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FROM BY-PRODUCTS TO BIOFUEL: CATALYZING THE CBG REVOLUTION IN SUGAR MILLS

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ABSTRACT
India's energy transition hinges on innovative, sustainable solutions to reduce dependence on fossil fuels and curb carbon emissions. Compressed Biogas (CBG), produced from organic and agro-industrial waste, has emerged as a promising green energy alternative. In this context, the Haryana State Federation of Cooperative Sugar Mills is evaluating the establishment of CBG plants using sugar mill by-products like press mud and bagasse. This initiative aligns with India's renewable energy targets and has the potential to deliver economic, environmental, and social benefits. This paper explores the feasibility, challenges, and strategic policy landscape shaping the CBG revolution in Haryana.

Keywords: *Compressed Biogas (CBG), Sugar Mills, Renewable Energy, Bagasse, Press Mud, Bio-Energy Policy, Waste-to-Energy, Sustainable Transportation, Circular Economy, Haryana, SATAT.*

INTRODUCTION
India's commitment to achieving net-zero carbon emissions by 2070 and increasing the renewable share in energy mix to 50% by 2030 necessitates the development of diverse clean energy solutions. Among them, Compressed Biogas (CBG) offers immense promise, particularly in rural and agro-industrial sectors. CBG is generated through anaerobic digestion of organic material, offering a clean substitute to natural gas. Recognizing this potential, the Government of India launched the SATAT (Sustainable Alternative Towards Affordable Transportation) initiative in 2018 to promote 5,000 CBG plants across the country.

As of October 2024, India's renewable energy capacity reached 203.18 GW, with solar contributing 92.12 GW, wind 47.72 GW, hydro 46.93 GW, and biopower—including biomass and biogas—at 11.32 GW (MNRE, 2024). The SATAT vision aims to produce 15 million metric tons of CBG annually, roughly 40% of India's current compressed natural gas (CNG) consumption.

HARYANA'S SUGAR MILLS: A VALUABLE FEEDSTOCK BASE
Haryana houses ten cooperative sugar mills with crushing capacities ranging from 1,750 TCD in Jind to 5,000 TCD in Panipat and Shahabad. Between 2021 and 2024, these mills processed an average of 42 lakh tons of sugarcane annually, yielding around 1.28 lakh tons of press mud and 77,117 tons of bagasse—key substrates for CBG production. These residues represent an annual CBG production potential of approximately 12,837 tons, including 5,126 tons from press mud and 7,711 tons from bagasse.

THE CBG PRODUCTION PROCESS
CBG is produced via anaerobic digestion, a microbial process that decomposes organic matter in the absence of oxygen, yielding biogas predominantly composed of methane and carbon dioxide. The biogas is subsequently purified and compressed to CBG quality, meeting IS 16087:2016 standards for automotive and industrial use. CBG's energy content and combustion characteristics are similar to CNG, making it a compatible green alternative fuel.

STRATEGIC ADVANTAGES AND ECONOMIC VIABILITY
The installation of CBG plants offers multiple advantages. With an average payback period of 2–3 years, these plants generate revenue through gas sales and by-products like fermented organic manure, eligible for government subsidies under the Fertilizer Control Order. CBG use in sugar mill operations can reduce conventional fuel dependency, minimize energy costs, and foster circular economy practices.

In addition, the production of high-quality organic manure supports sustainable agriculture by enhancing soil fertility and reducing chemical input use. CBG plants also contribute to rural employment, waste valorization, and energy self-reliance.

SITE SELECTION AND PROJECT DESIGN IN HARYANA
Ideal CBG plant locations should prioritize proximity to feedstock sources—sugar mills—and accessibility to agricultural lands for cultivating supplementary biomass like Napier grass. Regions such as Panipat, Karnal, and Sonipat are suitable due to their infrastructure, road connectivity, and clustering potential. Recommended plant capacities range from 5–10 TPD for standalone units to 25–50 TPD for clusters. Land requirements vary from 8–10 acres for medium-sized to 15–20 acres for large plants.

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Haryana's Bio-Energy Policy 2018 encourages renewable energy ventures through incentives like Panchayat land leasing at concessional rates, 100% exemption on registration charges, and facilitation of bank financing.

CHALLENGES HINDERING CBG SECTOR GROWTH

Despite the promising outlook, several barriers challenge CBG plant scalability. Chief among them is the inconsistent supply of segregated feedstock. Without proper source segregation, processing efficiency suffers. Moreover, feedstock price volatility adds financial uncertainty.

The lack of fixed pricing mechanisms for by-products like biogas fertilizer impairs profitability. Regulatory delays, multi-agency clearance requirements, and absence of a single-window system hinder investor confidence. Furthermore, many sugar mills face logistical constraints due to inadequate road networks and the limited spread of City Gas Distribution (CGD) infrastructure.

Banks, especially in the private sector, remain hesitant to fund CBG ventures due to perceived risks and the capital-intensive nature of the projects.

POLICY RECOMMENDATIONS AND FUTURE OUTLOOK

To unlock the sector's potential, India must implement coordinated policy reforms. These include:

- Streamlining regulatory clearances through a single-window system;
- Promoting source-segregated waste collection systems;
- Ensuring Minimum Support Prices (MSP) or market mechanisms for CBG by-products;
- Expanding CGD networks to accommodate rural gas consumption;
- Creating risk-sharing or credit guarantee facilities for banks funding green energy projects.

By addressing these systemic challenges, Haryana can pioneer a scalable CBG model with nationwide implications.

CONCLUSION

The adoption of CBG technology in Haryana's cooperative sugar mills represents a pivotal step toward India's sustainable energy future. By converting agro-industrial waste into clean energy, these projects offer an innovative solution for waste management, rural employment, and carbon mitigation. With appropriate policy support, financial facilitation, and stakeholder collaboration, Haryana can emerge as a model state in CBG-based circular energy economy.

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