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From Waste to Wealth: AI-Enabled Financial Insights into Briquette and Pellet Markets

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ABSTRACT

Purpose: The growing global emphasis on sustainable energy has accelerated the demand for biomass-based alternatives such as briquettes and pellets, which transform agricultural and industrial waste into renewable energy sources. Despite their potential to reduce carbon emissions and promote circular economy practices, market adoption of briquettes and pellets faces significant challenges including fluctuating raw material prices, fragmented supply chains, and inconsistent demand forecasting. This paper explores how artificial intelligence (AI) can be leveraged to generate actionable financial insights that enhance decision-making for stakeholders across the value chain.

Design/Methodology/Approach: By integrating predictive analytics, machine learning models, and real-time market intelligence, the study examines AI-driven approaches to price forecasting, cost optimization, investment evaluation, and risk management. The research highlights how AI tools can assist producers in identifying profitable sourcing strategies, enable investors to assess return potential with greater precision, and support policymakers in formulating evidence-based incentives for renewable energy markets. Case-based simulations demonstrate how AI can process large volumes of heterogeneous data, from agricultural outputs and energy prices to government subsidies and consumer demand patterns, thereby providing a comprehensive framework for sustainable business strategies.

Findings: The findings suggest that AI-enabled financial insights not only improve profitability and operational efficiency but also accelerate the transition from waste management to wealth creation through clean energy adoption.

Originality: Ultimately, this study showcases the transformative potential of AI in unlocking the economic value of biomass markets, fostering innovation, and aligning financial incentives with environmental sustainability goals.

Paper Type: Theme Based Paper

KEYWORDS: Artificial Intelligence | Briquette Market | Pellet Market | Financial Insights | Sustainable Energy

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Introduction

India is one of the world's fastest-growing economies, but it faces big challenges in energy use and waste management. Every year, the country produces millions of tons of agricultural and industrial waste, like crop residues and factory leftovers. If not handled well, this waste can harm the environment by causing pollution or being burned in open fields. But there is a positive side: this waste can be turned into useful energy sources called briquettes and pellets. Briquettes are blocks made from compressed waste, and pellets are small, dense cylinders of the same material. They can be burned for heat or electricity, helping reduce reliance on fossil fuels like coal.

In India, the government sees biomass energy as a key part of its plan for clean energy. Programs from the Ministry of New and Renewable Energy (MNRE) support setting up plants to make these briquettes and pellets. For example, there is financial help of up to Rs. 45 lakhs per plant for briquette and pellet manufacturing. This is important because India has a lot of surplus biomasses, about 242 million tonnes from farms and forests in recent years. If used right, this could generate a lot of power, maybe up to 30 gigawatts.

However, the market for briquettes and pellets is not growing as fast as it could. Prices of raw materials change a lot, supply chains are broken into small parts, and it's hard to predict how much demand there will be. This makes it risky for producers and investors. Here is where artificial intelligence (AI) comes in. AI uses computers to learn from data and make predictions. It can help forecast prices, cut costs, and manage risks better. This paper looks at how AI can provide financial insights to make the briquette and pellet markets stronger in India. We use data from official sources like MNRE and NITI Aayog to analyse the situation. The goal is to show how AI can turn waste into wealth, creating jobs, saving the environment, and boosting the economy.

Literature Review

This section reviews existing studies on the topic, organized into themes. We look at what researchers have said about biomass markets, challenges, and how AI can help in finance and energy.

Sustainable Energy and Biomass in India

Many studies show that biomass is a big opportunity for sustainable energy in India. Biomass comes from waste like rice husks, sugarcane bagasse, and forest residues. According to Hiloidhari et al. (2014), India has about 500 million tonnes of biomass each year, with 120-150 million tonnes left over after use. This surplus can be turned into energy. The MNRE (2023) reports that biomass can help meet India's goal of 500 gigawatts of renewable energy by 2030.

Briquettes and pellets are popular because they burn cleaner than loose waste and are easy to transport. A report by NITI Aayog and CEEW (2023) says pellets can be used for cooking in rural homes, reducing smoke and health problems. In power plants, pellets can be mixed with coal to cut emissions. Purohit and Chaturvedi (2016) estimate that using surplus biomass could generate 244 terawatt-hours of electricity by 2030, which is 6% of India's total power needs.

Government policies support this. The National Biomass Mission aims to use biomass in thermal power plants. As per MNRE (2025), there are subsidies for plants, like Rs. 9 lakhs per metric ton per hour capacity. This theme highlights how biomass fits into India's circular economy, turning waste into resources.

Challenges in Briquette and Pellet Markets

Despite the potential, there are hurdles. Fluctuating prices of raw materials are a big issue. In Rajasthan, a study by the Rajasthan Renewable Energy Corporation Ltd. (RRECL, 2011) found biomass prices vary from Rs. 1,386 to Rs. 2,077 per tonne, depending on season and location. Supply chains are fragmented, with farmers, traders, and plants not connected well.

Demand forecasting is hard because it depends on weather, crop yields, and policy changes. Purohit and Michaelowa (2018) note that transportation costs add up, making pellets more expensive than coal sometimes. The levelized cost of electricity from pellets is Rs. 8.35 per kWh, higher than coal's Rs. 6.92 per kWh.

Other challenges include low awareness among users and lack of standards for quality. NITI Aayog (2023) points out that for clean cooking, pellets cost Rs. 600-900 per month per household, which is too much for poor families. These issues slow market growth.

AI in Financial Forecasting and Optimization

AI is good at handling big data for finance. Machine learning (ML), a part of AI, can predict prices by looking at past trends. For example, in energy markets, AI models like neural networks forecast oil prices with high accuracy (Sayed et al., 2024). In India, AI can optimize costs by analysing supply chains.

Studies show AI helps in risk management. Yin et al. (2023) explain how AI uses predictive analytics to evaluate investments, looking at returns and risks. For renewable energy, AI can process data from weather, markets, and subsidies to give better insights.

In finance, AI reduces errors in forecasting. A review by Feng et al. (2024) says AI improves decision-making by 20-30% in green projects. This theme shows AI's role in making finance smarter.

Application of AI in Renewable Energy Sectors

AI is already used in renewables. In solar and wind, AI forecasts energy output (Jha & Bilalova, 2021). For biomass, AI can predict yields and prices. A study by Rathnam et al. (2013) suggests AI for optimizing co-firing in power plants.

In India, AI can help with biomass. For example, machine learning can analyze crop data to forecast raw material availability. Seepana et al. (2017) show AI models for pellet quality prediction. Globally, AI in biofuels optimizes production (Teixeira et al., 2012).

This theme links AI to energy, showing it can address biomass challenges.

Methodology

This study uses secondary data from official sources to analyse the briquette and pellet markets in India. We collected data from MNRE reports, NITI Aayog documents, and state-level studies like RRECL. For AI applications, we reviewed academic papers on machine learning in energy forecasting.

Data analysis involved reviewing market sizes, costs, and potentials. We used descriptive statistics to summarize trends. Case simulations were created using hypothetical data based on real figures, like pellet production costs from Purohit and Chaturvedi (2016). No primary data was collected; all insights come from published sources to ensure reliability.

Analysis and Discussion

Market Overview in India

The briquette and pellet market in India is growing. The biomass briquette market was worth USD 83.73 million in 2023 and is expected to reach USD 153.55 million by 2032 (Introspective Market Research, 2024). For pellets, it's projected to grow from USD 600 million in 2024 to USD 1,200 million by 2035 (Market Research Future, 2024).

India has huge biomass potential. Surplus from agriculture is 123 million tonnes, enough to replace 25% of coal use (Purohit & Michaelowa, 2018). In states like Punjab and Uttar Pradesh, crop residues are abundant. MNRE supports with subsidies: up to Rs. 45 lakhs for pellet plants.

But costs are a concern. Pellet production costs Rs. 4,473 per tonne for large units (Purohit & Chaturvedi, 2016). Transportation adds Rs. 175 per tonne for 50 km. Prices in Rajasthan range from Rs. 1,400 to Rs. 2,300 per tonne for raw biomass (RRECL, 2011).

Table 1: Cost breakdown

Parameter	Value (INR per tonne)	Source
Production Cost (large unit)	4,473	Purohit & Chaturvedi (2016)
Transportation (50 km)	175	Purohit & Chaturvedi (2016)
Farmer Selling Price (avg.)	1,386	RRECL (2011)
Trader Selling Price (avg.)	1,823	RRECL (2011)

AI-Driven Financial Insights

AI can help with price forecasting. Machine learning models like random forests or neural networks can predict biomass prices using data on crops, weather, and markets. For example, if crop yield is high, prices drop. AI can analyse real-time data to forecast this.

In cost optimization, AI identifies cheap sourcing. Using algorithms, producers can find the best suppliers. A simulation: Suppose a plant in Rajasthan uses AI to predict mustard residue prices. Based on RRECL data, AI forecasts a 15% price rise in off-season, so the plant stocks up early, saving 10% on costs.

For investment evaluation, AI assesses returns. Using data from MNRE, AI calculates ROI. If a pellet plant costs Rs. 5 crores with subsidy, AI predicts revenue from selling 10,000 tonnes at Rs. 10,000 per tonne, giving 20% return.

Risk management: AI spots risks like supply shortages. In a case, if drought hits, AI warns and suggests alternatives like importing from other states.

Case-Based Simulations

Case 1: Price Forecasting for a Pellet Producer in Punjab.

Data: Surplus biomass 20 million tonnes (Purohit & Michaelowa, 2018). AI model uses ML to process 5 years of price data. Simulation shows price at Rs. 2,500 per tonne next year, up 10%. Producer adjusts by signing contracts early.

Case 2: Cost Optimization for Briquette Plant in Rajasthan.

Using RRECL (2011) data, AI optimizes supply chain. It suggests buying from local farmers at Rs. 1,386 per tonne, reducing trader margins. Savings: Rs. 400 per tonne.

Case 3: Investment for Investor in Clean Cooking Pellets.

NITI Aayog (2023) data: Monthly cost Rs. 600-900 per household. AI evaluates market for 1,000 households, predicting Rs. 10 lakh revenue. With subsidy, payback in 3 years.

Case 4: Policy Support Simulation.

AI analyzes subsidies and demand. If government increases co-firing to 5%, demand rises 50 million tonnes (Bioenergy International, 2024). AI helps policymakers set incentives.

These cases show AI processes data for better decisions.

Table 2: AI application and benefit

AI Application	Benefit	Example Data Used
Price Forecasting	Reduces uncertainty	Crop yields, weather
Cost Optimization	Lowers expenses by 10-20%	Supply chain costs
Investment Evaluation	Improves ROI accuracy	Market size, subsidies
Risk Management	Mitigates losses	Risk factors like drought

Conclusion

The briquette and pellet markets in India hold great promise for turning waste into wealth. With surplus biomass and government support, they can reduce emissions and create jobs. But challenges like price fluctuations need solutions. AI provides financial insights through forecasting, optimization, and risk management. Our analysis, using official data, shows AI can boost profitability and efficiency. Producers can source better, investors can decide smarter, and policymakers can plan effectively. In the end, AI aligns finance with sustainability, helping India achieve clean energy goals.

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Annexure 17.2.3

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Reviewers Memorandum

Reviewer's Comment 1: The author addresses a highly relevant topic that connects artificial intelligence with sustainable energy markets, which is both timely and significant. The clarity in highlighting the purpose and methodology is commendable. Particularly strong is the articulation of how AI can aid different stakeholders—producers, investors, and policymakers—which broadens the paper's appeal..Overall, a well-structured and promising contribution.

Reviewer's Comment 2: The paper raises an important question of AI's role in advancing biomass-based markets, but it reads as somewhat generic in certain parts. While predictive analytics and machine learning are mentioned, there is limited detail on which algorithms, techniques, or decision models are considered, which may make the conceptual contribution appear broad rather than distinctive.The methodology section is generic, with little detail on what kind of predictive models or analytics tools are proposed.

Reviewer's Comment 3: The paper demonstrates originality in combining circular economy principles with AI-driven financial insights for biomass markets. The strength lies in the interdisciplinary approach, linking energy sustainability, waste management, and advanced analytics. The findings highlight practical implications such as profitability, efficiency, and policy formulation, which are valuable.

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Editorial Excerpt

The article has 1% of plagiarism which is the accepted percentage as per the norms and standards of the journal for publication. As per the editorial board's observations and blind reviewers' remarks the paper had some minor revisions which were communicated on a timely basis to the authors (Shivani and Jhansi), and accordingly, all the corrections had been incorporated as and when directed and required to do so. The comments related to this manuscript are noticeably related to the theme "From Waste to Wealth: AI-Enabled Financial Insights into Briquette and Pellet Markets" both subject-wise and research-wise. This manuscript presents a well-executed and relevant review that explore intellectual and thematic integration of AI and sustainable energy. This paper contributes by demonstrating how AI-driven financial insights can strengthen decision-making in biomass energy markets, bridging gaps between sustainability goals and economic viability. It offers a multi-stakeholder framework that informs producers, investors, and policymakers, while also advancing theoretical discussions on the integration of AI with renewable energy finance. Ultimately, it positions AI as a catalyst for accelerating the circular economy and clean energy adoption. After comprehensive reviews and the editorial board's remarks, the manuscript has been categorized and decided to publish under the "Theme based paper" category.

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The acknowledgment section is an essential part of all academic research papers. It provides appropriate recognition to all contributors for their hard work and effort taken while writing a paper. The data presented and analyzed in this paper by (Shivani and Jhansi) were collected first handily and wherever it has been taken the proper acknowledgment and endorsement depicts. The authors are highly indebted to others who facilitated accomplishing the research. Last but not least, endorse all reviewers and editors of GJEIS in publishing in the present issue.

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