



SPL. COVERAGE IBET 2026

INDIA BIO ENERGY & TECH EXPO

Spl. issue on GOBARDhan SCHEME



Shri Narendra Modi
Hon'ble Prime Minister of India



Shri Hardeep Singh Puri
Hon'ble Union Minister of Petroleum
& Natural Gas, Government of India

₹23,731 crore national outlay

Assured CBG Offtake

Stable Administered Pricing Framework

Capital Assistance of up to ₹2 crore per TPD

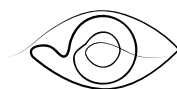
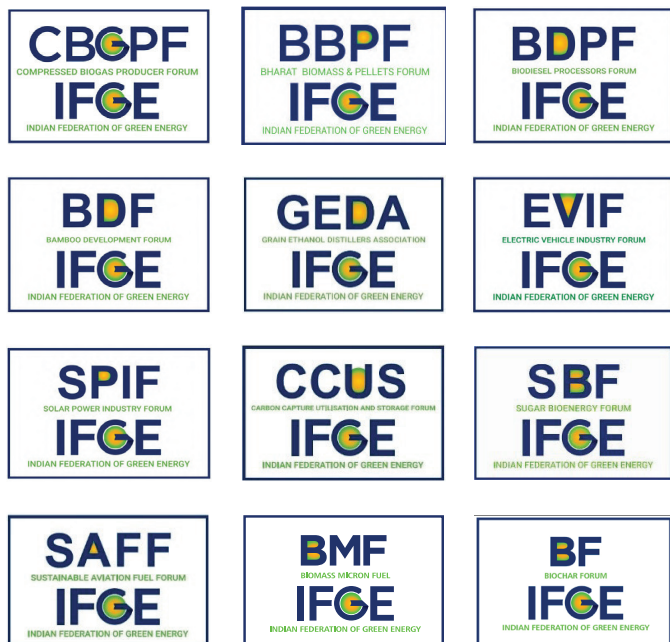
Pipeline Infrastructure Development

Credit Guarantee Mechanism

CBG Ecosystem Fund

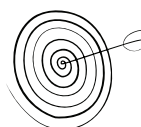


Forums of IFGE



Vision

Drive and deliver an integrated approach for establishing a sustainable energy ecosystem by working with all stakeholders across sectors, states and the nation.



Mission

Promote energy security through a sustainable energy ecosystem to meet India's fuel and electricity needs.

Be the voice of the Indian renewable sector in policy, projects, change management, and leadership.

Provide a platform for collaboration to support India's vision of becoming a global leader in renewable energy.

FORM IV (See rule 8)

S.No.	Particulars	Details
1	Place of Publication	1F-CS-43, First Floor, Ansal Plaza, Sector-1, Vaishali, Ghaziabad, Uttar Pradesh - 201010
2	Periodicity	Quarterly
3	Printer's Name	Innovative Designers & Printers
3 i	Whether citizen of India?	Yes
3 ii	Address	Innovative Designers & Printers, E-41, Sector 6, Noida - 201301
4	Publisher's Name	Sanjay Ganjoo
4 i	Whether citizen of India?	Yes
4 ii	Address	45C Pocket-B SFS Flats, Mayur Vihar Phase-3, Vasundhara Enclave, New Delhi - 110096
5	Editor's Name	Sanjay Ganjoo
5 i	Whether citizen of India?	Yes
5 ii	Address	45C Pocket-B SFS Flats, Mayur Vihar Phase-3, Vasundhara Enclave, New Delhi - 110096
6	Owner / Shareholders (above 1%)	Sanjay Ganjoo 45C Pocket-B SFS Flats, Mayur Vihar Phase-3, Vasundhara Enclave, New Delhi - 110096 Sandeep Shriram Theng Flat no 102, Welworth Celina , B-2 Plot no 270/B/1/1. (Bank of Baroda Lane, opposite to Mahabaleshwar Hotel, Baner Road, Pune 411045)
I, Sanjay Ganjoo, hereby declare that the particulars given above are true to the best of my knowledge and belief.		
Dated: 1 April 2026		sd/- Sanjay Ganjoo publisher

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Bharat Bioenergy Compass is printed and published by the Indian Federation of Green Energy (IFGE) and printed at Innovative Designers & Printers, E-41, Sector 6, Noida – 201301.

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Registration No.: UPENG/26/A0547

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Message from President



*Founder Chairman, Praj Industries
President, IFGE*

It gives me immense pleasure to share my thoughts for another edition of Bharat Bioenergy Horizon, as India's bioenergy journey enters an increasingly important phase of implementation and scale. Today, the priorities of energy security, decarbonisation, circular economy and rural prosperity are converging more strongly than ever, with bioenergy positioned at their intersection.

This edition focuses on two important developments-the progress of the GOBARdhan initiative and the recently concluded India Bioenergy & Tech Expo (IBET) 2026. Together, they represent complementary dimensions of India's bioenergy transition: enabling projects on the ground while fostering collaboration among policy-makers, industry, technology providers, investors and other stakeholders.

The GOBARdhan initiative is steadily transforming the way India perceives organic waste-from a disposal challenge into a valuable resource. The expanding Compressed Biogas (CBG) ecosystem demonstrates the growing confidence in this opportunity. Beyond plant development, recent efforts towards strengthening infrastructure, market linkages and utilisation of organic manure are helping build a more integrated value chain.

As the sector progresses, however, our focus must increasingly shift from project announcements to commercially sustainable operations. Reliable feedstock aggregation, efficient conversion technologies, financing, assured offtake, gas infrastructure and effective valorisation of digestate and organic fertilisers will be critical to achieving the desired scale.

This transition from ambition to implementation was also at the heart of the India Bioenergy & Tech Expo (IBET 2026). The event brought together stakeholders across CBG, ethanol, biomass, waste-to-energy, sustainable aviation fuel and other emerging low-carbon pathways. The deliberations reinforced an important message: technology alone cannot drive the bioenergy transition. Successful scale-up requires alignment between policy, technology, feedstock, infrastructure, financing and markets.

Platforms such as IBET have an important role in creating this convergence and translating dialogue into partnerships, investments and projects. I am particularly encouraged by the increasing participation of states and industries, which will be essential for developing region-specific bioenergy ecosystems around locally available resources.

Looking ahead, our vision must also expand from bioenergy towards a broader circular bioeconomy. India's abundant biological resources can become building blocks not only for clean fuels, but also for renewable chemicals, biomaterials, biofertilisers and other value-added products. Such integrated pathways can strengthen project economics while advancing energy security, rural prosperity and environmental sustainability.

I congratulate the IFGE team, policymakers, industry stakeholders, partners and participants contributing to this journey. Let us carry this momentum forward, from policy to projects, from waste to wealth, and from bioenergy towards a globally competitive Indian bioeconomy.

Warm regards,



(Dr. Pramod Chaudhari)

From DG's Desk

Festival Bonus: Announcement of GOBARDHAN Scheme on the eve of 3rd IBET 26'



Sanjay Ganjoo
Director General
IFGE

August 2026 has been a remarkable month for IFGE. The announcement of the **Gobardhan Scheme** (Galvanizing Organic Bio-Agro Resources Dhan), approved by the Cabinet on August 6, 2026, is a landmark moment for the bio-energy sector of India. Another important milestone was the **3rd India Bioenergy & Tech Expo** held at the Expo Centre, Greater Noida, from August 11 to 13, 2026.

The SATAT scheme for CBG was launched by MoPNG in 2018, but due to viability issues, the scheme was not attracting much interest from investors. Only 40 plants had come up in four years against an ambitious target of 5,000 plants that the government had expected to come up by 2023–24. IFGE launched a separate focused forum on CBG named the **CBG Producers Forum (CBGPF)** on December 14, 2022, in New Delhi in order to develop the sector.

Assessing the situation, IFGE felt that additional incentives and facilities needed to be extended to CBG producers in order to make their business viable and attract more investors. The CBGPF of IFGE started its outreach programme with policymakers, including the **PMO, MoPNG, MNRE, MoA, MoF, NITI Aayog and DDWS**, and made recommendations regarding pricing, aggregation, support for the disposal of digestate, off take, pipeline connectivity, and CFA.

The policymakers were quite receptive to these recommendations, which resulted in the announcement of many reforms and additional schemes over time, including MDA on FoM/LFoM, the BAM & DPI Scheme, price revisions, and CFA scheme revisions. The feedback on outcome of these revisions was continuously shared with policymakers.

It was felt that supplementary policies did help the industry to stabilize, but in terms of governance, more needed to be done. This resulted in bringing all schemes to develop the CBG sector under one umbrella and declaring MoPNG as the sole nodal ministry for administering the CBG sector. It was further felt that instead of a multiplicity of schemes, only one scheme should be introduced to support the sector.

The landmark **Gobardhan Scheme announced by MoPNG** is the result of such deliberations. It amalgamates most of the schemes and creates six growth engines for the CBG sector, including assured offtake, a stable CBG pricing framework, enhanced capital assistance, development of pipeline infrastructure, credit guarantee support, and a CBG Ecosystem Challenge Fund.

IFGE welcomes this move, **thanks Hon'ble PM & Hon'ble Minister for PNG** and feels that the Gobardhan Scheme will make the sector viable to attract more investments. It will also help ensure energy security for the country, reduce dependence on imported gas, generate wealth from waste, improve the income of farmers, reduce the carbon footprint, and create jobs.

The India Bioenergy & Tech Expo, launched in 2024, has proved to be an important platform for bioenergy, including CBG, to collect industry inputs, collate recommendations, and present them to policymakers. Besides helping the industry transact business, source technologies, and generate awareness, the platform has delivered results like the announcement of industry-friendly policies such as Gobardhan.

The announcement of this scheme just before the event on August 11, 2026, was nothing short of a festival bonus. All industry members welcomed the scheme and celebrated it during the event. **The State of Uttar Pradesh, a leader in the bioenergy sector with progressive policies and governance, deserves huge applause for inviting IFGE and hosting IBET '26 at Greater Noida.**

UPNEDA, under the leadership of **Shri A.K. Sharma, Hon'ble Minister of Energy & Additional Energy Sources, Government of Uttar Pradesh**, along with his entire team of officers and staff, ensured that the event reached the highest standards in participation and deliberations. **IFGE is grateful to the Government of UP and all participants for making the event a great success.**



Sanjay Ganjoo

Message from the Chairman Editorial Board



Dilip Patil

*Chairperson, Editorial Advisory
Board of Bharat Bioenergy Compass,
Regional Director (West), IFGE*

From Aspiration to Implementation: India's Bioenergy Moment

As we bring you this edition of Bharat Bioenergy Compass, the 3rd India Bioenergy & Tech Expo (IBET 2026) has just concluded and at a truly defining moment.

Held from 11th to 13th August 2026 at India Expo Centre & Mart, Greater Noida, under the theme “Advancing Bioenergy Solutions for a Low Carbon World”, IBET 2026 brought together over 800 delegates, 175+ speakers, 100+ exhibiting companies and 7,500+ visitors. Hosted by the Government of Uttar Pradesh with UPNEDA as co-organiser, and organised by IFGE in partnership with MM Active Sci-Tech Communications, the expo drove home one clear message: Technology alone will not deliver the bioenergy transition. Scale will need alignment across policy, feedstock, infrastructure, finance and markets.

The timing could not have been more significant. Just days before the expo, on 6th August 2026, the Union Cabinet approved GOBARDhan the National Circular Bioenergy Scheme with an outlay of ₹23,731 crore. This landmark decision brings fragmented initiatives under one unified framework led by the Ministry of Petroleum and Natural Gas. Built on six growth engines assured offtake, stable pricing, capital assistance, pipeline infrastructure, credit guarantees and an ecosystem challenge fund it shifts Compressed Biogas from a policy-supported pilot to a bankable infrastructure opportunity.

This edition captures the breadth and depth of that shift. K R Raghunath makes a strategic case for bioenergy as a pillar of India's energy security. Dr Srinivas L. Kasulla explains why feedstock radius ultimately decides project viability. Priyanka Khemka assesses India's CBG opportunity through a project finance lens, linking domestic momentum with global capital. Dr Nidhi Sahu unpacks the architecture of the new GOBARDhan Scheme. Rajesh Tope separates fact from myth on India's E20 journey and what lies ahead. Dr Sangeeta Srivastava reports on Godavari Biorefineries' pioneering CO₂-to-renewable DME pilot with ICT Mumbai. Sunil Rohom outlines what it will take to scale LA-PLA successfully. Vaibhav Dange shows how India is moving towards fuel autonomy through strategic energy transition. Satish Upadhyay and Alok Sinha examine biomass pellet procurement reforms and the need for effective co-firing. Ajay Kumar presents Merino Industries' large-scale model as both producer and consumer of bioenergy. Prasad Malagavi discusses how pelletization can accelerate India's green energy future. Alan Chandler and colleagues introduce Sugarcrete as a grey-to-green building material. Manish Dabkara argues for rooting energy security in soil. The NETRA team Dr. Amit Kumar Kulshreshtha, Shanta Kumar, Manish Sonker and Narendra Motiram Sakhare explores MSW and bioenergy pathways. Dr Sanjay Kolte and Dilip Patil show how bioenergy by-products are being turned from waste to wealth. Anurag Kumar Sachan interrogates the economics of bioenergy. And Manoj Tandon maps the biochar opportunity in India.

Together, these contributions mark a clear shift from single-technology discussions to integrated systems thinking, from policy announcements to implementation discipline, and from waste management to value creation.

But this edition also addresses some hard truths. The biomass co-firing mandate, despite its potential, still faces enforcement gaps beyond the NCR. CBG projects continue to deal with feedstock seasonality, transport costs and the challenge of collection radius. Ethanol, having achieved E20, must now move beyond blending mandates to a wider transport energy strategy. The gap between policy intent and on-the-ground execution remains and bridging it will need the same discipline, innovation and collaboration that IBET 2026 showcased.

For global investors, the message is clear: India's CBG market has de-risked its core value proposition and is emerging as a mainstream asset class. Capital will flow to platforms that can demonstrate long-term feedstock security, creditworthy offtake, transparent unit economics and strong operational delivery. The challenge is no longer availability of capital, but the market's ability to structure assets that meet institutional standards.

India's bioenergy moment is now. Let us seize it.

Dilip Patil

योगी आदित्यनाथ



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उत्तर प्रदेश
संदेश

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दिनांक : 12.08.2026

मुझे यह जानकारी अत्यंत प्रसन्नता हो रही है कि थर्ड इंडिया बायो एनर्जी एंड टेक (IBET) एक्सपो 2026 का आयोजन 11 से 13 अगस्त, 2026 तक इंडिया एक्सपो सेंटर एवं मार्ट, ग्रेटर नोएडा में किया जा रहा है।

आज पूरी दुनिया क्लीन एनर्जी, सस्टेनेबल डेवलपमेंट और एनर्जी इंडिपेंडेंस के विषय पर बहुत ही गंभीरता के साथ कार्य कर रही है। भारत के यशस्वी प्रधानमंत्री श्री नरेंद्र मोदी जी ने विकसित भारत के साथ ग्रीन ग्रोथ का जो संकल्प देश के सामने रखा है, उत्तर प्रदेश उसे धरातल पर उतारने के लिए पूरी प्रतिबद्धता के साथ कार्य कर रहा है।

उत्तर प्रदेश की शक्ति इसकी समृद्ध कृषि, प्रचुर बायोमास, मजबूत गन्ना एवं एथेनॉल उत्पादन तंत्र, बेहतर इंडस्ट्रियल बेस और इन्वेस्टमेंट फ्रेंडली इकोसिस्टम में भी निहित है। एग्रीकल्चरल रेसीड्यू (कृषि अवशेष) और आर्गेनिक वेस्ट (जैविक अपशिष्ट) को एनर्जी में परिवर्तित करके हम किसानों की आय बढ़ाने, ग्रामीण क्षेत्रों में रोजगार के नए अवसर सृजित करने, एनर्जी सिक्यूरिटी को मजबूत करने और पर्यावरण संरक्षण को सुनिश्चित करने की दिशा में आगे बढ़ रहे हैं।

हमारा स्पष्ट संकल्प है कि एग्रीकल्चरल रेसीड्यू (कृषि अवशेष) और आर्गेनिक वेस्ट (जैविक अपशिष्ट) किसी समस्या का कारण नहीं, बल्कि समृद्धि का साधन बने। जो पराली कल तक किसानों और पर्यावरण के लिए चुनौती मानी जाती थी, वही अब एनर्जी, एम्प्लॉयमेंट एंड एडिशनल इनकम (अतिरिक्त आय) का माध्यम बने, यही उत्तर प्रदेश की नई सोच है।

बायो एनर्जी पॉलिसी 2022 और ग्रीन हाइड्रोजन पॉलिसी 2024 के माध्यम से हम इन्वेस्टर्स को ऐट्रैक्टिव इंसेंटिव (आकर्षक प्रोत्साहन), सिंपल एंड ट्रांसपेरेंट अप्रूवल सिस्टम तथा लैंड एंड बेसिक इंफ्रास्ट्रक्चर से जुड़ी सुविधाएं उपलब्ध करा रहे हैं। आज उत्तर प्रदेश कंप्रेसड बायो गैस, इथेनॉल, बायो डीजल, बायो मास, वेस्ट-टू-एनर्जी, सस्टेनेबल एविएशन फ्यूल और ग्रीन हाइड्रोजन जैसी क्लीन एनर्जी टेक्नोलॉजी में निवेश के लिए एक प्रमुख डेस्टिनेशन के रूप में तेजी से उभर रहा है।

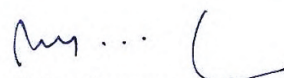
ग्रीन हाइड्रोजन में रिसर्च को बढ़ावा देने के लिए हमने IIT कानपुर और IIT-BHU के द्वारा सेंटर ऑफ एक्सीलेंस स्थापित करने को मंजूरी दी है। कई शहरों में म्यूनिसिपल सॉलिड वेस्ट (शहरी कचरे) से ऊर्जा बनाने वाले आधुनिक प्लांट संचालित किए जा रहे हैं। वर्तमान में उत्तर प्रदेश में 58 कंप्रेसड बायो गैस (CBG) प्लांट्स संचालित हैं।

पश्चिमी यूपी के मुजफ्फरनगर, मेरठ और सहारनपुर में कृषि अवशेषों (पराली) और गन्ने की प्रेसमड से बायोगैस बनाने का एक बहुत बड़ा नेटवर्क तैयार हो रहा है। बड़ी चीनी मिलों को अब बायो-रिफाइनरी में बदला जा रहा है, जहां इथेनॉल सहित विभिन्न प्रकार के बायो-फ्यूल का उत्पादन किया जा रहा है।

मुझे पूर्ण विश्वास है कि आई० बी० ई० टी० एक्सपो (IBET Expo) 2026 पॉलिसी मेकर्स, एंटरप्रेन्योर्स, इन्वेस्टर्स, रिसर्चर्स, स्टार्ट-अप्स और टेक्नोलॉजी एक्सपर्ट्स को एक साझा मंच प्रदान करेगा। यहां होने वाले विचार-विमर्श, इनोवेशन और मीनिंगफुल पार्टनरशिप (सार्थक साझेदारियां) भारत की भविष्य की ऊर्जा व्यवस्था को नई दिशा देंगे।

मैं देश-विदेश के सभी स्टैकहोल्डर्स (हितधारकों) से आह्वान करता हूँ कि वे उत्तर प्रदेश को बायो एनर्जी के क्षेत्र में देश का अग्रणी राज्य बनाने के हमारे संकल्प में सहभागी बनें तथा एनर्जी, एनवायरनमेंट, एंड इकॉनमी — इन तीनों के बीच संतुलन स्थापित करते हुए एक रेस्पॉंसिबल और सस्टेनेबल डेवलपमेंट के मार्ग पर आगे बढ़ें।

आयोजन के लिए मेरी शुभकामनाएं।


(योगी आदित्यनाथ)

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New GOBARdhan 2026 Scheme: A New Framework to Make Compressed Biogas a Viable Business

After years of policy development, project announcements and capacity creation, the key challenge is to make CBG a consistently viable and bankable business. The newly notified GOBARdhan Scheme seeks to address this through an integrated framework covering offtake, pricing, capital investment, pipeline connectivity, financing and utilisation of organic manure.

With a total outlay of ₹23,731 crore, the new GOBARdhan Scheme comes into force from 1 September 2026 and is administered by the Ministry of Petroleum and Natural Gas (MoPNG) from FY 2026–27 to FY 2035–36.

Six Components of GOBARdhan

The scheme comprises six major components: CBG Offtake Assurance Mechanism, CBG Affordability Support, Capital Assistance, Pipeline Infrastructure, Credit Guarantee Support and the CBG Ecosystem Challenge Fund.

Offtake Assurance and Market Creation

MoPNG will develop an Offtake Assurance Framework involving CGD entities, OMCs and other channels to establish firm demand for CBG. The framework targets a CBG obligation of 3% in FY 2026–27, 4% in FY 2027–28 and 5% from FY 2028–29 onwards in the specified CNG (T) and PNG (D) segments.

Importantly, failure to meet

offtake arrangements may attract regulatory or administrative measures, including rationalisation of APM/non-APM gas allocation or financial disincentives. This provides stronger demand visibility for project developers and lenders.

Stable Pricing and Affordability Support

The scheme introduces an Administered CBG Price (ACP) of ₹2,110/MMBtu, excluding applicable taxes and compression charges, for a minimum period of 10 years.

The Government will also provide CBG affordability support of up to ₹10/kg of CBG procured to the designated Synchro Operator, for the ten-year period from FY 2026–27 to FY 2035–36.

The ACP incorporates an incentive linked to the sale of CBG-plant by-products, including Fermented Organic Manure (FOM) and Liquid FOM (LFOM). Accordingly, CBG producers will remain responsible for the sale and appropriate utilisation of these by-products.

Capital Assistance

Eligible greenfield CBG plants can receive up to ₹2 crore/TPD, comprising ₹1.25 crore/TPD for plant machinery and up to ₹0.75 crore/TPD for feedstock aggregation, organic manure processing/value addition machinery and other eligible equipment.

Brownfield projects will be eligible for capital support only for addi-

tional CBG capacity. Projects in specified Special Category Areas – including the Northeastern States, Sikkim, Uttarakhand, Himachal Pradesh and the UTs of Jammu & Kashmir, Ladakh, Lakshadweep and Andaman & Nicobar Islands – will receive an additional 20% support on plant machinery assistance.

Pipeline Connectivity

To reduce transportation costs and enable grid injection, the scheme provides 80% support for eligible capital expenditure for cluster-based pipeline infrastructure up to 75 weighted km per CBG plant connecting to trunk pipelines.

For standalone plants, 50% eligible capex support is available for connectivity up to 75 km to the nearest CGD network or CGD retail outlet. Cascades can continue where pipeline connectivity is not feasible.

Credit Guarantee

For eligible MSME-based CBG projects, credit guarantee coverage will extend up to 85% of the outstanding amount at default, subject to a ceiling of ₹20 crore per general MSME project and ₹25 crore per women-led MSME project. This can significantly improve access to institutional finance.

However, CBG projects predominantly based on Municipal Solid Waste (MSW) are not eligible for capital assistance or credit guaran-

Six Growth Engines under GOBARDhan

Assured CBG Offtake

Stable CBG Pricing Framework

Capital Assistance

Development of Pipeline Infrastructure

Credit Guarantee Support

CBG Ecosystem Challenge Fund

4/4

50%, while suitable aggregation and storage infrastructure will be developed at FMC depots.

The Department of Agriculture & Farmers' Welfare will extend the exemption from authorization-letter requirements for FOM/LFOM manufacturers' sales until FY 2035–36, helping reduce regulatory barriers to organic-manure

With GOBARDHAN coming into force, overlapping interventions – including MDA, CFA for CBG under the Waste to Energy Programme, Biomass Aggregation Machinery, Pipeline Infrastructure Scheme and SATAT – will be subsumed or rationalised as specified in operational guidelines.

MoPNG will administer the scheme through a Steering Committee, Project Approval Board, Project Appraisal Committee, Project Management Agency and PPAC, covering approval, monitoring, pricing, implementation and reporting. Component-wise operational guidelines, SOPs, application formats and contractual frameworks will be issued separately.

A Turning Point for CBG Bankability

GOBARDHAN marks a shift from addressing individual constraints to creating a risk-mitigation framework across the CBG project lifecycle. Assured offtake, long-term pricing, capital assistance, pipeline support, credit guarantees, FOM/LFOM market development and carbon-market integration can collectively improve project bankability.

The next phase will depend on timely implementation, effective disbursement, feedstock planning, pipeline development, state-level policies and sustainable markets for organic by-products.

GOBARDHAN can provide the foundation for a scalable and commercially sustainable CBG industry. Its success will ultimately depend on coordinated implementation by the Central and State Governments, financial institutions, technology providers, developers and end-users. ■

tee support under the scheme.

Ecosystem Challenge Fund

The ₹500 crore CBG Ecosystem Challenge Fund will support domestic equipment development, process and yield improvement, R&D, by-product value addition and other ecosystem gaps.

It will also encourage district-level competition and development through feedstock resource assessment and mapping, aggregation infrastructure, district CBG development plans, capacity building, awareness and stakeholder mobilisation.

Strengthening the FOM/LFOM Market

A significant feature of the framework is the role assigned to the Department of Fertilizers (DoF) in creating demand for FOM/LFOM and PROM. Fertilizer Marketing Companies will be mandated to procure FOM from GOBARDHAN CBG plants in a graded manner, increasing from 20% to

commercialisation.

Carbon Market and Wider Ecosystem

The Ministry of Power, through the Bureau of Energy Efficiency, will publish the methodology for CBG-production projects under the Offset Mechanism of the Carbon Credit Trading Scheme (CCTS). This could create an additional revenue opportunity for CBG projects.

The scheme also provides for coordinated IEC campaigns by MoPNG, DoA&FW and DoF, with support from ICAR where required, to build awareness among developers, feedstock aggregators, states, financial institutions, farmers and end-users.

Implementation and Transition

Capital assistance, pipeline infrastructure, credit guarantees and the Ecosystem Challenge Fund will be implemented during the first five years, up to FY 2030–31.

Global Capital, Domestic Momentum: Evaluating India's CBG Opportunity Through a Project Finance Lens



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CBG production facilitates not just conversion of agricultural residue and organic waste into fuel but also reducing emissions while strengthening energy security, and generating economic activity in the country. India has 200+ operational/commissioned CBG plants, with another 350+ currently under construction and a much larger announced pipeline of 1000+ plants.¹ Large private conglomerates like Reliance and Adani are investing directly in CBG capacity, alongside the state-owned oil marketing companies, which have largely pursued the sector through joint ventures with specialist project developers. In-

ternational capital is also entering the space, led by climate-focused investors such as Climate Fund Managers, alongside platforms like EverEnviro – backed via the Green Growth Equity Fund by India's NIIF, the UK Government, and British Petroleum.

The new GOBARDhan National Circular Bioenergy Scheme is intended to take this policy support to the next level. Building on the market framework created by SATAT and subsequent CBG blending mandates, the ₹23,731 crore (about \$2.5 billion) scheme combines assured offtake, stable pricing, capital assistance, pipeline connectivity and access to

finance. Together, these measures are intended to drive nearly ten-fold growth in domestic CBG production and catalyse large-scale private investment over the next decade.

This article examines how policy support, domestic investment, and international capital are converging on bankable projects – and what risks remain as the market moves toward an institutional-scale industry.

Domestic Momentum, Global Capital

India's CBG build-out is already attracting substantial domestic capital. Reliance Industries has



announced a ₹6,500 (\$680 million) crore CBG investment programme, while Indian Oil, HPCL and Oil India are also developing significant CBG portfolios. Indian Oil Corporation has pursued CBG largely through joint ventures (with EverEnviro and GPS Renewables) and has issued letters of intent for 325 plants. Hindustan Petroleum has committed roughly ₹2,000 crore (\$210 million) to 24 plants, and Oil India is deploying up to ₹4,000 (\$420 million) crore across 25 plants, alongside a separate ₹400 crore (\$42 million) deal with Delhi's municipal corporation.

International capital is increasingly adding to this momentum. EverEnviro, established by EverSource Capital, the 50:50 joint venture between Everstone Capital and Lightsource bp, has announced plans to invest around ₹10,000 crore (\$1 billion) across a portfolio of CBG

plants. EverEnviro has executed roughly ₹2,000 (\$210 million) crore across 20+ CBG projects in MP, UP, Delhi, and Punjab, with ambitions to scale toward 100+ plants nationally. Climate Fund Managers has committed \$32.2 million (about ₹305 cr) to Akaia Green Fuels, following approximately \$3.3 million (about ₹30 cr) of earlier development funding. Strategic investors are also gaining exposure to the broader value chain. TotalEnergies, through its 37.4% stake in Adani Total Gas, has exposure to CBG projects being developed by Adani TotalEnergies Biomass, including the Barsana project in Uttar Pradesh.

This mix of domestic and international capital suggests that India's CBG opportunity is increasingly being viewed as an investable infrastructure market rather than simply a policy-led bioenergy programme.

The Bankability Gap: Feedstock – and Beyond

A plant with strong offtake and pricing can still miss targets if it can't secure feedstock at a competitive delivered cost. Residues are dispersed, seasonal, and increasingly contested as more plants compete for the same biomass. The Biomass Aggregation Machinery (BAM) scheme (₹564.75 crore outlay; 37 proposals, ~₹248 crore approved as of

March 2026) and GOBARDhan's Ecosystem Challenge Fund are addressing this, but the sector is de-risking revenue faster than physical supply.

Large developers – notably Reliance's Andhra Pradesh and Rajasthan projects – are moving toward cultivated energy crops like Napier grass instead of relying purely on collected agricultural residue. The appeal is a predictable, year-round harvest instead of a seasonal, geo-

CBG becoming more bankable in India

Pillar	India's Position	Why It Matters	Investor & Risk Perspective
Demand	Blending Obligation: FY26–27: 3% FY27–28: 4% FY28–29+: 5%	Creates structural, phased demand	De-risks offtake – but revenue security remains tied to the underlying credit quality of the buying City Gas Distribution (CGD) entity.
Price	Administered Price Framework: ₹2,110/MMBTU (~₹105/kg) base price Minimum 10-year horizon	Improves long-term revenue visibility	INR-denominated fixed pricing without explicit indexation introduces real FX and inflation risk for dollar-denominated equity or offshore debt.
Capex	Capital Assistance: Up to ₹2 crore per TPD of installed capacity	Lowers upfront equity & capital requirements	Shrinks the required equity check, but does not mitigate operational, execution, or project delivery risks.
Debt	Credit-Guarantee Mechanism: Capital guarantees for eligible MSME projects	Aims to reduce lender credit risk	Requires close scrutiny: Guaranteed loan percentages, coverage caps, and the guarantor's credit rating are not yet fully standardized; cannot be treated as fully de-risked upfront.
Infrastructure	Pipeline Connectivity: Subsidized integration into CGD networks	Eases evacuation and market-access constraints	Remains the weakest link today. Connectivity is limited; most plants rely on road cascades. Capital assistance for direct pipelines is promising, but still in early implementation phases.
Feedstock	Aggregation & Logistics Support: Biomass mapping, cluster setup, and ecosystem support	Addresses a core operational bottleneck	Still the single largest swing factor on plant-level IRR. Regulatory support here is in early stages compared to downstream offtake mechanisms



graphically scattered one. But it changes the nature of the risk. Instead of managing collection logistics across thousands of farms, a developer must secure, long-term access to land and ensure reliable irrigation for dedicated cultivation – making the challenge more akin to a plantation-economics than waste aggregation. Notably, current policy support – GOBARDhan’s Ecosystem Challenge Fund and the BAM subsidy – is built around aggregating and transporting waste-based feedstock (residue, dung, municipal organic waste), and not around land or water accessibility for cultivated crops. So the land/water risk in energy-crop-based projects sits largely outside what today’s feedstock policy actually covers.

Other Risks

FX exposure: A 10-year unhedged rupee exposure on an INR-fixed price is a first-order risk for dollar-denominated capital that the current framework doesn’t address.

State-level fragmentation: Land-allotment models, capital subsidies, and feedstock rules vary significantly across states. For example, Andhra Pradesh offers a 20% capital subsidy in addition to central assistance while Rajasthan is still deciding between land allotment and lease structures for energy-crop cultivation. These state-level differences represent a material underwriting variable that can be obscured by a narrative focused on the national policy framework.

The Opportunity Ahead

India’s CBG market has reached a tipping point. The sector has de-risked its fundamental value proposition and is emerging as a mainstream asset class with government policy support. Now, the central challenge is identifying platforms and project archetypes that can translate tailwind policy support into predictable, long-term yield, capable of withstanding global institutional diligence.

For global investors, the strategic opportunity lies in institutionalizing the sector and transitioning it from a fragmented landscape of single-asset developments into a scalable infrastructure vertical by pairing international patient capital with local execution expertise.

Capital allocation will increasingly favor platforms that offer bankable risk profiles – anchored by long-term feedstock security, creditworthy offtake arrangements, transparent unit economics, and operationally sound delivery models. The next phase of India’s energy transition will not be constrained by capital availability, but by the market’s capacity to package and structure assets that meet global institutional standards.

This defines the immediate market frontier – bridging the gap between India’s expanding project pipeline, and the global pool of institutional capital seeking high-conviction, bankable energy-transition assets. ■

Powering India's Circular Bioeconomy: Elan Energy and the GOBARDhan Opportunity



Ekasjyot Singh Barara
Director, Elan Energy

India's Compressed Biogas (CBG) sector has come a long way since the government launched the Sustainable Alternative Towards Affordable Transportation (SATAT) initiative in 2018. What began as a framework to create market pull for CBG produced from agricultural residues, cattle dung, and organic waste, has over the last several years, matured into a genuine national ecosystem, one now poised for its most significant leap yet.

That leap arrived in August 2026, when the Union Cabinet approved GOBARDhan (Galvanizing Organic Bio-Agro Resources Dhan), the National Circular Bioenergy Scheme, backed by an outlay of Rs. 23,731 crore. GOBARDhan is not simply an incremental policy update, it is a structural reset of how India intends to scale its bioenergy sector. By bringing assured CBG offtake, a stable pricing framework, capital assistance, pipeline infrastructure support, credit guarantees, and a dedicated CBG Ecosystem Challenge Fund together under one national um-

brella, the scheme is designed to solve the very problems that have historically slowed project bankability: fragmented incentives, inconsistent offtake commitments, and thin lender confidence.

The ambition is substantial. GOBARDhan targets nearly a ten-fold increase in domestic CBG production, while deliberately widening the base of participants to include MSMEs, cooperatives, and rural entrepreneurs alongside large developers. Its impact is expected to ripple well beyond energy metrics, strengthening India's energy security by displacing imported fossil fuels, creating new income streams for farmers and feedstock aggregators, improving the scientific management of organic waste, cutting greenhouse gas emissions, and expanding the market for organic manure products like FOM and LFOM. District-level feedstock mapping, aggregation infrastructure, and capacity-building programmes round out a genuinely circular-economy design.

Why Execution Will Decide GOBARDhan's Success

Policy architecture and capital availability, however, only solve half the problem. A scheme of this scale spanning hundreds of projects across diverse states, feedstocks, and technology configurations will ultimately be judged on execution: how well projects are engineered, how effectively stakeholders are coordinated, and how consistently plants perform once commissioned. This is precisely where Project Management Consultancy (PMC) shifts from a support function to a strategic necessity, particularly for the large public sector undertakings tasked with anchoring India's CBG rollout.

Successful CBG project delivery requires more than technical design. It demands seamless coordination between developers, technology providers, EPC contractors, financial institutions, oil marketing companies, and regulators along with rigorous quality assurance, risk management, construction supervision, and commissioning discipline. Projects that skip this coordination layer tend to face delays, cost overruns, and – most critically – underperformance after commissioning.

Elan Greentech Energies: A PMC Partner Built for Scale

This is the gap that Elan Energy has spent over two decades preparing to fill. With a background spanning



renewable energy, environmental engineering, and sustainability consulting, Elan has established itself as a specialized engineering and project management partner for strategic bioenergy projects across India, working closely with major public sector undertakings including GAIL India and BPCL.

Elan's role on these projects extends well beyond conventional monitoring. The company's mandate covers project planning, engineering review, construction supervision, quality assurance, commissioning support, vendor coordination, risk management, and operational readiness assessments. The full spectrum of activities that separate a project that merely gets built from one that performs reliably for its intended lifetime.

The scale of Elan's engagement speaks for itself. The company was awarded PMC contract(s) covering more than 30 Compressed Biogas projects distributed across multiple Indian states, an assignment that independent industry coverage has recognized as among the largest PMC engagements in India's CBG sector to date. Elan has also played a role in a genuinely pioneering initiative: India's first refinery-integrated CBG project at BPCL's Bina Refinery, which demonstrates how existing conventional energy infrastructure can be repurposed to accelerate the adoption of low-carbon fuels while improving resource efficiency.

From Commissioning to Sustained Performance: The Digester Clinic

Perhaps the most distinctive part of Elan's approach is its recognition that commissioning a plant is not the finish line. Many CBG facilities across India struggle after startup, with feedstock variability, biological instability, digester underperformance, and incon-



sistent methane yields eroding project economics well after the ribbon-cutting.

To address this, Elan established the Digester Clinic – India's first dedicated technical platform focused specifically on anaerobic digestion optimization and biological troubleshooting for CBG plants. Digester Clinic combines scientific diagnostics, feedstock characterization, continuous process monitoring, and targeted operational interventions to help plants recover lost gas yield, reduce downtime, and improve long-term stability. By pairing R&D-driven insight with field-level operational support, the platform reflects Elan's broader philosophy: that engineering decisions made at the design stage must remain tightly aligned with what a plant actually needs to run well for twenty years, not just on the inauguration day.

A Broader Renewable Energy Footprint

While CBG and GOBARDhan represent a major growth vector, Elan's presence in India's renewable energy landscape extends further. The company is active across solar power development, carbon credit advisory, and biodiesel, green hydrogen, wastewater and environmental engineering, giving it a multidisciplinary vantage point that few pure-play CBG consultancies can match. This breadth allows Elan to bring cross-sector engineering lessons from solar EPC discipline to wastewater process control, into its bioenergy project

work, and vice versa.

Elan's ambitions also extend beyond India's borders. Through Elan Greentech (UK) Limited, the company has established a presence in the United Kingdom, positioning itself to participate in international renewable energy and infrastructure opportunities and to bring its project management and engineering expertise to markets beyond South Asia. As global capital increasingly looks for credible operating partners in the energy transition, this UK platform gives Elan a foothold to extend relationships with international investors and technology providers back into its core Indian bioenergy business.

Looking Ahead

As GOBARDhan moves from policy to implementation, the Indian CBG sector is entering a phase where execution quality will matter as much as capital deployment. Projects will need partners who understand not just how to build a plant, but how to keep it running at its designed potential year after year. Through its PMC leadership on marquee PSU assignments, its pioneering work on the Bina Refinery integration, and its investment in operational innovation through the Digester Clinic, Elan Greentech Energies has positioned itself as one of the partners best equipped to help translate GOBARDhan's national ambitions into plants that deliver reliably, efficiently, and sustainably for the farmers, communities, and investors who depend on them. ■

Bioenergy as a Strategic Pillar for India's Energy Security: Pathways to Reduce Fossil Fuel Imports



K R Raghunath
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KIS Group

The ongoing conflict in the Middle East has reinforced a critical reality: countries dependent on energy imports remain vulnerable to geopolitical disruptions. India imports a substantial share of its crude oil, LNG, LPG, and chemical fertilizers, making its transportation, industry, agriculture, and economy susceptible to global supply shocks.

In this context, bioenergy – particularly biomethane or Compressed BioGas (CBG/BioCNG) – emerges as a strategic national asset. As a domestically produced, renewable, and scalable fuel, it can reduce fossil fuel imports, strengthen energy security, and improve India's resilience against global uncertainties.

KIS Group recognized this opportunity nearly two decades ago, pioneering biogas and biomethane solutions well before they gained global prominence. Today, it is encouraging to see countries worldwide embracing and scaling this vital renewable energy source

Bioenergy: A Strategic Asset for National Energy Security

Reliable, Indigenous Renewable Fuel

BioCNG offers a unique advantage among renewable fuels. Unlike solar and wind, it is storable,

transportable, and dispatchable, ensuring a reliable energy supply whenever needed. It can directly replace imported LNG, LPG, crude oil, and chemical fertilizers, reducing India's dependence on global energy markets.

As geopolitical tensions disrupt energy supplies and trade, every cubic metre of domestically produced biomethane strengthens India's energy security, import substitution, and economic resilience.

Shield Against Geopolitical Volatility

Domestic energy production is increasingly a matter of national security. Locally produced BioCNG provides a dependable fuel supply for transportation, industry, agriculture, and essential services, insulating communities from global supply-chain disruptions and price volatility.

KIS Group's operational BioCNG plants demonstrate how decentralized, indigenous energy production can ensure continuity even during periods of global market uncertainty.

India's First Cow-Dung-Based BioCNG Dispenser: A Milestone in Energy Self-Reliance

In 2020, KIS Group commis-

sioned India's first commercial cow-dung-based BioCNG dispensing station for Banas Dairy, Asia's largest dairy cooperative. The project showcased how agricultural and livestock waste can be converted into vehicle-grade renewable fuel.

Beyond its technological achievement, the project established a scalable circular economy model – transforming locally available biomass into clean transportation fuel while creating value for farmers, industry, and the environment.

KIS Group's Cow-Dung-Based BioCNG Plants with Fuel Dispensing Infrastructure

BioCNG Plant 1 – Commissioned in 2020

Feedstock: Cow Dung

India's first commercial BioCNG dispensing station supplying vehicle-grade renewable fuel, this landmark project proved that dairy waste can replace fossil-derived CNG with domestically produced BioCNG. It established a scalable, replicable model for converting rural biomass into clean energy, supporting energy security, import substitution, decarbonization, and India's vision of energy self-reliance.





- 40 TPD Cow dung + Potato Waste-Based Project
- Biogas Generation – 2000 m³/Day
- Location – Bhukhala, Gujarat
- Asia's First Commercial BioCNG® Dispenser



BioCNG Plant 2

- BioCNG Retail / Dispenser
- With Suzuki and Banas Dairy, Which Home Minister Amit Shah Ji inaugurated

Circular Economy: Turning Waste into Wealth

KIS Group's BioCNG projects demonstrate a true circular economy by converting waste into clean fuel, organic fertilizer, and rural income. Farmers earn additional revenue by supplying cow dung and other feedstocks, while nutrient-rich digestate returns to fields, improving soil health and reducing dependence on imported fertilizers.

This integrated model creates a self-sustaining ecosystem that strengthens local livelihoods, reduces fossil fuel imports, and supports India's long-term energy security and decarbonization goals.

Industrial Wastewater to BioCNG: Expanding India's Feedstock Horizon

KIS Group developed India's first BioCNG plant using paper mill wastewater, proving that renewable gas production extends beyond agricultural waste.

BioCNG Plant 4

Feedstock: Paper mill wastewater.

Achievement: India's first BioCNG project converting industrial wastewater into vehicle-grade renewable fuel.

Output: BioCNG supplied directly to a BPCL CNG dispensing station.

The project demonstrated that industrial wastewater is a reliable, scalable feedstock, enabling industries to convert waste into clean energy while reducing environmental impact and replacing imported natural gas with indigenous BioCNG.

Scaling Potential: From 4 Plants to 4,000 – or 40,000

India has abundant BioCNG feedstocks, including cow dung, press mud, Napier grass, municipal waste, food waste, industrial wastewater, and agricultural residues.

With the right policies and implementation support, India can establish thousands of decentralized BioCNG plants that generate clean energy, create jobs, reduce imports, and deliver significant environmental benefits.

BioCNG is not just an alternative fuel – it is a catalyst for energy security, rural development, and sustainable economic growth.

Napier Grass: India's Dedicated Energy Crop

KIS Group is developing large-scale Napier grass-based BioCNG projects to ensure a reliable feedstock supply. With its high biomass yield, ability to grow on marginal land, and stable income potential for farmers, Napier grass supports both energy security and rural development. It offers a predictable feedstock supply and has the potential to become the backbone of India's BioCNG industry, much like sugarcane is for ethanol.

Municipal Waste to BioCNG: A PPP Opportunity

KIS Group is advancing municipal waste-to-BioCNG projects through Public-Private Partnerships (PPP), converting urban waste into clean fuel and organic fertilizer. The model reduces land-fill burden, lowers waste management costs, replaces imported



BioCNG Plant 3

- BioCNG Retail / Dispenser
- With Suzuki and Banas Dairy, which Gujarat's Governor inaugurated

CNG, and creates jobs in waste collection, logistics, and plant operations. It supports Swachh Bharat, Atmanirbhar Bharat, and India's circular economy goals.

Rural Economic Transformation Through Bioenergy

Bioenergy transforms agricultural and organic waste into clean energy, farmer income, and rural employment. Farmers benefit from crop residues, cow dung, and energy crops like Napier grass, while BioCNG plants create skilled and semi-skilled jobs. Digestate reduces dependence on imported fertilizers and promotes sustainable agriculture.

The environmental gains are equally important: methane capture lowers greenhouse gas emissions, crop residue utilization

reduces stubble burning and air pollution, and organic waste conversion protects soil and water resources.

Bioenergy uniquely delivers energy security, rural prosperity, environmental sustainability, and economic growth through a single integrated solution.

The Road Ahead: Bioenergy as a National Imperative

India's clean energy future requires a balanced mix of solar, wind, green hydrogen, and bioenergy. Bioenergy is uniquely positioned to strengthen energy security, waste management, rural development, and environmental sustainability simultaneously.

To scale BioCNG, India must accelerate policy implementation, strengthen feedstock supply

chains, incentivize decentralized plants, integrate BioCNG with gas grids and CGD networks, and expand PPP models for municipal waste projects.

With abundant feedstock, strong engineering expertise, entrepreneurial capability, and supportive policies, India has the potential to become a global bioenergy leader. The challenge is no longer whether bioenergy can contribute, but how quickly it can be scaled.

At KIS Group, we remain committed to driving this transition through innovation, execution excellence, and strategic partnerships. Bioenergy is not just a renewable fuel – it is a strategic pillar of India's energy independence, economic resilience, rural prosperity, and sustainable growth. ■

E20 & Beyond: Strengthening India's Energy Security

India has achieved a milestone that few major economies can claim: petrol sold at every pump nationwide now contains 20% domestically produced ethanol. Mandated as the national standard fuel in April 2026, E20 marks the culmination of a journey that began with pilot discussions in the early 2000s and was formally launched in 2003. Reaching this target five years ahead of the original 2030 deadline is not merely a finish line; it is a launchpad. Ethanol has evolved from a simple environmental initiative into a strategic pillar of India's energy security architecture.

For a country that imports nearly 88% of its crude oil, spending roughly ₹22 lakh crore annually, the stakes are monumental. The policy debate has now shifted. The question is no longer whether India can sustain E20, but how we can reposition ethanol from a fixed blending component into a robust "transport energy backbone" capable of shielding the nation from global crude price volatility.

The E20 Milestone and Economic Impact

The macroeconomic benefits of the Ethanol Blended Petrol (EBP) programme, heavily accelerated since 2014, have been transformative. The transition has delivered on multiple fronts:

Foreign Exchange Savings: Over ₹1.97 lakh crore saved by reducing reliance on imported oil.

Import Substitution: Displacement of approximately 316 lakh metric tonnes of crude oil.

Environmental Impact: Avoidance of nearly 952 lakh metric tonnes of CO₂ emissions.

Rural Economy: Over ₹1.66 lakh crore channeled directly to farmers through the value chain.

Capacity Expansion: A nearly five-fold increase in production capacity, scaling from 421 crore litres in 2014 to roughly 2,000 crore litres in 2026.

This rapid scale-up was made possible by a structural pivot in feedstock. Once entirely dependent on sugarcane, India's ethanol ecosystem is now grain-dom-



Rajesh Tope

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Samarth SSK Ltd.*

inant. In the 2025-26 Ethanol Supply Year (ESY), Oil Marketing Companies (OMCs) received over 1,305 crore litres in grain-based offers, with maize accounting for 63.8%. This diversification means India can comfortably sustain E20 without diverting sugar. With total ethanol production hitting roughly 1,900 crore litres against OMC purchases of 1,048 crore litres, the industry now possesses a healthy surplus buffer.

Energy Security in a Volatile World

The geopolitical landscape has injected profound urgency into the ethanol programme. Middle East conflicts and fragile global



supply chains highlight India's vulnerability to imported energy. The Reserve Bank of India estimates that a 10% rise in crude prices drives a 0.20% increase in domestic inflation. Every barrel replaced by domestic ethanol is a barrel insulated from OPEC quotas, shipping disruptions, and currency depreciation.

The economic logic is equally compelling. While E20 production may cost more than pure petrol when global crude trades at \$70 per barrel, the economics heavily favor ethanol when crude crosses the \$120 threshold. More importantly, 20% of every litre of petrol sold in India is now priced entirely independently of Brent crude volatility. Furthermore, E85 fuel is projected to be priced around ₹20 cheaper per litre than regular petrol, offering consumers a direct financial incentive to embrace the transition.

The Multi-Grade Roadmap and Future Demand

E20 is the baseline, not the ceiling. The Bureau of Indian Standards (BIS) has already formalized the technical framework for higher blends (E22, E25, E27, and E30) under IS 2796. By June 2026, public OMCs began rolling out

E85 fuel across 48 outlets, with an aggressive expansion plan targeting 5,000 outlets by December 2027.

As Union Minister Nitin Gadkari stated in April 2026, the ultimate aspiration is 100% blending. To support this, automakers like Maruti Suzuki and Hero MotoCorp are rapidly introducing flex-fuel vehicles.

However, the industry must also look beyond road transport. The Council on Energy, Environment and Water (CEEW) projects that India's petrol demand will peak around 2032 as electric vehicles (EVs) dominate new sales. Because ethanol plants operate for 20-30 years, producers must hedge against a shrinking petrol market by diversifying into:

SAF/diesel: Sustainable Aviation Fuel (SAF) remains under research, while ethanol-diesel blends are at pilot and demonstration stage.

Marine and cooking fuels.

Structural Challenges and the Path Forward

Despite the momentum, the path beyond E20 faces several friction points that require strategic policy interventions:

Food vs. Fuel Tensions: The shift to grain-based has made India a net importer of maize, raising delicate food-versus-fuel trade-offs.

Infrastructure and Taxation: Upgrading dispensing systems for higher blends requires massive capital. Furthermore, the 28% GST levied on flex-fuel vehicles – compared to just 5% for EVs remains a significant barrier to consumer adoption.

Market-Responsive Pricing: The current cost-based administrative pricing provides producer certainty but fails to react to market signals. A flexible pricing mechanism is needed to adapt to global crude fluctuations.

Second-Generation (2G) Ethanol: 2G ethanol derived from agricultural residue is technologically ready but faces scale and cost challenges due to biomass logistics.

India stands at a strategic inflection point. The foundational infrastructure is firmly in place, and the E20 rollout has proven that large-scale energy transitions are possible. The challenge now is system design: creating a multi-grade fuel architecture that can adapt to global markets, expand beyond a single blending mandate, and align with India's broader electrification goals.

Few nations with heavy fuel import dependence possess a domestically produced, industrially scalable alternative already embedded within their transport system; India does. The question now is how strategically we leverage this asset to power our future. ■



Godavari Biorefineries Pilots CO₂-to-Renewable DME Technology with ICT Mumbai



Dr. Sangeeta Srivastava
Co-Chairperson, IFGE: SBF & Executive
Director, Godavari Biorefineries Ltd.

When we talk about India's ethanol programme, the conversation usually centres on fuel blending, energy security and farmer incomes. Those achievements are significant. Yet another opportunity is emerging within every ethanol distillery.

Every time sugar is fermented to produce ethanol, substantial quantities of carbon dioxide are released. Traditionally, this biogenic CO₂ has been treated as a by-product. Today, the question is different: can this renewable carbon become a valuable feedstock

for the next generation of clean fuels?

At Godavari Biorefineries Ltd. (GBL), we have taken an important step toward answering that question. We have commissioned a pilot plant to convert fermentation-derived biogenic CO₂ into renewable Dimethyl Ether (DME) using green hydrogen. This pilot has been established in collaboration with the Institute of Chemical Technology (ICT), Mumbai, one of India's leading institutions in chemical engineering and catalysis research. Professor G.D.

Yadav, Padma Shri awardee, Bhatnagar Fellow, and former Vice Chancellor of ICT Mumbai, is the Principal Investigator from ICT and brings with him an exceptional record of scientific innovation.

This is no longer merely a laboratory concept. The pilot facility has been installed and commissioned, and testing has commenced using actual fermentation-derived CO₂. We are now entering the

most important phase of technology development: optimising catalyst performance, validating process stability, and generating engineering data for scale-up.

A true industry-academia partnership

Successful commercialisation requires complementary expertise.

An industrial partner understands continuous plant operation, feedstock variability, reliability, safety, and economics. An academic institution contributes deep expertise in catalyst design, reaction engineering, thermodynamics, and process intensification.

This project brings these strengths together. GBL and ICT Mumbai are jointly evaluating an innovative, single-step catalytic process that converts carbon dioxide and hydrogen directly into DME.

The collaboration received the prestigious K.V. Mariwala Award for Effective Chemical Industry-Academia Partnership 2025, recognising both the scientific innovation and translational approach adopted by the partners. Recognition is encouraging, but the true measure of success will be sustained performance under real industrial operating conditions.

Professor G.D. Yadav aptly sum-



marises the broader significance of this work:

“The transition to a sustainable future requires us to view carbon dioxide not as a waste product, but as a valuable renewable carbon resource. This pilot project represents an important step in demonstrating how science, engineering and industry can work together to transform biogenic CO₂ into clean fuels such as dimethyl ether. If successful, this technology has the potential to strengthen India’s circular bioeconomy, enhance energy security and create greater value from the sugar and ethanol industries.”

Current status

Construction and commissioning of the pilot facility have been completed.

The current phase focuses on catalyst evaluation under realistic operating conditions. Carbon dioxide hydrogenation presents several scientific and engineering challenges. Water is formed as a reaction product, trace impurities may accompany fermentation-derived CO₂, and the process operates under elevated pressure and temperature.

The central objective of the pilot is, therefore, straightforward: to determine whether the catalyst can maintain high activity, selectivity, and stability over extended operating periods while delivering consistent DME production.

Commercial deployment will depend on three factors:

Successful long-duration pilot performance,

Favourable techno-economic analysis, and

Increasing availability of competitively priced green hydrogen.

Looking ahead, green hydrogen will be a critical enabler for wider deployment of renewable DME and other carbon utilisation pathways. At GBL, hydrogen generated in situ as a co-product of certain dehydrogenation processes also presents opportunities for further resource valorisation. As these technologies mature, integrating renewable hydrogen with biogenic carbon has the potential to move beyond net-zero ambitions towards net-negative carbon outcomes.

Until these milestones are achieved, commercial implementation should be regarded as a future opportunity rather than a committed business plan.

This represents GBL’s current position on the project.

A valuable renewable feed-stock already available

One advantage of this technology is that the principal carbon feed-stock already exists within ethanol plants.

The CO₂ generated during fermentation is biogenic carbon.

Sugarcane absorbs atmospheric carbon dioxide during growth, which is subsequently released during ethanol production. Instead of venting this renewable carbon back into the atmosphere, we are exploring ways to convert it into an additional renewable fuel.

At our integrated biorefinery, fermentation generates approximately 600 tonnes of CO₂ per day. Based on reaction stoichiometry, this quantity could theoretically support production of nearly 200 tonnes per day of renewable DME at commercial scale.

Actual production will depend upon catalyst performance, reactor design, heat management, hydrogen availability, and overall process efficiency and economics.

Why DME matters

DME is attracting increasing global interest as a clean energy carrier.

It burns without sulphur emissions, produces extremely low particulate matter and significantly lower soot than conventional diesel, making it attractive for heavy-duty transportation, agricultural equipment, and stationary power generation.





DME also offers an important infrastructure advantage. It liquefies at approximately 5 bar, similar to LPG, allowing much of the existing LPG storage, transportation, and distribution infrastructure to be utilised with relatively modest modifications. It can also be blended with LPG, providing a pathway for gradual market adoption while reducing dependence on imported fossil fuels.

With a volumetric energy density of approximately 21 MJ/L, DME is also an attractive renewable energy carrier.

The technology

Conventionally, DME is manufactured in two separate steps. Carbon dioxide is first converted into methanol, which is subsequently dehydrated to produce DME.

The technology being evaluated by GBL and ICT Mumbai integrates both reactions into a single catalytic reactor.

Carbon dioxide and hydrogen are simultaneously converted to methanol, which is immediately dehydrated to DME over the acidic component of a bi-functional catalyst.

Because methanol is consumed as soon as it forms, chemical equilibrium is shifted towards greater overall conversion. This integrated approach has the potential to simplify plant design, reduce capital costs, and improve process efficiency.

The principal technical challenge remains catalyst durability in the presence of water, making long-term pilot operation essential before any commercial decisions are taken.

Potential impact

India today operates more than 400 ethanol distilleries, most of which currently vent fermentation-derived CO₂.

If carbon utilisation technologies become technically and economically viable, they could transform these facilities into integrated renewable carbon biorefineries producing fuels, chemicals, energy and other value-added products from the same agricultural feedstock.

Such an approach aligns closely with India's BioE3 Mission, circular economy principles, and

the national vision of converting waste into wealth while creating greater value addition in rural areas.

Nevertheless, engineering reality must guide commercial decisions. Reliable catalyst performance, affordable green hydrogen, robust process economics and compliance with fuel quality specifications remain essential prerequisites for large-scale deployment.

Looking ahead

Our immediate objective is clear: operate the pilot plant, collect high-quality engineering data, and continue improving catalyst and process performance.

If the technology demonstrates sustained technical and economic viability, it could provide a new pathway for integrating carbon utilisation into India's expanding bio-based manufacturing ecosystem.

Renewable DME is not intended to replace ethanol. Rather, it has the potential to complement ethanol, broadening the portfolio of renewable fuels and renewable carbon-based products derived from agricultural biomass.

India's energy transition will be achieved not through a single technology, but through a portfolio of innovations that make better use of domestic renewable resources.

The project represents one of India's first integrated demonstrations of direct catalytic conversion of fermentation-derived biogenic CO₂ into renewable DME, bringing together industrial biotechnology, heterogeneous catalysis and process engineering in a single circular carbon platform. ■

Scaling LA-PLA Successfully: Integrating Market, Technology and Economics

Why application-led market development, end-to-end technology, and differentiated economics must advance together

The world produces about 431 million tonnes of plastics each year. Global biobased-plastics capacity stood at 2.31 million tonnes in 2025, with PLA representing roughly one quarter, about 0.6 million tonnes.¹ If PLA were to address only 2% of today's plastics market, the implied opportunity would be approximately 8.6 million tonnes annually, more than fourteen times current PLA capacity. This is not an argument for replacing every polymer. It shows the headroom available when PLA is directed to applications where renewable carbon, performance, safety and an appropriate end-of-life pathway create value. The commercialization question is not whether the opportunity is large, but where to enter first.

Market first: choose where PLA can win

Market analysis should begin at sector level. Food and food service, clothing and textiles, personal care, healthcare, agriculture, consumer goods, mobility and electronics have different performance expectations, qualification cycles, price benchmarks and sustainability drivers. The opportunity lies at the intersection of addressable volume, PLA's functionality, customer readiness and a credible end-of-life system.

¹ European Bioplastics, "Bioplastics Market Development Update 2025," December 2025.

Within this landscape, selected single-use plastic products offer a logical near-term focus. They combine high volumes and short life spans with regulatory and brand pressure for renewable alternatives. PLA can be particularly relevant where products are food-contaminated or difficult to recycle mechanically, and a defined recovery route exists. The target should be selective substitution: material, collection system, and local infrastructure must be designed together.

Build the market before the plant is ready

Market development cannot wait for commissioning. Before plant capacity is finalized, resin manufacturers should validate sector demand, functionalities, converter capability, certification, willingness to pay, end-of-life expectations, and anchor offtake. Customer trials should define qualification milestones, ramp-up volumes, and pricing logic. This turns market intelligence into an engineering input and reduces demand risk.

Once the priority applications and value pools are clear, the project can move backwards from market need to technology design.

Start with the application, then design the molecule

An application-led approach begins with the performance that the



Sunil Rohom

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market will buy and works backwards through formulation and compounding, PLA resin, polymerization, lactide, lactic acid (LA), fermentation and feedstock. Technology translates market requirements into a repeatable material solution.

Key specifications should remain visible without allowing chemistry to overwhelm the business case. LA purity and optical composition influence lactide; lactide quality and yield affect polymerization; and PLA molecular weight, crystallinity and rheology shape processing.²

Strengthening the PLA Ecosystem to Accelerate Market Adoption

PLA ecosystem shapes globally in several layers: LA production, polymerization for PLA production, development of formulations, compounding, and form product manufacturing. Production ecosystems have developed across North America, Europe, and East and Southeast Asia through technology licensors, resin producers, and compounders.

India, however, does not need to begin from zero. It already has a well-developed plastics ecosystem comprising compounders, con-

² S. Inkinen et al., "From Lactic Acid to Poly (lactic acid) : Characterization and Analysis of PLA and Its Precursors," *Biomacromolecules* 12 (2011): 523-532.



verters, processors, machinery suppliers, and application manufacturers across food and food service, clothing and textiles, consumer goods, agriculture, health-care, mobility and other sectors. Several Indian companies also compound and formulate bioplastics for different performance requirements. The missing link is upstream: commercial-scale domestic manufacturing of resin remains limited, leaving the market largely dependent on imports. This restricts supply-chain responsiveness, exposes users to logistics and currency risks, and makes it harder to develop application-specific grades collaboratively.

This gap creates a significant strategic opportunity. With India's growing plastics demand and the considerable headroom for selective PLA substitution, an Indian technology player capable of connecting domestic feedstocks with lactic acid, lactide and PLA production could materially strengthen the ecosystem. The objective should extend beyond establishing resin capacity. By working closely with compounders, converters and end users, such a player can accelerate grade development, customer trials, certification and application qualification. This would create a continuous feedback loop between market requirements and technology development, helping India meet emerging demand while building a more resilient and competitive domestic PLA value chain.

Technology Integration: From Demonstration to Commercial Scale

Praj is addressing this missing link through an indigenously developed, molecule-to-market PLA ecosystem spanning lactic acid

production using various feedstocks, lactide production, an integrated demonstration facility, partnership-enabled PLA polymerization, and application development with ICT Mumbai and various other partners. Together, these capabilities connect Indian biotechnology with commercial polymer engineering and market validation.

Praj: One stop solution for LA-PLA

Praj also offers a single-window solution for LA-PLA projects, bringing technology licensing, engineering services, and plant construction under one roof. This integrated delivery model provides single-point accountability, reduces customers' interface and execution risks, and improves cost, schedule and performance certainty from concept to commercial operation.

Competing on Full-Cycle Economics

Bioplastics will inevitably compete with fossil-based plastics. Fossil-based plastics are often cheaper at the factory gate because they benefit from mature, large-scale, and highly optimized supply chains. However, their apparent price advantage rarely reflects the full cost of careless disposal-including pollution management, ecosystem damage, potential health impacts, and the long-term burden placed on communities. Viewed across the complete lifecycle, bioplastics can therefore be considerably less costly to society and the environment. Where these benefits are measurable and credible, the market may also accept a reasonable green premium.

Technology will be critical to narrowing the initial resin-price gap. Higher feedstock conversion, High

process efficiencies, optimised chemical and utility consumption, and integrated plant design can lower production costs across the value chain. Application-led compounding- including blending PLA with compatible, cost-effective bioplastics or fillers where performance permits, can further improve affordability without compromising functionality or end-of-life objectives.

Even then, there is no single economic model for every PLA application. Food-related applications may derive value from food-contact assurance, hygiene, product protection, and responsible management of contaminated waste, making a modest premium more acceptable. Clothing and textiles are more likely to be driven by renewable carbon, traceability, brand commitments, and fibre performance and sustainability targets. The relevant benchmark is, therefore, not simply the cost of neat PLA resin, but the cost of a qualified application solution, covering feedstock, production, compounding, conversion, certification, logistics, and end-of-life. Commercial success will come from optimizing this entire cost curve for each priority market.

The leadership takeaway is positive and practical. The 1-2% substitution scenario shows that PLA does not need to replace the entire plastics market to become a significantly larger industrial platform. The winners will be those who identify the right markets, assemble the complete technology chain, and align economics to each application. When these decisions advance together, PLA scale-up becomes not only technically possible, but commercially lucrative. ■

Driving India Towards Fuel Autonomy: A Masterclass in Strategic Energy Transition



Vaibhav Dange
Founder Director, IFGE

In the global push for decarbonization, few economies have matched India's speed, scale, and strategic clarity in shifting toward biofuels. Led by the Ministry of Petroleum and Natural Gas (MoPNG) in close alignment with inter-ministerial partners, India has moved from being a modest ethanol blender to becoming one of the world's largest and fastest-growing bioenergy markets.

Today, as E20 petrol rolls out across the country and the groundwork for E85 fuel networks begins, it is clear that this is not just a fuel transition. It is a structural reset of rural economics, industrial capacity, and national energy security.

What makes India's approach different is that it did not wait for perfect conditions. It built them.

Solving the "Chicken-and-Egg" Problem First

A common question about alternative fuels is: "Why build fuel infrastructure before Flex-Fuel Vehicles are widely available?"

MoPNG answered this directly. Global automakers will not invest billions to redesign engines and supply chains without certainty that fuel will be available at scale. Conversely, fuel companies will not invest in ethanol logistics and retail networks without demand.

The Ministry broke this loop by committing to supply first. Anchored by the NITI Aayog's E20 Roadmap, firm blending targets, long-term procurement, and investments in storage and retail infrastructure created a guaranteed demand corridor. This gave India's leading OEMs the policy certainty to develop and launch Flex-Fuel Vehicle (FFV) prototypes and production models on schedule.

The result: fuel supply is being created in parallel with vehicle rollout, not after it. That is the difference between announcing a target and executing a transition.

Addressing Water and Food Security Concerns

Critics often argue that moving to higher blends like E85 will put unsustainable pressure on water and food crops, especially sugarcane.

The data and policy design tell

a different story. India's ethanol strategy is built on a diversified, resilient feedstock matrix designed specifically to avoid these trade-offs.

Grain-Based Ethanol Synergy: A large share of current and future capacity comes from maize and surplus or damaged food grains. Distilleries have created a secondary market for farmers, boosting farm incomes without diverting food grains from public distribution while providing a buffer during surplus years.

The 2G Biomass Revolution: Second-Generation (2G) ethanol plants use agricultural residue – paddy straw, wheat straw, cotton stalks, and bagasse. By converting field waste into fuel, 2G plants address air pollution while adding a new revenue stream for farmers. Commercial-scale 2G plants are now operational under the PM-





JIVAN scheme and the broader National Policy on Biofuels.

Closed-Loop Sugar Complexes: Modern integrated sugar mills have made significant gains in water efficiency. Through condensate recycling, zero-liquid discharge systems, and co-generation, many new facilities operate with minimal fresh water draw. The focus is on maximizing output per drop, not simply expanding acreage.

Together, these three pillars ensure that higher blending does not mean higher stress on water or food systems.

Beyond Carbon: Measuring Success in Economic Terms

The Ethanol Blended Petrol (EBP) programme's impact extends far beyond emissions.

Foreign Exchange Savings: Every litre of ethanol blended is a litre of crude oil not imported. Cumulatively, the EBP programme has saved the national exchequer tens of thousands of crores in import costs, strengthening India's trade balance and insulating consumers from volatile global oil prices.

Direct Transfer to Rural India: Fuel expenditure is being redirect-

ed into the farm economy. Timely payments to sugarcane farmers, grain growers, and biomass aggregators have created a stable income source in rural districts, alongside employment generated by distilleries and logistics.

Industrial and Technological Upgradation: The programme has catalyzed over ₹50,000 crore in investment into new distilleries, 2G plants, and supply chain infrastructure. India is now building and exporting ethanol plant technology – market-driven industrial growth anchored by clear policy.

Policy Leadership and Ecosystem Building

What enabled this transition was consistent execution across the value chain: engaging sugar technologists on yield, agricultural scientists on feedstock diversification, oil marketing companies on logistics, and automakers on engine calibration.

This "One Ecosystem" approach meant that targets were matched with supply, quality standards, pricing mechanisms, and infrastructure. Policy signals were clear and credible – which is why

OEMs committed, banks financed distilleries, and farmers planted with confidence.

The rollout of E20 is now well underway, while pilot E85 stations are being set up in high-consumption corridors to test logistics, dispensing, and consumer acceptance ahead of wider FFV adoption. This sequencing – supply, then vehicles, then higher blends – is deliberate and working.

Conclusion: From Import Dependence to Fuel Autonomy

India's biofuel journey demonstrates that energy transitions succeed when they solve multiple problems at once: energy security, farmer prosperity, industrial growth, and emissions reduction.

We are no longer just planning for a green transport future. We are building it, one blend, one distillery, and one vehicle at a time.

The vision set by India's energy leadership has turned a technical fuel specification into a national platform for self-reliance. As E20 becomes mainstream and E85 networks expand, India is not just following the global energy transition it is helping to define it. ■

Need for Procurement Strategy Reforms in Biomass Pellet Procurement for Thermal Power Plants for their Positive Impact on Biomass Co-firing



Satish Upadhyay

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2026 Update - NCR and Non-NCR Tender Reforms and the Road Ahead for Industry Partners

The biomass co-firing programme has emerged as a key national initiative to reduce coal consumption, address crop-residue burning, lower greenhouse gas emissions, and support rural livelihoods. Implementation has been shaped both by the quantum of contracts awarded and by how much of that quantity is genuinely supplied. Procurement frameworks across Thermal Power Plants (TPPs) have accordingly moved from lowest-price discovery toward sustainable, supply-assurance-oriented models, a transition now extending into non-National Capital Region (non-NCR) markets.

Evolution of Procurement Strategy

From Seven-Year Contracts to Calibrated Short Cycles

NTPC's early biomass tenders, launched in 2021, favoured four-to seven-year contracts to create assured demand, improve bankability, and facilitate Priority Sector Lending. However, aggressively low bids often underestimated seasonal feedstock, transport, and working-capital costs. With limited performance enforcement,

awarded quantities achieved only ~11% materialisation, prompting a gradual shift to shorter tenures.

As benchmark pricing emerged in mid-2023, NCR tenders moved to two-year contracts. Non-NCR markets went further: NTPC's 2024 Solapur tender, via BiofuelCircle, was for only 90 days, effectively a low-commitment pilot. The June 2026 non-NCR tender reverses this trend, extending tenure eightfold to 730 days – signalling renewed confidence in providing manufacturers the medium-term visibility needed to invest.

Benchmark Pricing, Vendor-Cap Splitting and Measurable Impact

The Ministry of Power's revised biomass policy of 16 June 2023, supported by a CEA-led Biomass Pellet Price Benchmarking Committee, replaced lowest-price discovery with transparent, region-linked benchmark pricing. NTPC complemented this with vendor allocation caps – 50 TPD for manufacturers and 20 TPD for traders – with the balance filled through bucket-filling.

This shifted procurement from large, concentrated awards to

smaller, capacity-matched commitments, enabling more manufacturers, particularly MSMEs, to participate. The impact was substantial: biomass received at power plants increased from 2.6 lakh tonnes in 2023-24 to 16 lakh tonnes in 2024-25 and 30 lakh tonnes in 2025-26.

The improvement in execution was equally significant. Benchmark-price POs achieved ~60% materialisation, compared with ~27% for discovered-price tenders and just ~11% under the earliest long-term contracts. The reforms have therefore reduced speculative bidding, widened MSME participation, and shifted the procurement benchmark from lowest price to assured, deliverable supply.

Comparative Procurement Models Across India's Thermal Power Plants

Eleven tenders across Central PSUs, state Gencos, and private generators reveal a sector converging around three core instruments: benchmark or GCV-linked pricing, capped vendor allocation, and geographic sourcing – while differing on how aggressively each is applied.

Central Public Sector Undertakings

NTPC anchors NCR procurement to a two-year term at the benchmark price of ₹8,282.40/MT (3,400 kcal/kg, including GST), with MSME exemptions and mandatory Punjab/Haryana/NCR paddy-straw sourcing. THDC's Khurja tender runs for one year, linking freight to delivered GCV and providing fast-track arbitration. DVC tenders separately for its five coal stations through GeM, restricting suppliers to manufacturers within 300 km; repeated low response, including no-bid rounds, has been attributed by its chairman to scarce and costly feedstock rather than tender design. NLCIL extends procurement to Tuticorin and Rajasthan, including its NTPL JV, which has co-fired biomass since December 2023. Its contracts combine a low ₹2 lakh EMD with a stringent seven-year, ₹59.66 lakh supply track-record requirement.

State Generation Utilities

Karnataka Power Corporation Limited adopts the most concentrated approach: a one-year term, extendable by two years, limited

to large manufacturers meeting ₹756 crore turnover and 1.8 lakh MT experience thresholds, with no MSME exemption and a ₹3.78 crore EMD. Punjab State Power Corporation Limited procures only non-torrefied paddy-straw pellets through its state portal, with a one-year term and ₹20 lakh EMD, also without MSME exemption.

Haryana Power Generation Corporation Limited mandates torrefied pellets but stands apart by permitting post-Year-1 price escalation, indexed to diesel, electricity, raw materials, and labour – directly addressing the firm-price risk borne by suppliers elsewhere. Uttar Pradesh Rajya Vidyut Utpadan Nigam Limited handles some of the largest volumes, reaching 13 lakh MT annually across its Harduaganj stations. Its model includes a continuing security deposit of ₹5,000 per quoted TPD, recovered from running bills, alongside a graded EMD.

Independent Power Producers

In Punjab, Nabha Power uses one-year reverse auctions with sourcing within 250 km, requiring bidders to demonstrate actual

supply equivalent to at least 40% of their quoted quantity in one of the previous three years. Talwandi Sabo Power has deepened vertical integration, commissioning a 1,000 TPD captive torrefied-pellet plant while continuing market tenders of up to seven years, with a grace period of up to 21 months for plant-side delays. Jhajjar Power, Haryana runs both long- and short-term tenders, with at least one requiring more than 50% Haryana-origin paddy straw.

Across all eleven tenders, three structural patterns emerge – . First, procurement models balance scale against participation: NTPC and PSPCL broaden access, while KPCL and UPRVUNL impose much higher entry barriers. Second, geographic anchoring is almost universal: DVC's 300 km, Nabha's 250 km, and Punjab/Haryana sourcing mandates aim to reduce logistics costs and supply-chain risk. Yet DVC demonstrates that proximity alone cannot overcome uneconomic feedstock.

Third, IPPs are beginning to hedge market risk directly, with Talwandi Sabo's captive pellet plant the clearest example.

Latest Update: NTPC's Non-NCR Tender Reforms (June 2026)

NTPC has extended several of these reforms and introduced new ones, to seven non-NCR stations: Sipat, Korba, Mouda, North Karanpura, Darlipali, Lara and Gadarwara. Tenders for all seven were floated simultaneously on 17 June 2026 via GeM, covering approximately 12.3 lakh Metric Tonnes (MT) of non-torrefied pellets over a 730-day period – roughly 6.15 lakh MT annually,



or about 1,685 Tonnes Per Day (TPD).

Parameter	June 2026 Non-NCR Status
Procurement Platform	The Government e-Marketplace (GeM), aligning with the NCR procurement route.
Bidding Method	Single-Stage Two-Envelope bidding (Techno-Commercial, then Price) replaces the earlier time-pressured reverse auction.
Eligibility	Open to all Class-I local suppliers - manufacturers, future manufacturers, traders and consortiums - not MSEs alone.
Contract Period	730 days (2 years) - the current tenure baseline for non-NCR contracts (see tender-duration history above).
Bid Flexibility	Part-quantity bidding and consortium participation now permitted; future manufacturers eligible with CA-certified project plans.
Feedstock Sourcing	No NCR-specific geographical restriction - agro-residue may be sourced regionally at each station.
Price Benchmark	None notified for Central, Southern or Eastern India - price discovery remains fully open, unlike the NCR model.

These reforms lower entry barriers though two structural gaps remain. First, no floor or benchmark pricing for Central, Southern or Eastern India leaving price sustainability to competitive bidding despite regional cost differences. Second, the tendered volume corresponds to only around 1% biomass co-firing across these seven stations, against the applicable 5% policy mandate; full compliance would require closer to 30.75 lakh MT annually - a demand gap of roughly 24.6 lakh MT. At an indicative ₹1.98–₹2.32 per 1,000 kcal, the addressable market could expand from about ₹414–485 crore today to ₹2,070–2,426 crore at full mandate.

Implications for Pellet Manufacturers

For small and medium manu-

facturers, benchmark pricing and capacity-matched allocation have improved market access and confidence to expand. Working capital, storage, logistics, and seasonal feedstock availability continue to test viability. However, in non-NCR markets, the missing enforcement of mandate of the government, missing benchmark price, lack of regular tender offers by all TPPs and modest 1% volume commitment after delay still constrain bankability, favouring modular over immediate green-field scale-up.

Critical Issues Facing Industry Players

Beyond contract design and pricing, operational, logistical, and economic constraints continue to be major bottlenecks.

Procurement Cycles, Predictability and Accountability

Tender delays remain a recurring concern. The June 2026 non-NCR tender alone has seen five successive bid-date corrigenda. While the new 730-day contract term is a step forward, genuine bankability requires longer-term visibility with escalation-linked pricing, similar to renewable power agreements.

Predictability must also be matched by accountability: formal debarment for chronic non-performers, structured performance evaluation, and time-bound reallocation of unfulfilled quantities to capable suppliers could narrow the persistent gap between awarded and delivered volumes. Localised procurement within a defined 100–250 km radius also merits wider pilots to align supply with regional feedstock economics.

Standardising Pellet Quality

Pellet quality remains an unfinished agenda. While GCV, moisture, and fines broadly follow BIS specifications, but ash content, bulk density, and testing protocols still vary across plants. A nationally standardised specification, supported by accredited third-party testing, would reduce gate-rejection disputes and provide manufacturers with greater certainty.

A particularly important reform is reducing the permitted pellet diameter from the current 25 mm ceiling to 10–12 mm. Smaller, more uniform pellets are easier to test comprehensively and harder to adulterate with wet core material, soil, or foreign matter. They also dry more uniformly, making moisture assessment more reliable – potentially curbing several malpractices affecting the supply chain.

Logistics, Seasonality and the Ash Challenge

Transport is among the largest, least visible components of delivered pellet cost, particularly for non-NCR plants dependent on longer supply routes. Regional aggregation hubs, covered transport, efficient fleets, and rationalised haulage could improve delivered economics as significantly as pricing reforms.

Co-firing also creates a downstream biomass-ash challenge. Biomass ash differs materially from coal ash, complicating established handling and utilisation systems. Procurement must also align with the harvest cycle: off-season production and storage increase cost and risk, whereas harvest-linked procurement can provide farmers with a timely economic alternative to field burning.

The Economics of Co-firing: From Cost Transparency to New Revenue

A fundamental question remains: what is the true all-in cost of biomass co-firing for a generating station? Although biomass has a broadly comparable calorific value to coal, co-firing adds handling and feeding costs and requires tighter temperature control because biomass has high volatile matter and can increase self-combustion risk. It may also impose a heat-rate penalty of up to ~1.5%, affecting variable costs and a plant's position in the merit-order dispatch.

A standardised methodology for total co-firing cost – covering biomass, transport, handling, and ash – would allow generators and regulators to compare economics transparently and establish appropriate merit-order and tariff treatment.

Torrefied biomass remains attractive because its handling characteristics more closely resemble coal, but higher capital costs and uncertain project economics remain barriers. Bridging this gap may require revenue streams beyond electricity tariffs, with carbon-credit monetisation offering a potentially important pathway.

A Word to Our Industry Partners: Supply Discipline and Market Integrity

Reform has shifted the sector's central test from winning contracts to delivering them. Suppliers that consistently meet committed quantities – through lean as well as peak seasons – build the track record needed for repeat orders and higher allocations in future bucket-filling rounds. Partial



or delayed delivery weakens the materialisation data that supports benchmark pricing and risks tighter qualification norms for the entire vendor base. Reliable, timely supply is therefore the industry's strongest case for sustaining these reforms.

Quality must be equally non-negotiable. Adulteration or moisture manipulation may create a short-term advantage, but ultimately damages the entire supply chain, inviting liquidated damages, termination, and debarment while eroding trust in compliant suppliers. Each detected violation can trigger tighter sampling, additional testing, and stricter acceptance norms – raising costs for everyone. Protecting the integrity of every consignment is not just individual compliance; it is collective self-interest and the foundation of a credible biomass market.

Conclusion

The evidence is clear: sustainable pricing and assured supply – not aggressive price discovery – are

the keys to meeting India's biomass co-firing targets. Benchmark-based, multi-vendor procurement aligned with supplier capacity has already increased materialisation several-fold. Extending this model to non-NCR markets, backed by credible benchmarks and a phased pathway to the full 5–7% co-firing mandate, could take pellet demand from India's grid-connected thermal fleet alone beyond 1 lakh MT per day.

Realising this potential requires five priorities: nationwide enforcement of the co-firing initiative; shorter, predictable tender cycles and long-term offtake contracts; a single national quality standard, including the proposed 10–12 mm pellet diameter, backed by accountable testing and performance-based evaluation; efficient, harvest-synchronised logistics; and transparent accounting of the total cost of co-firing. This would provide a stronger basis for merit-order treatment and potential revenue support, including carbon-credit monetisation.

None of these are structural barriers. They are solvable design choices. In just four years, India has demonstrated its ability to redesign biomass procurement at national scale when evidence demanded it. Institutionalising these reforms – alongside disciplined, full-quantity, quality-assured supply from industry – can move biomass co-firing from a promising policy initiative to a mature, investable energy market, while reducing stubble burning, strengthening rural incomes, and positioning biomass as a meaningful pillar of India's energy transition. ■

Biomass Co-firing in Thermal Power Plants: Need for Effective Implementation



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Strengthen, Enforce and Monitor, an assessment of the SAMARTH Mission after the Ministry of Power's Comprehensive Policy of November 2025

India's Ministry of Power, through the SAMARTH Mission (Sustainable Agrarian Mission on the Use of Agro Residue in Thermal Power Plants) launched in July 2021, laid the groundwork for mandatory co-firing of biomass pellets in coal-based thermal power plants – an environmental imperative and a socio-economic tool addressing rural income stagnation, agricultural waste, air pollution and climate change.

The policy has evolved in three stages: the 2021 policy was revised in 2023 to mandate 5% co-firing from FY 2024-25, rising to 7% from FY 2025-26; and in November 2025 the Ministry issued a Comprehensive Policy for biomass and torrefied munic-

ipal solid waste (MSW) charcoal, superseding all earlier guidelines. Its principal provisions are summarised in Table 1.

The framework brings gains: tariff clarity removes generators' biggest objection; counting towards the Renewable Consumption Obligation gives Discoms a reason to support it; a formal exemption committee replaces informal non-compliance; and including MSW charcoal links the mission to urban waste management.

But two features deserve scrutiny. Outside the NCR the obligation stays at 5%, with the promised escalation to 7% quietly dropped; and "pellets and/or torrefied MSW charcoal" lets a non-NCR plant meet its entire obligation

with MSW charcoal alone, diluting the farmer-income and stubble-burning objectives that gave SAMARTH its name. The case made here is the opposite: a firm national escalation path, a floor share reserved for agro-residue pellets, and enforcement with teeth outside the NCR as well as within it.

A Policy with Multidimensional Benefits

The heart of this policy is turning agrarian residues into a valuable resource. India generates close to 750 million tonnes of biomass a year, of which about 230 million tonnes of agricultural residue is surplus. Monetising crop residues offers millions of farmers an additional income of ₹2,000-6,000

Table 1: The November 2025 Comprehensive Policy – What Has Changed

Provision	Comprehensive Policy, Ministry of Power, November 2025
Scope	Single framework for biomass pellets and torrefied MSW charcoal; supersedes the 2021 and 2023 rules..
Mandate – NCR plants	From FY 2025-26, 5% pellets plus 2% pellets and/or MSW charcoal (7% aggregate); at least 50% of raw material must be paddy straw/crop residue from NCR and adjoining districts.
Mandate – plants outside NCR	From FY 2025-26, a 5% blend of pellets and/or MSW charcoal; the earlier escalation to 7% has not been carried forward.
Exemptions	Case-by-case, via a CEA-chaired committee with CAQM, NTPC, BHEL, CPRI, the Agriculture Ministry and SAMARTH.
Tariff treatment	Section 62 plants pass fuel cost through the Energy Charge Rate; Section 63 plants claim under Change in Law; the ECR increase is excluded from Merit Order Despatch.
Renewable obligation	Co-fired power counts towards Discoms' Renewable Consumption Obligation.
Procurement	Model long-term contracts and regional benchmark pellet pricing continue.

per acre, reducing dependence on unpredictable monsoons and crop prices.

The policy has also spurred pellet manufacturing units in interior rural areas. Rated pellet capacity has roughly doubled to about 30,800 tonnes per day, building supply chains for residue collection, storage and delivery and creating jobs in regions marked by underemployment.

Environmental Imperatives and Climate Goals

India grapples with severe air pollution, aggravated by crop stubble burning; co-firing offers a profitable alternative to burning residue in the field. CAQM reports that 71 thermal plants, including 11 in the NCR, were co-firing by August 2025, and attributes an estimated 80% reduction in stubble burning in Punjab and Haryana to the programme. CEA estimates co-firing has avoided about 5.7 million tonnes of carbon dioxide since FY 2019-20 – a scalable pathway to greener energy without an immediate coal phase-out, supporting India's Nationally Determined Contributions.

Global Experience Confirms the Path

Germany, Sweden, the UK, Denmark and the Netherlands use biomass co-firing as a bridge to carbon neutrality; Japan, South Korea and Indonesia have expanded it in Asia; North America uses it as a transitional strategy in coal-heavy systems. India's experience parallels these trends but carries unique urgency: nowhere else does the policy touch the incomes of so many farmers, the air quality of so many cities and so large a coal fleet at once.

The Implementation Gap: Why Enforcement and Monitoring Matter

The distance between policy and practice is the central problem. Even in the NCR, where enforcement is strongest, CAQM has found the biomass share at several plants below 1%, co-firing only intermittent. For FY 2024-25, CAQM imposed ₹61.85 crore in compensation on six plants in Punjab, Haryana and Uttar Pradesh after finding their compliance efforts wanting – welcome, but revealing, since outside the NCR no comparable mechanism exists at all.

The reasons are well known: an executive policy with no statutory force outside the NCR; no published compliance data; no penalty beyond CAQM's jurisdiction; delayed payments; cancelled tenders; and exemptions with no sunset. Each is an enforcement failure, not a design failure. Strict implementation would extend benefits to more farmers, sustain the fall in stubble burning, create bankable demand, and deliver measurable climate progress; half-hearted implementation would jeopardise rural incomes and undo those gains.

A Legal Framework for the Whole Country

The mandate rests on an executive policy that acquires legal force only in the NCR, through the CAQM Act. A national mission cannot run on a regional legal base. Four steps would give it uniform standing:

Coordination Across Ministries

Co-firing sits at the junction of five ministries, none of which controls the whole chain: Power sets the mandate and tariff; MNRE funds pellet plants; Agriculture finances balers and Custom Hiring Centres through FPOs; MSME governs pellet units' registration and credit; and MoEFCC, with CPCB and CAQM, holds the compliance levers. Each acts in its own silo, leaving a pellet entrepreneur to navigate all five.

What is needed is an Empowered Inter-Ministerial Group on Biomass, chaired at Cabinet Secretary level with the five Secretaries and the CEA Chairperson, meeting quarterly, to: publish a national biomass residue map; converge the ministries' subsidy schemes into one SAMARTH window;



mirror the structure at State and district level, with the District Magistrate linking farmers, FPOs and plants; resolve payment disputes through a standing grievance mechanism; and align procurement with the kharif harvest, when stubble burning peaks.

Making SAMARTH More Effective: Ten Steps

SAMARTH has done ground work in outreach, vendor listing and benchmark pricing, but implementation by TPPs remains poor. It needs to become an enforcement agency, not a facilitation cell:

Bringing Co-firing into the Carbon Credit Framework

Co-firing creates a real climate benefit that no one is paid for. The Carbon Credit Trading Scheme, 2023, administered by BEE, gives India a compliance and offset market, alongside an Article 6.2 list for bilateral trading. Co-firing can become a carbon asset through:

A notified offset methodology, baselined on coal displaced and monitored through existing fuel-accounting data.

Honest additionality: since mandated co-firing isn't additional by convention, credit only tonnage above the mandate, and credit avoided open-field burning separately to the pellet-supply side.

Credit-sharing down the chain, so contracts specify the split between plant, manufacturer and farmer group, or value stops at the plant gate.

Readiness for the power sector as a future CCTS-obligated entity, when co-firing will yield tradeable surplus credits.

An international window under Article 6.2 and voluntary standards, to attract foreign capital.

A link to the Green Credit Programme, rewarding avoided stubble burning directly at village level.

Together, these steps would turn a compliance cost into a revenue line for generators and a second income for the rural supply chain, making the mandate self-enforcing.

Conclusion

India is at a critical juncture where energy security, rural welfare and environmental stewardship must align. The SAMARTH Mission and the biomass co-firing mandate integrate these objectives elegantly. The November 2025 Comprehensive Policy has strengthened the commercial framework; it must not be allowed to weaken the mandate itself.

What the policy now needs is a national legal footing, coordinated action across the five ministries that govern the chain, a SAMARTH Mission equipped to monitor and enforce, and a carbon-market pathway that rewards every tonne of coal displaced.

By doing so, India will not only honour its climate commitments but empower millions of farmers, foster rural prosperity and move closer to a green energy future that is inclusive, balanced and sustainable. ■



Merino Industries as a Bio-energy Producer and Consumer in India at Large Scale



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For over two decades, Merino Industries Limited has transformed agricultural and industrial residues – rice husks, sawdust, and process wastes – into clean thermal energy at industrial scale, setting a compelling benchmark for bio-energy adoption in Indian manufacturing.

In an era when India urgently seeks to decouple industrial growth from fossil fuel dependence, Merino Industries Limited (MIL) stands as a quiet but formidable pioneer. Since 2005, the largest factory within the Merino group in Hapur (Uttar Pradesh) - focused on decorative laminates, wood panels, compact boards, potato processing and furniture - has been systematically replacing coal

with locally available agro-residues and agro-forestry wastes. Today, approximately 99% of Merino's total thermal energy requirements are met from biomass and process waste in Merino factory Hapur – a feat achieved through two decades of engineering innovation, institutional learning, and visionary leadership.

The backbone of Merino's bio-energy system is the direct combustion of rice husks and sawdust – two agri-industrial residues abundantly available in the Indo-Gangetic belt of western Uttar Pradesh. Rather than incurring the energy cost, and carbon penalty of densifying these materials into briquettes or pellets, Merino made a deliberate engineer-

ing choice: combust them raw and maximise their energy yield through system design rather than feedstock processing. This philosophy saved enormous upstream energy and capital while keeping the supply chain simple and local.

The visionary behind this approach is Shri Prakash Lohia, Chairman and Managing Director of Merino Industries. From 2005 onwards, Shri Lohia drove the development of fluidised bed combustion technology within Merino's own factories – systems engineered to handle raw, heterogeneous biomass such as rice husk and sawdust with varying moisture content. The challenge was fundamental: wet raw biomass delivers poor calorific value and unstable combustion. His solution was both elegant and ingenious – coupling in-house incinerators' exhaust heat energy with the biomass feed system, using the waste thermal energy from industrial process incinerators to pre-dry incoming biomass to optimal dryness before it entered the combustion chamber. The result was a closed-loop thermal cascade that simultaneously solved the dryness problem, maximised calorific value recovery, and eliminated energy wastage – a genuine engineering marvel in industrial bio-energy design.



Biomass-fired boilers at MIL Hapur, operational since 2005 – burning rice husks and sawdust as direct fuel to generate process steam and thermal energy for manufacturing operations

“Around 85% of Merino’s total thermal energy across three states, namely, Uttar Pradesh (Hapur), Haryana (Rohad) and Gujarat (Dahej and Halol) now comes from biomass and process waste – mitigating over 197,700 tonnes of CO₂ equivalent emissions in a single year.”

MERINO BIO-ENERGY AT A GLANCE – FY 2025-26

- 84,957 MT of agro-waste (rice husk, sawdust, woodchips) consumed as fuel
- 53,666 MT of industrial process waste converted to thermal energy
- 197,700 MT CO₂ equivalent GHG emissions mitigated vs. coal baseline
- 100% non-fossil thermal energy at Halol; 99% at Hapur; 98% at Rohad
- 31.5 MW waste-to-energy plant in Halol (Gujarat) & biomass based boilers thermal systems across manufacturing locations in Hapur (UP), Rohad (Haryana) and Dahej (Gujarat)
- 1.56 million GJ of thermal energy generated across Hapur, Rohad & Halol plants

Merino’s waste-to-energy systems extend this philosophy to industrial process wastes. Sanding and trimming dust from board manufacturing, woodchip rejects

from particleboard raw material processing, and other combustible factory wastes are fed into incinerators that contribute around 18% of the total energy mix.



Waste-to-Energy (WiE) System – MIL Halol, Gujarat



In-House Incinerators – Process Waste Thermal Energy Recovery, Merino Factories

Combined, biomass and waste-to-energy systems account for over 72% of Merino’s annual energy (electrical and thermal) needs across its five manufacturing locations – Hapur (UP), Rohad (Haryana), Dahej and Halol (Gujarat), and Hosur (Tamil Nadu). The thermal energy generated – 1.56 million GJ in FY 2025-26 – powers pressing, drying, heating, and steam generation processes, all fundamentals to laminates and board manufacturing.

Beyond energy, Merino has turned biomass ash into an agricultural resource. The ash generated from combusting

rice husk and sawdust is rich in potash and phosphorus. In collaboration with Visvesvaraya National Institute of Technology (VNIT), Nagpur, Merino has developed a specialised microbial consortia that stabilises the pH and electrical conductivity of this bio-ash, making it a viable substitute for up to 25% of chemical fertilisers. Waste begetting energy; energy begetting fertility – the circular logic is complete.

The aggregate environmental impact is substantial. In FY 2025-26 alone, Merino’s bio-energy systems mitigated an estimated 197,722 metric tonnes of greenhouse gas emissions through the use of biogenic fuels and process wastes in place of coal. This positions Merino not merely as a consumer of bio-energy but as a large-scale producer of positive climate outcomes – demonstrating that disciplined engineering, long-term leadership commitment, and local resource utilisation can achieve what policy mandates alone rarely accomplish. For India’s industrial sector, Merino’s journey since 2005 offers a replicable, scalable, and commercially sound model for the bio-energy transition. ■

Biomass Pelletization: Accelerating India's Green Energy Future



Prasad Malagavi
Territory Sales Manager, CPM

Biomass Pelletization: A Critical Pillar of the Energy Transition

As nations intensify efforts to achieve climate commitments and strengthen energy security, renewable energy is becoming the foundation of future energy systems. While solar and wind energy continue to expand rapidly, biomass is gaining increasing recognition as a reliable and dispatchable renewable energy source that can complement intermittent renewables and support round-the-clock energy requirements.

For India, biomass represents a unique opportunity to address multiple challenges simultaneously: reducing dependence on fossil fuels, mitigating agricultural residue burning, creating rural employment, and supporting the country's ambitious decarbonization goals. At the center of this opportunity lies biomass pelletization, a technology that converts agricultural residues, forestry by-products, and organic biomass into a standardized, energy-dense fuel suitable for industrial and power generation applications.

Unlocking Value from Agricultural Residues

India generates hundreds of millions of tonnes of agricultural residues annually, much of which remains underutilized. In many regions, crop residues are openly

burned, contributing to air pollution and greenhouse gas emissions. Biomass pelletization offers a sustainable alternative by transforming these residues into a valuable renewable fuel.

Biomass pellets provide several advantages:

- Higher energy density compared to loose biomass
- Improved handling, storage, and transportation efficiency
- Consistent fuel quality for industrial applications
- Reduced emissions compared to conventional fossil fuels
- Enhanced utilization of agricultural and forestry waste streams

As industries seek cleaner energy alternatives, biomass pellets are increasingly being adopted for thermal applications, co-firing in power plants, and various industrial energy requirements.



Technology Driving Industry Growth

The long-term success of the biomass sector depends on efficient and reliable pellet production technologies. Modern pelletization systems are designed to improve pellet quality, maximize throughput, and reduce operating costs while minimizing energy consumption.

At CPM, continuous innovation remains central to supporting the evolving needs of the bioenergy industry.

Direct Drive Pellet Mill Technology eliminates traditional gearbox and belt-driven configurations, resulting in improved operational efficiency, lower maintenance requirements, and enhanced machine reliability.



Twin Track Technology optimizes material compression during the pelletizing process, enabling higher production capacities, improved pellet durability, lower specific energy consumption, and more stable operating performance.

Lube 4 Life Roller Assembly is a sealed, lubrication-free system engineered to eliminate manual greasing requirements, prevent product contamination, and significantly extend bearing life, thereby reducing maintenance costs and downtime.

MyInsights, CPM's digital monitoring platform, transforms pellet production equipment into intelligent assets by providing real-time performance visibility, predictive maintenance insights, operational analytics, and comprehensive consumable traceability. Such digital solutions are helping manufacturers improve plant performance while enabling data-driven decision-making.

Advancing Sustainability Through Efficient Manufacturing

Sustainability is no longer limited to the end use of biomass fuels; it must also be embedded within the manufacturing process itself. Efficient pellet production can significantly reduce the overall environmental footprint of biomass energy systems.

Advanced process technologies contribute to sustainability by:

Reducing energy consumption

per tonne of pellets produced

Improving feedstock utilization efficiency

Minimizing process waste

Extending equipment service life

Enhancing overall plant productivity

Integrated automation, optimized grinding and conditioning systems, and intelligent process controls help biomass manufacturers achieve higher efficiencies while supporting broader sustainability objectives.

Growth Opportunities Across Emerging Markets

India, Southeast Asia, and Africa are emerging as key growth regions for biomass pellet manufacturing. These markets benefit from abundant biomass availability, growing industrial energy demand, and supportive government policies promoting renewable energy adoption.

In India, initiatives focused on biomass co-firing, waste-to-wealth programs, and sustainable energy development are creating significant opportunities for pellet producers. The increasing emphasis on reducing crop residue burning further strengthens the case for expanding biomass pellet manufacturing infrastructure.

Technology providers have an important role to play in enabling this growth by delivering scalable, feedstock-flexible solutions capable of processing diverse biomass materials while maintaining con-

sistent pellet quality.

Building the Future Bioeconomy

The transition toward a circular and low-carbon economy will require greater utilization of renewable and locally available resources. Biomass is uniquely positioned to contribute to this transformation by converting agricultural and forestry residues into valuable energy products.

Future industry priorities will include:

Developing more energy-efficient pelletization technologies

Increasing feedstock flexibility

Expanding digitalization and automation capabilities

Enhancing plant reliability and productivity

Supporting customers in achieving sustainability targets

Through continued innovation, investment, and collaboration across the value chain, biomass can play a pivotal role in creating a resilient and sustainable energy future.

Conclusion

Biomass pelletization is rapidly emerging as a strategic enabler of the global and Indian energy transition. By converting agricultural and forestry residues into high-value renewable fuel, the industry is contributing to cleaner energy production, reduced emissions, improved rural livelihoods, and enhanced energy security.

As demand for sustainable fuels continues to grow, advancements in pelletization technology will remain essential for unlocking the full potential of biomass and accelerating the development of a robust green energy ecosystem. ■



Rooted in the Soil, Built for the Future: How Bioenergy Can Anchor India's Energy Security



Manish Dabkara

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India's energy future may be most securely built not from imported crude or liquefied gas shipped across oceans, but from the paddy straw left in Punjab's fields, the press mud outside Uttar Pradesh sugar mills, and the municipal waste fermenting in city dumps from Indore to Guwahati. The raw material is already here. What we are still building is the will and infrastructure to use it.

Recent geopolitical turbulence has forced a hard reckoning with how exposed India's energy system really is. Roughly 85% of crude oil requirements are met through imports – a dependence paid for every quarter in foreign exchange outflows and every season in inflationary pressure on transport, food, and manufacturing. The Russia-Ukraine war and tensions in the Strait of Hormuz have made one thing clear: nations that do not control their energy sources do not fully control their futures.

The Bioenergy Proposition

Bioenergy is not a new idea for India – biogas digesters have existed in rural households for generations. What is new is the scale and strategic clarity of the current push. The initial momentum established under the SATAT initiative is now transitioning into an institutionalized, full-scale

ecosystem. Through the notification of the unified Central Sector GOBARdhan Scheme backed by a landmark ₹23,731-crore outlay, India has consolidated earlier fragmented interventions into a ten-year national roadmap. Alongside revisions to the National Policy on Biofuels to widen the feedstock basket and achieving the 20% ethanol blending target ahead of the original 2030 timeline, these are not marginal experiments. They represent a coordinated attempt to redirect biomass into the energy mainstream.

India generates over 500 million tonnes of agricultural residue annually. Its cattle population – the largest in the world – produces organic waste that could fuel thousands of biogas plants. Urban India adds roughly 62 million tonnes of solid waste each year. Biomass is not scarce here. What has been

scarce is the financial architecture and technical ecosystem to convert it into modern energy carriers at scale.

Security Through Decentralisation

One of the underappreciated advantages of bioenergy from an energy security standpoint is its structural decentralisation. Unlike a large thermal power plant or a petroleum refinery where single points of failure could affect millions, a network of biogas plants, bio-CNG stations, and biomass gasifiers is inherently distributed. An attack on a pipeline, a shipping disruption, a price spike in global commodity markets: none of these events shuts down a biogas unit running on agricultural residue.

This resilience matters beyond theory. In 2022, when LPG prices surged following the Ukraine con-





flict, rural households using bio-gas-based cooking solutions were insulated from that shock. When diesel prices hit historic highs, farmers and transport operators with access to bio-CNG had an alternative. Energy security at the national level is ultimately built from energy security at the household and village level – and bioenergy delivers at both.

The CCUS Dimension and Market Mechanisms

A dimension deserving more attention is the coupling of bioenergy with carbon capture, utilisation, and storage – BECCS. In a country committed to net zero by 2070, generating energy while removing CO₂ from the atmosphere is not a luxury feature; it may prove essential. Facilities that capture biogenic carbon during fermentation or combustion and either permanently store it or utilise it in industrial clusters and pharmaceutical manufacturing can deliver verified negative emissions.

However, translating advanced carbon-removal concepts and bio-methane production into commercial realities requires clear market instruments. Integrating CBG methodologies into the Offset mechanism under India's domestic Carbon Credit Trading Scheme (CCTS) creates a monetizable value stream that directly bridges high-level decarbonization goals

with day-to-day project viability.

Solving the Structural Bottle-necks

Realizing this potential has historically faced severe headwinds: fragmented, seasonal feedstock supply chains, steep capital expenditures, and cautious lending from banks unfamiliar with bioenergy risk profiles.

The revised policy landscape systematically dismantles these pain points with targeted financial and regulatory architecture:

Long-Term Revenue Visibility: Revenue volatility is now buffered by an Administered CBG Price (ACP) fixed at ₹2,110 per MMBtu for ten years, complemented by a firm offtake mandate requiring City Gas Distribution entities to blend 3% CBG in FY 2026–27, scaling up to 5% by FY 2028–29.

De-risking Upfront Capital: Greenfield facilities are backed by capital assistance of up to ₹2 crore per Ton Per Day (TPD) capacity, addressing both plant machinery (₹1.25 crore/TPD) and vital feedstock aggregation equipment (₹0.75 crore/TPD).

Infrastructure & Evacuation: A ₹5,133-crore allocation provides up to 50–80% capital support for pipeline networks connecting standalone plants and clusters across up to 75 km to trunk lines or city gas grids.

Debt Enablement & Co-product Monetisation: Institutional debt is unlocked through a dedicated credit guarantee mechanism covering up to 85% of default exposure (capped at ₹20–25 crore for MSMEs). Simultaneously, the transition from the previous ₹1,500/MT Market Development Assistance (MDA) to a mandatory 20% to 50% graded off-take obligation on Fertilizer Marketing Companies ensures a stable commercial market for Fermented Organic Manure (FOM).

A Strategic Priority, Not a Supplementary One

India has correctly identified solar and wind as the backbone of its clean energy transition. But electricity alone cannot secure India's energy future. The transport sector, heavy industry, and the heating needs of hundreds of millions require gaseous fuels and heat. Bioenergy is the cleanest, most domestically abundant answer to those needs that exists at scale.

The geopolitical moment we are in cannot be squandered. With the GOBARDHAN framework providing the institutional scaffold, the priority must now pivot to state-level pipeline clearances, bank credit disbursement, and rapid feedstock aggregation.

India did not choose its geography, but it has been gifted by it. A subcontinent with this bio-mass endowment, this agricultural scale, and this demographic weight – 1.4 billion people who generate organic waste every single day – is sitting on a domestic energy resource of remarkable depth. The task before us is simply to use it wisely, urgently, and at the scale the moment demands. ■



Waste to Energy: Unlocking India's MSW and Bioenergy Potential for Energy Security

The conversion of municipal solid waste (MSW) into energy and useful products can reduce dependence on landfilling and associated methane emissions. Agricultural residues can similarly be converted into pellets and torrefied fuels, providing an alternative to open-field stubble burning.

Through integrated conversion pathways, waste and biomass can be transformed into solid biofuels via pelletisation and torrefaction, while gasification can convert them into syngas for power generation and the production

of value-added products such as hydrogen, methanol, ethanol, Sustainable Aviation Fuel (SAF) and dimethyl ether (DME). This integrated Waste-to-Energy-Bioenergy-Hydrogen ecosystem can simultaneously address key challenges related to waste management, energy security, air pollution and greenhouse-gas emis-

sions. From MSW to Energy and Power

Municipal solid waste contains certain combustible materials such as organic matter, paper, plastics, textiles and wood, along with non-combustible inert fractions. Proper segregation and processing of the combustible



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10 TPD Torrefied Pellets Manufacturing Plant at NTPC NETRA, Gr. Noida



400 kWe MSW RDF based Steam Enhanced Gasification Plant at NTPC NETRA, Gr. Noida

fraction into refuse-derived fuel (RDF) are therefore essential for efficient energy recovery.

A representative 15 TPD MSW/RDF gasification configuration can process RDF through a series of pre-treatment steps including screening, magnetic separation, shredding and densification, prior to gasification. The resulting producer gas can then be cooled and cleaned for use in an internal combustion (IC) engine. At this scale, the system can be designed to generate approximately 400 kWe of electricity, depending on feedstock characteristics and operating conditions.

This pathway can convert combustible waste otherwise destined for landfill into useful, dispatchable electricity and demonstrates the potential of Waste-to-Energy as a resource-recovery approach using locally available feedstock.

From MSW to Hydrogen: Moving Beyond Electricity

Gasification can produce hydrogen by conditioning and separating H₂-rich syngas. Indicative assessments show syngas containing 12–14% H₂ and 16–18% CO, corresponding to potential hydrogen production of about 270 kg/day.

With oxygen enrichment, production could increase to around 378 kg/day, subject to feedstock characteristics and overall process performance.

MSW/RDF → Gasification → Syn-gas Conditioning → H₂ Separation → Hydrogen

Waste-derived hydrogen should not automatically be termed Green Hydrogen. The classification depends on applicable standards and demonstrated lifecycle emissions.

MSW to Pellets and Power

Beyond gasification, MSW can be converted into RDF pellets or torrefied fuel for use in industrial boilers and, where feasible, coal-based power plants. Torrefaction improves fuel properties, but careful control of ash, chlorine, sulphur and moisture is essential. The Ministry of Power's Novem-

ber 2025 policy recognises torrefied MSW charcoal as a potential co-firing fuel in coal-based thermal power plants, subject to technical requirements.

Agricultural Waste to Pellets and Power

India's agricultural residues represent a significant indigenous energy resource that can create value for farmers, reduce stubble burning and partially displace fossil fuels. Pelletisation improves handling and bulk density, while torrefaction can enhance fuel quality and energy density.

Illustrative observations indicate that torrefaction can increase the gross calorific value (GCV) of dried biomass. Under representative conditions, GCV may increase from about 2951 kcal/kg to approximately 3593 kcal/kg at 230°C and 3897 kcal/kg at 260°C,





Sewage Water to Green Hydrogen Facility at NTC NETRA, Gr. Noida

depending on biomass type and process conditions.

Agricultural Residue → Drying
→ Torrefaction → Pelletisation →
Co-firing/Power

This pathway can convert seasonal residues into a more transportable and uniform solid fuel, while existing biomass co-firing initiatives can support utilisation and supply-chain development.

Sewage Water to Green Hydrogen

Treated sewage water can be suitably purified and used as feedwater for Green Hydrogen production, reducing dependence on high-quality freshwater. An integrated system can combine EDR purification, PEM electrolysis, solar PV, hydrogen storage and fuel-cell power generation.

Treated Sewage Water → EDR Purification → PEM Electrolyser
← Solar PV → Green Hydrogen →
Storage/Fuel Cell

This approach supports water conservation and circular resource utilisation, particularly where STPs, renewable energy, and hydrogen demand can be integrated.

Towards an Integrated Energy-Security Model

The greatest opportunity lies in integrating these pathways according to resource characteristics, local infrastructure, and energy needs. Agricultural waste can be converted into torrefied pellets for power and co-firing; MSW can be processed into RDF, power, syngas or hydrogen; and treated STP water, combined with renewable electricity, can support Green Hydrogen production.

This approach combines the stored chemical energy in biomass and waste with renewable electricity. Hydrogen can complement these resources as an energy carrier, industrial feedstock, and potential medium for long-duration energy storage. Together, these resources can contribute to a resilient and circular energy system.

The Way Forward

The next step is to move from isolated demonstrations towards integrated Waste-to-Energy, Bio-energy, and Hydrogen hubs. This will require focus on improved MSW segregation, reliable feedstock supply, fuel-quality standards, torrefied-fuel utilisation,

advanced gasification and syngas-cleaning systems, and effective solar-electrolyser integration.

Further opportunities lie in converting syngas into higher-value products such as methanol, ethanol, Sustainable Aviation Fuel (SAF) and DME, while continuing to evaluate technologies for hydrogen recovery and purification. Techno-economic, environmental, and lifecycle assessments will remain essential for identifying suitable pathways.

The key question is not simply how much energy can be generated from waste, but which energy carrier or product – electricity, solid fuel, syngas, hydrogen or chemicals – offers the greatest technical, environmental, and economic value for each resource.

With sound feedstock management, appropriate technology selection and robust environmental safeguards, India's municipal waste, agricultural residues, treated wastewater, and renewable energy resources can support circular energy systems. Such systems can improve resource efficiency, strengthen energy security, and contribute to sustainable development. ■

From Waste to Wealth: How India is Turning Bioenergy by-Products into Gold



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For decades, bioenergy carried a quiet contradiction: the very processes made to deliver clean energy also created large volumes of waste. Biodiesel production by transesterification typically yields about 10% crude glycerol as an unavoidable by-product. In anaerobic digestion for biogas, the left-over digestate unfermented solids and liquids can account for 80–90% of the input biomass by mass. In the past, these residues were often treated as liabilities: crude glycerol was discarded or burnt, and excess digestate was dumped without proper nutrient management, leading to nitrate leaching, surface runoff, and emissions of

methane and ammonia. This linear approach not only harmed the environment but also wasted potential value.

Today, policy and economics are shifting. “Waste valorization” turning residues into marketable products has moved from an environmental ideal to a core business strategy. India is now building one of the world’s most ambitious frameworks to make this shift happen at scale.

The circular bioeconomy replaces the old take-make-dispose model with cascading use of biomass, extracting maximum value at each step. Agricultural residues

like paddy straw can be digested to produce Compressed Biogas (CBG), while the digestate is refined into bio-fertilizers or converted to biochar for carbon sequestration. Sugarcane delivers juice for ethanol, bagasse for cogeneration or pulp, and press mud for CBG and wax extraction. Used cooking oil and animal fats, when converted to renewable diesel, yield crude glycerol that can be refined for pharmaceuticals, solvents, and bioplastics such as PHA. This cascading model is central to India’s strategy because it simultaneously advances energy security, farmer incomes, and waste management.



On 6 August 2026, the Union Cabinet approved GOBARDhan (Galvanizing Organic Bio-Agro Resources Dhan), the National Circular Bioenergy Scheme, with a total outlay of ₹23,731 crore. The scheme will run from FY 2026–27 to FY 2035–36 and aims to raise domestic CBG production nearly ten-fold, bringing the entire CBG value chain under the Ministry of Petroleum and Natural Gas. It builds on earlier initiatives SATAT, Market Development Assistance for organic manure, Biomass Aggregation Machinery, and the National Bioenergy Programme under which over 200 CBG plants have already been commissioned.

The scheme rests on six integrated components:

Assured offtake: City Gas Distribution (CGD) entities must procure CBG to meet a blending

obligation of 3% in FY 2026–27, 4% in FY 2027–28, and 5% from FY 2028–29 onwards in CNG (transport) and PNG (domestic) segments. This turns the mandate into a clear, long-term demand signal and improves project bankability.

Stable pricing: A government-backed administered price of ₹2,110 per MMBTU (about ₹105 per kg) with a minimum 10-year framework. The price is supported through a mix of government support and market-based cost sharing to give producers revenue visibility while protecting consumer affordability.

Capital assistance: Up to ₹2 crore per tonne per day (TPD) of installed CBG capacity for eligible greenfield projects, covering core plant machinery as well as feedstock aggregation, organic manure processing, and value-addi-

tion assets; brownfield expansions are also eligible.

Pipeline infrastructure: Dedicated financial support to connect CBG plants to trunk pipelines and CGD networks, reducing transport costs and ensuring injection.

Credit guarantee: A specialized credit guarantee mechanism for eligible MSME-based CBG projects to absorb first-loss risk and de-risk bank lending.

Ecosystem Challenge Fund: A fund for district-level planning, feedstock assessment, logistics mapping, technology adoption, capacity building, and stakeholder awareness.

India meets nearly half of its natural gas demand through imports, with about 55–60% of LNG imports passing through the Strait of Hormuz. Recent geopolitical disruptions have highlighted this vulnerability. By substituting imported crude and LNG, the government projects macroeconomic benefits exceeding ₹40,000 crore in foreign-exchange savings.

National targets are executed by states, and Maharashtra has emerged as a primary testing ground.

The Government of Maharashtra cleared the CBG Policy 2026, officially released on 5th May 2026, with a ₹500 crore outlay for FY 2026-27 as Viability Gap Funding. The policy introduces a Hybrid Annuity Model where the government shares project costs through periodic payments and mandates a minimum processing capacity of 200 tonnes per day of segregated organic waste per project. It provides Via-



bility Gap Funding of up to ₹75 lakh per TPD, capped at ₹15 crore per project, along with 2.5% SGST reimbursement and concessional land at 0.7% of Ready Reckoner rate. Crucially, it mandates that municipalities, not developers, must bring segregated organic waste to the plant gate. As per independent analysis, when the municipality delivers waste, a 5 TPD CBG plant recovers investment in about 5 years; when the developer has to collect it, monthly operating cost more than doubles and payback stretches to more than 5 years, making it unbankable. The policy also promotes cluster mapping to allow smaller municipalities to pool waste, and creates a three-tier governance framework with a State-level Steering Committee led by the Chief Secretary and District Committees led by District Collectors.

In July 2026, the state approved the Maharashtra Bioplastics Policy 2026, valid from 2026 to 2031. With a total outlay of Rs 10,892 crore - including Rs 782 crore in the first five years and Rs 10,110 crore over the subsequent 20 years - it targets 2,00,000 TPA of PLA and biopolymer capacity, aims to attract Rs 25,000 crore investment, create 1.31 lakh direct and indirect jobs and generate Rs 30,039 crore in revenue. The policy aims to replace 30% of single-use plastic in selected sectors with compostable alternatives, cut PLA import dependence by 50%, integrate 1 lakh farmers into the value chain and achieve \$1 billion in exports. A provision of Rs 50 crore was made for 2026-27. Incentives include capital subsidy, SGST reimbursement, electricity duty and stamp duty exemptions. Maharashtra's sugar, corn, molasses and bagasse



base gives it a natural feedstock advantage for bioplastics.

Beyond these measures, Maharashtra has also moved to address distress in its sugar sector. The state has 210 operational cooperative and private mills, many of which are under financial stress due to mounting operational debt and pending cane dues. The Government Resolution dated 26 February 2026 allows stressed cooperatives to monetize primary by-products bagasse, molasses, and press mud through Build-Operate-Transfer (BOT) and Build-Own-Operate-Transfer (BOOT) partnerships with private developers. These partnerships can run for 5–15 year concessions and support the production of CBG, Sustainable Aviation Fuel, bioplastics, and biochemicals.

Four hurdles remain:

High capex: a commercial CBG plant costs ₹6–7 crore per TPD, so a 5 TPD facility needs ₹35–50 crore and requires 100–150 tonnes of clean, segregated organic waste daily, since 25–30 tonnes of waste yields 1 tonne of CBG.

Feedstock seasonality: residues are bulky and decentralized.

Lack of uniform Bureau of Indian Standards (BIS) for fermented organic manure and biochar causes price volatility.

Absence of a single-window clearance system spanning environment, municipal and energy approvals delays project commissioning.

Solutions include expanding domestic fabrication of digesters and refining equipment, formal BIS certification to build farmer trust, centralized digital single-window clearances, and strengthening FPO-led aggregation networks.

Bioenergy is undergoing a structural transition. Waste is no longer just a liability to be minimized, but an underutilized asset. As demonstrated by the GOBARDhan scheme, Maharashtra's policies and global benchmarks, integrating waste valorization into supply chains can convert residual biomass into energy security, drive rural prosperity and advance decarbonization - the foundation of a truly circular bioeconomy. ■

The Economics of Bioenergy

Energy security has become a strategic imperative for India's fast-growing economy. Geopolitical disruptions – from instability in Venezuela and tensions in the Middle East to sanctions on Russia following the Ukraine conflict – have exposed the fragility of global energy supply chains and the risks of import dependence. India has responded through a combination of diversified energy sourcing, pragmatic diplomacy, and strategic petroleum reserves. At the same time, it is strengthening long-term energy self-reliance by expanding domestic bioenergy, particularly compressed biogas and bioethanol, as part of its clean energy transition. The goal is clear: reduce fossil fuel imports by producing more energy from indigenous resources. But as this transition gathers pace, a critical question emerges: what is the true economic and environmental cost of achieving energy security?

Biofuels are characterized into four generations, distinguished by their feedstock and conversion technology, progressing from food crops to non-food biomass, algae, and engineered biological systems to improve efficiency while reducing pressure on food, land, and water resources.

Yet, the label “bio” does not automatically mean green or carbon-neutral. Biofuels consume water, energy, and material resources, and require land across their entire value chain. For instance, first-generation bioethanol carries environmental costs from cultivation, irrigation, fertilis-

er and pesticide use, harvesting, transport, processing, distillation, dehydration, and blending. Since fertiliser production itself is energy-intensive, assessing biofuels requires a comprehensive life-cycle analysis that measures emissions and resource use from feedstock cultivation to final fuel consumption – not just tailpipe emissions.

Lifecycle assessment becomes more complex when a feedstock produces multiple products and by-products. In the sugarcane-to-ethanol value chain, sugar, ethanol, bagasse, straw, tops, and press mud all carry economic value. Bagasse often powers sugar mills through captive heat and electricity generation, while other residues have agricultural or commercial uses. How emissions are allocated across these outputs can significantly change ethanol's reported carbon footprint. The same applies to CBG, where digestate – including FOM and LFOM – is produced alongside the gas. Its collection, treatment, transport, and utilization are major cost drivers, making waste management a core part of the bioenergy business model, not a secondary issue.

A robust assessment must also consider Energy Return on Energy Invested (EROEI – the ratio of usable energy produced to the energy consumed across production, processing, transport, and distribution. Biofuels should deliver a clear net energy gain. In addition, a comprehensive life-cycle assessment must evaluate greenhouse gas emissions, air



Anurag Kumar Sachan

(Independent Energy, Sustainability and Policy Consultant)

pollutants, wastewater, chemicals, solid waste, land-use impacts, and water consumption across the entire value chain. It must also account for ethanol's lower energy density than petrol, comparing emissions on an energy-equivalent basis while distinguishing biogenic from fossil carbon. The real question is not whether a fuel is biological, but whether the entire system delivers a measurable environmental advantage.

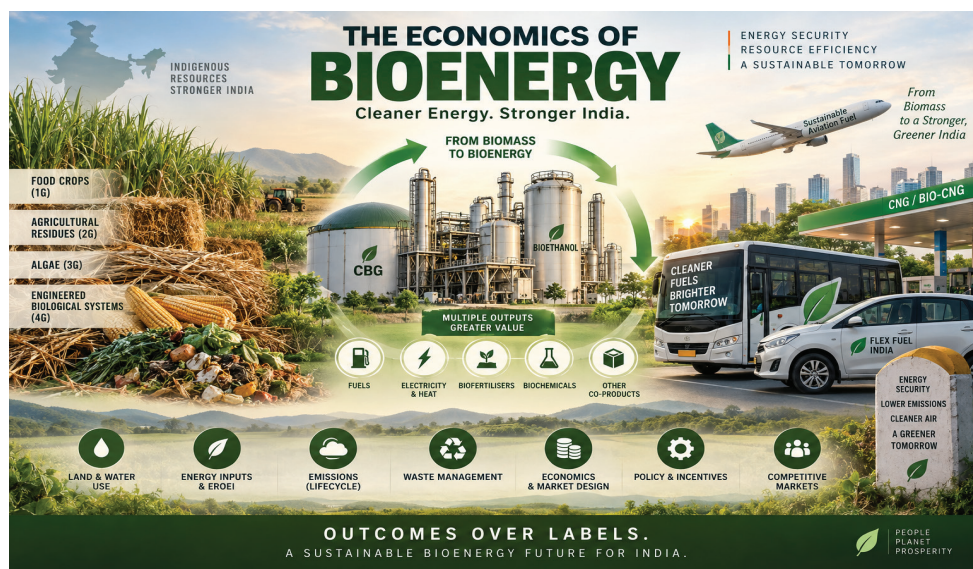
Biofuels must be assessed not only by how they are produced, but also by the infrastructure development to use them. Compressed biogas requires purification and upgrading before it can enter the City Gas Distribution network or replace fossil CNG, demanding investments in compression, storage, metering, and transport. Similarly, higher ethanol blending requires upgrades to storage, blending, dispensing, logistics, and, in some cases, vehicle compatibility. Ethanol's lower calorific value can also affect fuel economy. These integration costs are often overlooked when comparing biofuels with fossil fuels.

The economics of biofuels are equally shaped by the structure of the biofuel market, which is influenced by government policy, blending mandates, administered prices, and fiscal incentives. Ethanol prices vary by feedstock – in-

cluding sugarcane juice, B-heavy and C-heavy molasses, maize, damaged food grains, and FCI rice – to encourage domestic production. While this supports targeted sectors, it also influences investment and feedstock selection. In recent years, the pricing framework has encouraged a strong shift toward maize-based ethanol, highlighting how policy can shape resource allocation as much as efficiency or sustainability.

Biofuels are also not inherently cheaper than fossil fuels. Under the new pricing mechanism, CBG is priced at about ₹2,110/MMBtu (around ₹100/kg) – often higher than domestic or imported LNG on an energy-equivalent basis. Bioethanol has a weighted average ex-mill price of ₹66.61/litre; after GST, transport, and other costs, the delivered price to Oil Marketing Companies exceeds ₹71/litre, compared with an ex-refinery petrol price of about ₹69/litre. While comparisons should be made on an energy-equivalent basis, the message is clear: higher biofuel production costs do not disappear – they are borne by consumers, absorbed within the value chain, or supported through government subsidies.

Government support has been instrumental in scaling India's biofuel sector. The National Policy on Biofuels, 2018, supported by viability-gap funding, tax incentives, accelerated depreciation, differential pricing, and incentives for advanced biofuels, helped create substantial ethanol production capacity and enabled India to achieve its 20% ethanol-blending target ahead of the original 2030 deadline. The next challenge is economic sustainability. With significant 1G ethanol capacity already in place, the industry must expand into higher-value markets, including exports and, where



technically and commercially viable, advanced fuels such as SAF.

The Way Forward: From Biofuel to Sustainable Bioenergy

India now needs to move from “biofuel as a category” to “bioenergy as a measured outcome.” The policy question should not simply be whether a fuel is biological or renewable, but whether it delivers measurable gains in energy security, resource efficiency, lifecycle emissions, economic value, and environmental sustainability.

First, policy should become progressively technology- and feedstock-neutral. Producers should be free to optimise feedstock, technology, location, and end-use, while multi-feedstock and multi-product plants should be encouraged to respond to changing resource availability and market conditions.

Second, lifecycle sustainability must become central to bioenergy policy. Land, water, energy, materials, emissions, waste, and co-products should be assessed consistently across fuel pathways. This would distinguish genuine environmental gains from impacts simply shifted elsewhere in the value chain.

Third, incentives should increasingly be performance-based. Fuels with lower lifecycle emissions, reduced water and land use, posi-

tive energy balances, and effective waste utilisation should receive greater support. Carbon pricing and credits can help monetise these environmental advantages.

Fourth, waste and residue utilisation should be integral to the business model. The goal should not be to maximise a single fuel, but the economic and environmental value extracted from every tonne of biomass – through fuels, electricity, heat, fertilisers, chemicals, and other co-products.

Finally, India should move towards a regulated but competitive bioenergy market. Producers need greater flexibility in feedstock and downstream markets, while maintaining stringent fuel-quality, and environmental standards.

The central lesson is simple: “bio” does not automatically mean “green.” Its true value must be assessed across the entire system – from feedstock and resource consumption to conversion, waste management, infrastructure, and final energy use.

India's next phase of bioenergy policy should therefore prioritise outcomes over labels, performance over mandates, and sustainability over substitution. The objective should not be to maximise biofuel volumes, but to maximise the sustainable energy value created from India's biomass and waste resources. ■

Biochar in India

Industry Overview • India • 2025–26

Turning agricultural waste into a carbon-negative resource for soil health, clean energy, and climate action



Manoj Tandon
eGateway India Private Limited

Key Market Highlights

Particulars	Details
India biochar market size	USD 72 million in 2024
Projected market size	USD 184 million by 2033
Market CAGR	11% during 2025–2033
Carbon credit value	USD 100–180 per tonne CO ₂ e
Annual agricultural residue generation	500–550 million tonnes
Biochar production potential	15–26 million tonnes annually

What is Biochar?

Biochar is a stable, carbon-rich solid produced by heating organic biomass such as crop residue, wood waste, municipal solid waste and other biomass materials in a low-oxygen environment. This process is known as pyrolysis and is typically conducted at temperatures ranging from 300°C to 700°C.

Biochar is porous, long-lasting and functions as a natural carbon sink. Unlike charcoal, biochar is

specifically engineered for soil application and carbon sequestration. It can lock carbon for approximately 100 to 1,000 years.

Basic Production Flow
Biomass Feedstock → Pyrolysis at 300–700°C → Biochar + Syngas + Bio-oil

Slow pyrolysis generally favours higher biochar yield, approximately 35%, while fast pyrolysis yields around 20% biochar.

Raw Material Availability in India

BIOCHAR

Powering a Sustainable India

From Soil to Infrastructure, Water to Industry

Soil Health & Agriculture

- ✓ Improves soil fertility
- ✓ Reduces fertilizer use
- ✓ Enhances water retention
- ✓ Boosts crop yield

Roads & Construction

- ✓ Bio-bitumen for roads
- ✓ Stronger & longer lasting pavements
- ✓ Lower carbon emissions

Water Purification

- ✓ Adsorbs contaminants
- ✓ Improves water quality
- ✓ Cost-effective & natural

Cement & Steel Industry

- ✓ Partial replacement
- ✓ Lower fuel use
- ✓ Reduced emissions

Waste to Value

- ✓ Utilizes agri-residues
- ✓ Converts waste to wealth
- ✓ Supports circular economy

Climate Action

- ✓ Long-term carbon storage
- ✓ Supports India's Net Zero goals
- ✓ Nature-based solution

Higher Incomes for Farmers

New Green Jobs & Enterprises

Lower Imports & Energy Security

Sustainable Future for Generations

India generates around 500–550 million tonnes of crop residue annually. Wheat, paddy, sugarcane and maize account for nearly 63% of the total crop residue output.

Key Producing States

State	Crop Residue Availability
Uttar Pradesh	72 million tonnes
Punjab	45.6 million tonnes
Haryana	24.7 million tonnes
Maharashtra	Significant availability
Odisha	Significant availability
Karnataka	Significant availability

In addition, India generates approximately 60 million tonnes of municipal solid waste annually, much of which is currently land-filled or openly burned. This creates a significant opportunity for conversion into biochar.

Feedstock Types

Biochar can be produced from the following feedstocks:

Feedstock Category	Examples
Agricultural residue	Paddy straw, wheat stubble, bagasse, maize residue
Forestry waste	Wood waste, sawdust, forest residues
Animal manure	Cattle dung and other manure
Biomass plantation	Dedicated biomass crops
Residential / municipal waste	Segregated organic waste and other suitable biomass fractions

Key Applications of Biochar

Biochar has multiple applications across agriculture, climate, industry and energy sectors.

Application Area	Use
Soil amendment	Improves soil quality, water retention and fertility
Carbon credits	Enables carbon sequestration and credit generation
Steel / construction	Can be used in industrial and construction materials
Water treatment	Used as adsorbent for wastewater treatment

Application Area	Use
Horticulture	Supports plant growth and nursery applications
Energy generation	Byproducts such as syngas and bio-oil can be used for energy

Market Snapshot and Policy Context

The Indian biochar market reached approximately USD 72 million in 2024 and is projected to grow to around USD 184 million by 2033, reflecting a CAGR of approximately 11%.

Government support from the Ministry of Agriculture and the National Bio-Energy Mission is expected to accelerate adoption. In January 2025, Google and Microsoft reportedly signed an agreement to purchase 100,000 tonnes of carbon removal credits from an Indian company.

In October 2024, SAIL and BHP partnered to explore the use of biochar in blast furnaces. India has also launched a carbon credit trading market on 21 March



2026, where biochar is expected to emerge as an important methodology under international carbon registry frameworks.

Recent Biochar Projects in India

Location	Project Details
Karnataka	Two projects: one focused on biochar and bio-oil; another focused on biocarbon, sustainable charcoal and biochar
Tamil Nadu	One project focused on bio-oil

Benefits, Challenges and By-products of Biochar

Key Benefits

Benefit Area	Details
Soil health	Improves water retention, aeration and microbial activity. Can boost crop yields by 10–25% and reduce chemical fertilizer use by 10–20%.
Carbon sequestration	Stores carbon for 100–1,000 years. India has potential to sequester around 0.1 GT CO ₂ e per year using 30–50% of surplus agricultural waste.
Wastewater treatment	Can treat approximately 200–500 litres of water per kg of biochar. Potential demand is estimated at 2.5–6.3 million tonnes for treating India's untreated wastewater.
Construction	Adding 2–5% biochar to concrete can increase strength, improve heat resistance by 20% and sequester around 115 kg CO ₂ per m ³ .
Pollution control	Reduces N ₂ O emissions from soil by 30–50%. Also replaces open burning of stubble, reducing particulate matter and greenhouse gas emissions.
Farmer income	Carbon credit generation at USD 100–180 per tonne CO ₂ e can create additional revenue streams for small-holder farmers.

Potential Byproducts

Byproduct	Description and Potential
Syngas	A mixture of carbon monoxide and hydrogen. It can be combusted for power generation. India's potential is estimated at 8–13 TWh per year of electricity, replacing 0.4–0.7 million tonnes of coal annually.
Bio-oil	Liquid fuel substitute for diesel or kerosene. It could offset 12–19 million tonnes of fossil fuel use, equivalent to around 8% of India's diesel/kerosene use, cutting over 2% of India's fossil fuel emissions.
Activated carbon	A high-value derivative used for industrial water and air filtration, chemical manufacturing and pharmaceuticals. It offers significant revenue upside for biochar producers.

Challenges in India

Challenge	Description
No standardized market	Absence of uniform quality standards and carbon accounting protocols reduces investor confidence.
Awareness gap	Farmers and industries lack technical knowledge of biochar's multi-sector benefits and application methods.
Scalability	Decentralized production models face logistical and financial constraints, while supply chains remain fragmented.
Policy integration	Biochar is not yet fully integrated into state climate action plans, bioenergy programmes or crop residue management at scale.
Technology cost	Pyrolysis units require upfront capital investment. Affordable indigenous equipment is still limited outside urban hubs.

Challenge	Description
Feedstock logistics	Aggregating dispersed crop residue at sufficient commercial volumes remains operationally complex.

Outlook and Opportunity

With India's carbon trading market launching in 2026 and agricultural residue availability exceeding 600 million tonnes annually, biochar is positioned at the intersection of climate finance, sustainable agriculture and clean energy.

Strategic priorities for the sector include:

Priority Area	Action Required
Carbon market integration	Integrate biochar into national and international carbon credit frameworks.
Village-level deployment	Deploy low-cost pyrolysis technology at panchayat and village level.
Feedstock supply chains	Build regional biomass supply chains across Uttar Pradesh, Punjab, Haryana and other high-residue states.
Export opportunity	Unlock export markets for activated carbon and related biochar-based products.
Domestic industrial use	Promote biochar applications in agriculture, wastewater treatment, construction and steel sectors.

The global market is expected to grow from approximately USD 3.1 billion in 2025 to USD 6.5 billion by 2030. With its large biomass base, India has the potential to capture a significant share of this emerging market. ■

Grey to Green Building: Sugarcrete®



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Building grey

The approximate annual global construction material sector value ranged from US\$1.2 trillion in 2022 to US\$1.7 trillion in 2024, around 13% of which relates to bricks and blocks. Whether an insulation panel or block causes harm in its production is treated as secondary to the capital it generates and the surplus it accumulates for those who control the operation. We have reached a point in which construction - an industry that should be creating solutions - is instead creating.

In 2018, global aggregate production totalled 33.7 ± 1.3 billion tons. Gypsum extraction - used, among other things, to manufacture the ubiquitous plasterboard which makes our walls uniformly flat, can foster mould, and can leach polluting sulphates when disposed of - reached around 338 million tonnes in 2025, with production expected to grow at an annual rate of 5.5% until 2030. The global demand for sand reached 50 billion tonnes in 2025, up from a lowly 9.6 billion tonnes in 1970, intensifying pressures that contribute to natural disaster risks. Finally, there is cement: the material that literally holds the contemporary construction sector together. Global cement production reached 3.8 billion tonnes in 2025, with peaks diverging regionally until 2030. The greatest

demand is expected in Sub-Saharan Africa, where climate related impacts are ironically among the most severe.

Sugarcrete® has the potential to transform our understanding of what a brick can be. The availability of 625 million tonnes of sugarcane processing bio-residue provides the ability to address the scale of the problem. This simple unit of building has a reasonably long pedigree, common knowledge estimates dried mud bricks being used in Jericho and Southern Turkey as far back as 7,000BC. The firing of that simple original was the first step towards a scale of construction that is now normalised, monetised and globalised. Firing also marked an early step towards the carbon and pollution crises that emerge when the scale of demand requires a corresponding scale of fuel consumption. The brick is not simply the clay prism held in the hand. It is the landscape from which its material was extracted; the hands that shaped it; the fuel used to fire it; the landscape from which that fuel was extracted; the hands that cut the biomass or dug the coal; and the lungs that absorbed the dust.

The Food and Agriculture Organization of the United Nations places India as the fourth-largest agricultural producer, generating millions of tonnes of bio-waste each year. Much of this material is either burnt or left to decompose, releasing both methane and the CO₂, alongside other pollutants including sulphur dioxide (SO₂) and nitrogen oxide (NO_x) or CH₄. These emissions contribute greatly to the pressing issue of air pollution and health risk across the country. Of the world's 30 cities with the worst air pollution, 17 are in India. In India's context, air pollution is a critical issue. According to the 'State of Global Air Report 2025', India had more than 2 million deaths attributable to air pollution in 2023. This air pollution crisis in the country is driven largely by three main activities: transportation, industry such as brick making, and open field burning of agricultural residues.

Building green

Using sophisticated Dynamic Life Cycle Assessment, Sugarcrete® has demonstrated that systematically diverting agricultural residues from field burning or biomass-generated combustion into long-lived building products con-

sistently reduces radiative forcing - the measure of the imbalance between incoming solar energy and outgoing heat energy in the Earth's atmosphere that drives global warming. When all combustion residues are diverted and replaced with renewable backfill, the projected benefit increased to a cooling effect of -0.41 °C over 100 years period. Expanding this approach across 50 Mega hectares of high-yield crops extends this projected temperature reduction to -0.61 °C, despite the emissions associated with initial land-use change. Avoiding even half a degree of global warming could have existential impact on sea level rise and equatorial habitability.

Figure 1. Global allocation of collectable agricultural residues (~4.4 Gt dry matter yr⁻¹, averaged 2019–2023) across baseline fate categories. Flows are proportional to dry matter volumes and colour-coded by fate: combustion (open burning and combined energy and power (CHP)), animal feed, field return/decay, stored in products such as paper and building materials, and unrecoverable losses.

Sugarcrete® is part of the transformation of construction as a source

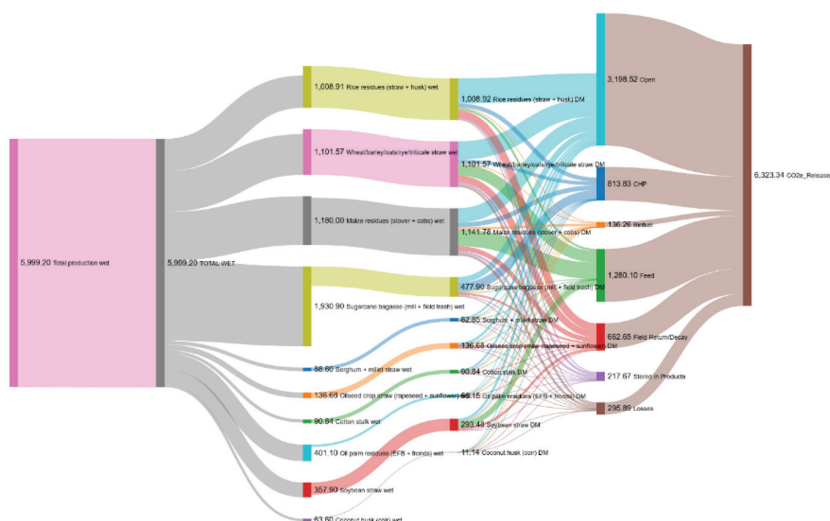
of problems to construction as part of the solution -not only to the climate crisis, but to a wider network of interconnected challenges. Sugarcrete® purpose is therefore not simply to make a better brick, but to rethink the landscape of problems surrounding the materials, systems and communities that make construction possible. At the centre of this networked problem is the realisation that waste, like weeds are simply a material in the wrong place or at the wrong time. Change its place and/or its timing, and waste can become resource. Turning that principle into practice requires more than repurposing materials instead of disposing them; it requires the reimagining of an ethical supply chain from the outset. Sugarcrete® has sought to tread the line between industry partnerships operating within performance/profit constraints, and developing micro-finance frameworks that can empower local rural producers to escape unethical employment cycles within the fired brick industry.

In Uttar Pradesh alone, 22.5 million metric tonnes of sugarcane harvested equates to almost 45% of India's yield. Sugar sequesters upto 40 times more carbon per

unit of land than forestry, while one cubic metre of Sugarcrete® encapsulates approximately 170 kilograms of CO₂ emissions. Replacing fired clay bricks or concrete blocks with Sugarcrete® in a single storey house in India could therefore save approximately 2 tonnes of CO₂ emissions. Sugarcrete® bricks bring Carbon Credits investment – valued at approximately \$50 per tonne – within reach, potentially reducing the overall cost of the bricks by around 20%. At the 'end of building life', Sugarcrete® can be reused in future construction and, eventually returned to the soil as an agricultural improver along with its alkaline binder.



Figure 2. Sugarcrete® image credit Megan Jones.



Where do our raw materials come from, and where do they go? What do they contain, and what do they release? How do they work in use, how long do they last, what value do they create, and who benefits or suffers as a result? These are the intensely pertinent questions behind any proposed low carbon construction innovation and underpin the development of Sugarcrete®. The quantity of carbon involved is only the beginning. ■

3rd Edition of India Bioenergy & Tech Expo 2026 (IBET 2026)

The 3rd India Bioenergy & Tech Expo (IBET 2026) was held from 11–13 August 2026 at India Expo Centre & Mart, Greater Noida, Uttar Pradesh, under the theme “Advancing Bioenergy Solutions for a Low Carbon World.”

Jointly organised by the Indian Federation of Green Energy (IFGE) and MM Active Sci-Tech Communications, the expo was hosted by the Government of Uttar Pradesh, with UPNEDA as co-organiser. It was supported by the Ministry of Road Transport and Highways, Ministry of New and Renewable Energy, Ministry of Power, and Department of Bio-technology, Government of India.

The three-day event brought together policymakers, government officials, technology providers, project developers, investors, researchers, industry leaders and entrepreneurs, creating a platform for industry dialogue, collaboration and business opportunities. Alongside a sector-focused exhibition, IBET 2026 featured conferences, CEO and leadership roundtables, busi-



ness meetings and networking, covering key technologies, policies and opportunities shaping India's emerging bioenergy and clean-energy economy.

A Memorable Moment for Bharat Bioenergy Compass

A special moment at IBET 2026 was the inauguration of the Bharat Bioenergy Compass website by Chief Guest Shri A.K. Sharma, Hon'ble Minister for Energy & Additional Sources of Energy, Government of Uttar Pradesh. The launch marked a new step for the IFGE publication, providing a dedicated platform to share news, developments, policies and industry perspectives from India's growing bioenergy sector.

A High-Impact Platform for India's Bioenergy Sector

The 3rd IBET brought together 800+ delegates, 175+ speakers, 20 sessions, 6 sectoral leadership roundtables, 100+ exhibiting companies and 7,500+ visitors, creating a strong platform for industry engagement, knowledge exchange and business opportunities.

The conference explored critical areas across the bioenergy value chain, including CBG, biomass briquettes and pellets, ethanol, CCUS, biochar, green attributes and carbon credits, farmer income opportunities, markets and supply chains, and financing for bioenergy projects.

The edition was particularly timely, coinciding with the launch of the GOBARDhan Scheme by the Government of India. Chief Guest Shri A.K. Sharma, Hon'ble Minister for Energy & Additional Sources of Energy, Government of Uttar Pradesh, highlighted the state's Bioenergy Policy and its potential to become a business-friendly bioenergy hub. He called for flexible policies, stronger infrastructure, greater farmer participation, skill development and continuous



industry feedback to accelerate investment. He also highlighted Uttar Pradesh's work on a new, industry-led Bioenergy Policy, with greater emphasis on competitiveness, industrial clusters and improved returns on investment.

Policy, Industry and Investment Priorities

Key priorities emerging from the discussions included reliable rural power and road connectivity, domestic CBG equipment manufacturing, stronger UPNEDA capacity, and a dedicated Centre of Excellence for skills and technology development.

The event brought technology companies, project developers, investors and policymakers together to explore partnerships, investment opportunities and the commercial deployment of bioenergy solutions. The CEO Roundtable attracted more than 40 CEOs, while sectoral leadership roundtables focused on green hydrogen, biomass pellets and briquettes, sustainable aviation fuel, CBG-CGD desynchronisation, state CBG policies, green shipping corridors and marine fuels.

The programme also saw participation from senior representatives of the Government of Uttar Pradesh, Central ministries and

key institutions, including the Bureau of Energy Efficiency, Central Electricity Authority, Centre for High Technology, National Institute of Bio-Energy (Sardar Swaran Singh National Institute of Bio-Energy), Karnataka State Bioenergy Development Board, and leading players from the CBG and biomass-pellet sectors.

A key focus was India's ambitious CBG scale-up. Shri Alok Tripathi, Joint Secretary, Ministry of Petroleum and Natural Gas, stated that India aims to raise CBG production to 5 million standard cubic metres per day (mmscmd) over the next five to ten years, from around 0.4 mmscmd currently, with nearly 300 additional plants under construction.

The discussions also highlighted persistent sectoral challenges, including feedstock availability and pricing, assured offtake and by-product management. Proposed measures under the

GOBARDhan framework include stronger CBG-CGD and trunk-pipeline connectivity, long-term pricing visibility and financial support for capacity creation – all aimed at strengthening the commercial viability of the sector.

Sector-Focused Insights Across the Bioenergy Value Chain

The IBET Expo featured focused discussions covering the breadth of India's bioenergy value chain, including ethanol and distilleries, biomass-based briquettes and pellets, emerging fuels and technologies, CCUS and biochar, financing and global collaboration, and farmer engagement.

The three-day expo highlighted a clear evolution in India's bioenergy landscape – from individual technologies towards an integrated ecosystem connecting feedstock, technology, infrastructure, finance, markets and policy. CBG, biomass pellets, ethanol, SAF, bio-hydrogen, CCUS and biochar were examined through both commercial and policy lenses, reflecting the sector's growing focus on scale and bankability.

Looking Ahead: IBET Expo 2027

Join us for the 4th IBET Expo, 1–3 September 2027, at India Expo Mart & Centre, Greater Noida, Uttar Pradesh, Delhi NCR. ■



IFGE LOGBOOK

(July-September 2026)



Delegation from IFGE met with Shri Shripad Yesso Naik, Hon'ble Minister of State, MNRE to discuss the Implementation of Biomass Co-Firing Mandate at NTPC's Thermal Power Plants on 09.07.2026



Delegation from IFGE met with Shri Santosh Sarangi, Secretary MNRE highlighted concerns over reduced biomass pellet offtake by TPPs and its impact on the viability of processing units, urging timely intervention to safeguard the industry and sustain its economic, employment, farmer livelihood, and environmental benefits on 13.07.2026



All India Distillers' Association (AIDA) Green Energy Seminar 2026 under the theme "Clean Mobility Pathways for India's Energy Future"
Date: 02.09.26, Venue: Hotel Le Meridien, New Delhi
Organised by All India Distillers' Association (AIDA)
Mr. Sanjay Ganjoo, DG, IFGE Moderated the session on State Policy & Dr. Nidhi Sahu, DGM, IFGE shares her view in the session High-Powered Women Leaders in Bioenergy & Sustainability

Delegation from IFGE CBG Producer Forum met with Sh. Alok Tripathi, JS, MoPNG regarding pending MDA claims and FOM/LFOM disbursement & market facilitation on 03.09.2026



A delegation from IFGE-BBPF had a fruitful meeting with Sh. Ravindra Kumar, Director (Operations), NTPC Limited, to discuss the implementation of India's biomass co-firing mandate and the challenges faced by the biomass pellet industry on 07.09.2026



4th Edition of "The India Sugar & Bio-Energy Conference 2026"
Organised by: Indian Sugar & Bioenergy Manufacturers Association (ISMA)
Venue: JW Marriott Hotel, Aerocity, New Delhi on 09.09.2026 to 10.09.2026
IFGE joined as Association Partner



Mr. Sanjay Ganjoo, DG, IFGE spoke at News 24 Media Bharat Nirman Summit on importance of Green Energy for Energy Security of the country on 24.08.2026

IFGE LOGBOOK (July-September 2026)

FUNDAMENTALS OF ANAEROBIC DIGESTION

- The Microbiology of the Process
- Maintaining Microbial Activity
- Parameters to be Monitored



Online training programme on Compressed Biogas (CBG), titled "Compressed Biogas (CBG): Powering the Circular Economy". Dr. Nidhi Sahu presented on Fundamentals of Anaerobic Digestion. Organised by: Centre for Science and Environment on 15-27 Sept. 2026



Industry Guides' Meet 2026
Organized by: Amity University
Venue: Amity University, Greater Noida on 17.09.2026
Dr. Nidhi Sahu, DGM, IFGE, shared her views on strengthening collaboration between academia and industry

WEBINAR

BUILDING A BIOENERGY NATION
A BLUEPRINT FOR BIOGAS
SCALING CBG FROM FIELD TO POLICY

FRIDAY, JULY 24, 2026
3:00-4:30 PM IST | ON ZOOM

[CLICK HERE TO REGISTER](#)

COMRESSED BIOGAS (CBG)
A NATIONAL BLUEPRINT FOR UPSCALING POLICY AND PRACTICE

OUR PANELISTS

 Sanjay Ganjoo Director General, CSE	 Dr. Nidhi Sahu Deputy General Manager, IFGE
 Srinivas Kallala Founding Partner, Biofuels Engineering Systems LLP	 Shekhil Saini Programme Manager, Renewable Energy, CSE

FOR MORE DETAILS CONTACT:
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Mr. Sanjay Ganjoo, DG, IFGE, addressing a webinar hosted by CSE on A Blueprint for Biogas scaling CBG from Field to Policy

BBPF
BHARAT BIOMASS & PELLETS FORUM
IFGE
INDIAN FEDERATION OF GREEN ENERGY

DISCUSSION REGARDING
Biomass Pellet Procurement by TPPs:
Addressing Industry Challenges & Assessing Sectoral Impact

DATE: 3rd September 2026
TIME: 11:00 AM to 1:00 PM

 Mr. Subodh Kumar National Advisor IFGE, IIS, NTPC & Former CEO, Indian Oil	 Mr. Satish Upadhyay IFGE, Chairperson, Bharat Biomass & Pellets Forum BBPF and Former Mission Director, SAMARTH MISSION	 Mr. Sanjay Ganjoo Director General IFGE
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MODERATOR

Mr. Aman Kwatra
National Coordinator
Bharat Biomass & Pellets Forum

FOR ANY ASSISTANCE, PLEASE CONTACT:
Anamika Ghosh
M: 88261 30681 | E: anamika@ifge@gmail.com

BBPF
BHARAT BIOMASS & PELLETS FORUM
IFGE
INDIAN FEDERATION OF GREEN ENERGY

Stronger Dialogue
for a Sustainable Tomorrow

WEBINAR
Discussion regarding
latest changes in NTPC tenders
and suggestions from Industry
to NTPC for future amendments.

Date: 21st September 2026
Time: 03:00 - 04:00 PM

MODERATOR

Aman Kwatra
National Coordinator, IFGE:
Bharat Biomass & Pellets Forum

For any assistance, please contact:
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E: anamika.ifge@gmail.com

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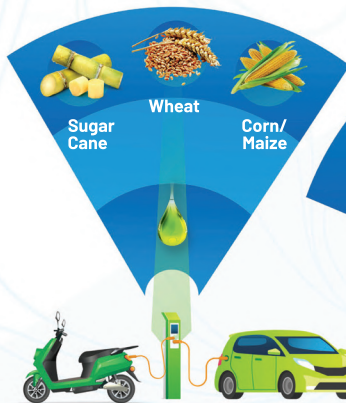


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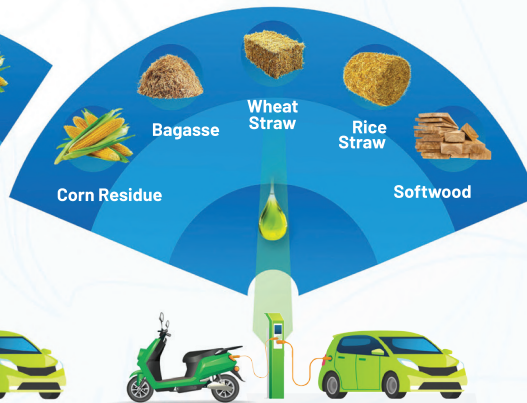
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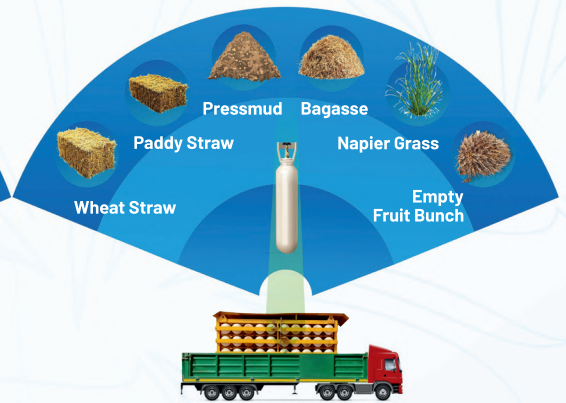
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