies. These include a **capital subsidy of 15%** on plant, machinery, and building costs, capped at

₹20 lakh. Such support enhances the financial feasibility of briquetting units and encourages their expansion into rural and semi-urban areas.

14.4. Other Incentives

Additional benefits include **tax exemptions under Section 80JJA** of the Income Tax Act for a period of **five consecutive assessment years**, which enhances post-tax profitability. States also provide **refunds on stamp duty paid for land**, **exemptions from electricity duty**, and **waivers on land conversion fees**, reducing the overall establishment and operating costs of the plant.

15. WAY FORWARD

To unlock the full potential of bagasse-based briquetting, a phased and participatory approach is essential. Initial pilot projects should be implemented in high sugarcane-yielding mills areas. Public-private partnerships can be used to bring in investment and technical know-how.

Further, integration with local governance structures such as panchayats and farmer cooperatives will ensure better raw material aggregation and community ownership. Capacity- building programs for rural youth and self-help groups (SHGs) will create a skilled workforce to operate and manage such facilities sustainably.

16. CONCLUSION

The establishment of bagasse-based biomass briquetting plants presents a transformative opportunity for India's renewable energy landscape, rural industrialization, and climate resilience agenda. This research has systematically demonstrated the technical, financial, environmental, and socio-economic viability of deploying briquetting units across the country, particularly in sugarcane-rich states.

The project implementation models—ranging from in-house mill operations to integrated agro- industrial value chains—offer tailored solutions to meet the diverse needs of cooperative sugar mills and private players. Each model supports localized entrepreneurship, optimizes resource utilization, and aligns with the broader goals of a circular economy.

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With over 90–100 million tons of bagasse generated annually; India possesses an abundant, renewable feedstock for briquetting. The technology's ability to convert this underutilized agricultural residue into dense, high-calorific briquettes provides a sustainable alternative to fossil fuels such as coal and lignite. Moreover, strategic solutions like moisture reduction systems, raw material blending, and robust storage infrastructure can mitigate the seasonal and quality challenges inherent to bagasse handling.

The technical setup is relatively straightforward, requiring modest capital investment and low manpower, making it an attractive proposition for MSMEs, farmer producer organizations, and rural entrepreneurs. A well-designed 2 TPH plant can achieve profitability within 2 to 4 months, supported by favourable returns, consistent demand in thermal applications, and significant policy incentives.

Environmentally, the deployment of bagasse briquetting plants contributes meaningfully to India's climate change mitigation commitments. By replacing fossil fuels and preventing the open burning of biomass residues, these plants significantly curb greenhouse gas emissions, particulate matter pollution, and soil degradation. Each tonne of coal replaced with briquettes can potentially eliminate 2.5 tonnes of CO_2 emissions, making this intervention a powerful tool in decarbonizing India's industrial energy consumption.

Socio-economically, the industry promises decentralized employment, enhances farmer income through biomass monetization, and revitalizes rural economies. It directly supports India's Sustainable Development Goals—particularly SDGs 7, 8, 12, and 13—by promoting clean energy, decent work, sustainable consumption, and climate action.

Government support through schemes like the Agriculture Infrastructure Fund, MNRE's CFA, and state-specific MSME incentives further strengthens the ecosystem for bagasse briquetting. These interventions lower entry barriers, de-risk investment, and accelerate project implementation, particularly in underserved rural areas.

In conclusion, bagasse briquetting is not just a renewable energy initiative—it is a multi- dimensional solution that addresses energy security, rural development, environmental sustainability, and climate change. For India to fully harness this potential, it is imperative to foster stakeholder collaboration, expand awareness campaigns, streamline policy delivery, and incentivize innovation in biomass utilization. A future where sugar mills become hubs of renewable energy and circular economy is not only possible—it is necessary for a cleaner, greener, and more inclusive India.

REFERENCES

1. Ministry of New and Renewable Energy (MNRE). (2023). *Biomass Briquettes and Pellets: Policy Guidelines*. Government of India.
2. Indian Sugar Mills Association (ISMA). (2023). *Annual Report 2022–23*.
3. Ministry of Agriculture & Farmers Welfare. (2022). *Sugarcane Production and Processing Statistics*.
4. International Energy Agency (IEA). (2021). *Renewables 2021: Analysis and Forecast to 2026*.
5. Central Pollution Control Board (CPCB). (2022). *Report on Crop Residue Management and Biomass Utilization in India*.
6. NABARD. (2022). *Financing Models for Agri-Biomass-Based Enterprises*.
7. FAO. (2020). *Opportunities for Agriculture-Based Renewable Energy Systems in Developing Countries*.
8. GIZ India. (2021). *Biomass Energy for Rural India: Technical and Financial Feasibility Studies*.
9. TERI. (2020). *Biomass Resource Atlas of India*.
10. Planning Commission of India. (2014). *Report of the Expert Group on 175 GW Renewable Energy Target*.
11. Confederation of Indian Industry (CII). (2023). *Biomass Utilization in Industrial Energy Applications*.
12. Ministry of Environment, Forest and Climate Change (MoEFCC). (2023). *India's Third Biennial Update Report to the UNFCCC*.
13. IPCC. (2022). *Climate Change 2022: Mitigation of Climate Change*.

ISSN 2394 - 7780

14. United Nations Development Programme (UNDP). (2021). *India and the SDGs: Synergies in Action*.
15. International Renewable Energy Agency (IRENA). (2020). *Bioenergy for the Energy Transition: Status and Outlook*.
16. Singh, R., & Kumar, A. (2021). *Techno-Economic Assessment of Bagasse-Based Briquetting Plants in India*. *Renewable Energy Journal*, 152, 340–351.
17. Patel, M., & Joshi, R. (2022). *Comparative Analysis of Biomass Briquetting Technologies*. *International Journal of Environmental Engineering*, 10(2), 112–120.
18. Sharma, V., & Gupta, P. (2023). *Circular Economy Approaches in the Indian Sugar Industry*. *Journal of Cleaner Production*, 310, 127434.
19. MSME Ministry. (2023). *Incentive Framework for Biomass Processing Units under State Industrial Policies*.
20. CERC. (2021). *Benchmark Tariff Determination for Biomass Power Projects*.
21. Central Electricity Authority (CEA). (2022). *All India Electricity Statistics: General Review*.
22. World Bank. (2020). *Clean Energy Transition in South Asia: Opportunities and Challenges*.
23. IIT Delhi - Centre for Rural Development and Technology. (2022). *Best Practices in Rural Bioenergy Enterprises*.
24. BioEnergy India Magazine. (2023). *Market Trends in Biomass Briquetting and Pelletization*.
25. Carbon Trust. (2021). *Briquetting for Decarbonization: A Low-Cost Climate Solution*.