An IFGE Publication

BHARAT

BIOENERGY HORIZON

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BIOENERGY | BIOFUEL | BIOMASS | WASTE TO ENERGY

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IFGE
Indian Federation of Green Energy

DELEGATION TO EUBCE

33rd European Biomass Conference & Exhibition

Date: 9-12 June 2025

Venue: Valencia Conference Centre, Spain

Join EUBCE 2025

EUBCE is the Largest European Bioenergy event attended by more than 1000 delegates from all over the world.

IFGE led a delegation of 25 Indian members in EUBCE 2024 at France.

Glimpses of IFGE Delegation to EUBCE 2024

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- **Grain Ethanol Distillers Association**
- **Electric Vehicle Industry Forum**
- **Solar Power Industry Forum**
- **Carbon Capture Utilisation & Storage Forum**
- **Sugar Bioenergy Forum**
- **Sustainable Aviation Fuel Forum**
- **Bio Mobility Forum**

CONTENTS

Messages

Talk Time

Sectoral Views

CONTENTS

Article

Message

Dr. Pramod Chaudhari
Founder and Chairman
Praj Industries, President, IFGE

With immense pride, I announce the publication of the debut edition of ***Bharat Bioenergy Horizon***, a magazine dedicated to bioenergy, a crucial pillar in India's Bioenergy transition. As the President of the **Indian Federation of Green Energy (IFGE)**, an organization founded in 2014 to advocate for renewable energy solutions, I am pleased to witness this milestone that reflects our ongoing commitment to advancing sustainable energy in India.

India, one of the world's fastest-growing economies, faces a critical challenge in meeting its energy demands while minimizing environmental impact. With over 70% of our energy still reliant on fossil fuels, transitioning to cleaner, renewable sources is urgent. The government has set ambitious targets under the National Biofuels Policy and the Renewable Energy Development Program to promote biofuels, biomass, and biogas. Thanks to its vast agricultural residue and diverse ecosystems, India holds significant potential to lead the world in biomass-based energy production.

While India's bioenergy sector is well-informed for growth, it faces challenges in ecosystem development, investment, policy alignment, and infrastructure. Despite these obstacles, there have been notable strides in biomass power plants, biofuel production, and biogas projects. However, these efforts must be scaled to meet India's energy goals.

This is where ***Bharat Bioenergy Horizon*** steps in. The publication will serve as a comprehensive resource, offering insights into technological innovations, policy shifts, and industry success stories. It aims to be a platform for knowledge-sharing where innovators, entrepreneurs, researchers, and policymakers can collaborate to address the challenges and opportunities in the bioenergy space.

The magazine will explore how India can align its bioenergy strategies with national renewable energy objectives, focusing on regulatory frameworks, investment incentives, and waste management. It will also highlight emerging technologies, such as second-generation biofuels, waste-to-energy solutions and co-product valorization which are key to reducing India's reliance on fossil fuels and mitigating environmental concerns.

In addition, ***Bharat Bioenergy Horizon*** will examine innovative financing models that can bring the necessary capital to scale bioenergy projects. As green finance grows, bioenergy must attract investment to reach its full potential. The publication will present successful funding strategies, offering valuable insights for industry leaders and investors.

One of the most exciting aspects of bioenergy is its ability to empower rural communities. Bioenergy can drive rural development by providing decentralized energy solutions and creating jobs. Through case studies, the magazine will showcase how bioenergy projects transform local economies, creating a model for sustainable rural growth.

Ultimately, ***Bharat Bioenergy Horizon*** will offer more than just an overview of the sector; it will provide a roadmap for its growth. The magazine aims to foster collaboration, drive policy discourse, and highlight successful projects that can inspire further initiatives. It will empower industry stakeholders with the knowledge and tools to navigate the bioenergy landscape.

As India continues its push toward renewable energy, bioenergy will play a pivotal role. By addressing the sector's challenges through collaboration and information-sharing, ***Bharat Bioenergy Horizon*** will contribute to the growth of bioenergy in India, helping the country remain at the forefront of the global renewable energy movement.

I extend my heartfelt congratulations to the editorial team and contributors for bringing this vision to life. Your dedication will help make ***Bharat Bioenergy Horizon*** a trusted platform that shapes the future of bioenergy in India.

I invite all our members, partners, and readers to engage with this exciting new publication as we continue to advocate for a sustainable and energy-secure future for our country.

Together, let us unlock the full potential of bioenergy and create a greener, more sustainable India.

Message

Sanjay Ganjoo
Director General, IFGE

I am delighted to introduce ***Bharat Bioenergy Horizon***, a new initiative by the Indian Federation of Green Energy (IFGE), dedicated to highlighting the critical role of bioenergy in shaping a sustainable and energy-efficient future for India.

As the world accelerates its transition to cleaner, renewable energy sources, bioenergy stands at the forefront of this transformation. With its immense potential to enhance energy security while addressing environmental challenges, bioenergy offers a viable pathway toward a greener and more resilient energy ecosystem.

India has set ambitious bioenergy targets, including 20% ethanol blending by 2025/26, 5% biodiesel blending by 2030, 5% CBG blending by 2028/29, 7% biomass co-firing in coal plants by 2026, and 2% biojet blending for international flights by 2028.

The country's demand for biogases is projected to grow by 25% by 2030, with CBG leading the expansion. Currently, India consumes 180 million tonnes of bioenergy feedstocks annually, sourced from sugarcane, corn, and agricultural residues. By 2030, this demand is expected to rise by 50%, necessitating innovative collection methods—such as expanding used cooking oil and organic waste collection—to support biodiesel and biogas production.

Through ***Bharat Bioenergy Horizon***, IFGE aims to create a comprehensive platform for sharing knowledge, innovations, and best practices within the bioenergy sector. This magazine will serve as a valuable resource for industry experts, policymakers, researchers, and investors, offering insights into the latest advancements, technologies, and trends shaping the field. We believe this initiative will foster collaboration, attract investment, and accelerate the adoption of bioenergy solutions across India.

At IFGE, we remain committed to driving the growth of green energy and sustainability across all sectors. We are confident that ***Bharat Bioenergy Horizon*** will play a key role in raising awareness, promoting research, and stimulating investment in bioenergy. With each edition, we aspire to inspire government agencies, businesses, academia, and the public to take proactive steps toward a cleaner and more sustainable energy future.

I extend my heartfelt appreciation to the editorial team and all the contributors for their dedication and hard work in bringing this vision to life. We look forward to your continued support as we embark on this exciting journey together.

Message

Dilip Patil
Chairperson Editorial Advisory Board, Co-Chairperson IFGE: SBF, MD, KATS SSK Ltd

Respected Readers,

It is indeed a matter of great pride and privilege to present before you the inaugural issue of '***Bharat Bioenergy Horizon***,' the official magazine of the Indian Federation of Green Energy (IFGE). At this crucial juncture, when our nation is making remarkable strides in environmental sustainability and energy security, this publication comes forth as a vital platform for dialogue, innovation, and knowledge-sharing in our country's flourishing green energy sector.

The launching of ***Bharat Bioenergy Horizon*** stands testament to our steadfast commitment towards promoting a thorough understanding of sustainable energy solutions, with special emphasis on bioenergy and its transformative potential. Being the Co-chair person of IFGE's sugar and energy forum, I have been fortunate to witness the phenomenal progress our nation has achieved in harnessing renewable energy sources, particularly in integrating our robust sugar industry with clean energy production.

This magazine is envisioned not merely as a compilation of articles but as a knowledge bridge connecting researchers, industry experts, policymakers, and enthusiasts in the green energy ecosystem. Through meticulously curated research papers, enlightening interviews, and comprehensive news coverage, ***Bharat Bioenergy Horizon*** shall showcase the latest developments, technological breakthroughs, and policy initiatives shaping our nation's sustainable energy landscape.

In the forthcoming issues, our esteemed readers can look forward to expert analysis of emerging trends, success stories from the field, and detailed insights into innovative solutions that are steering India towards its renewable energy goals. We firmly believe that knowledge-sharing and exchange of experiences are of paramount importance for accelerating the adoption of green energy technologies and creating a more sustainable future for our coming generations.

I wish to express my sincere gratitude to the IFGE leadership, our valued contributing authors, and the dedicated editorial team for their unstinted support in bringing this vision to fruition. As we commence this meaningful journey, I cordially invite our readers to actively engage with the content, share their valuable perspectives, and contribute to the ongoing dialogue about India's green energy future.

Your precious feedback and kind suggestions will be instrumental in shaping ***Bharat Bioenergy Horizon*** as a premier publication in the renewable energy sector.

With warm regards.

Message

Pralhad Joshi
Hon'ble Minister MNRE

प्रल्हाद जोशी
PRALHAD JOSHI
ಪ್ರಲ್ಹಾದ ಜೋಶಿ

सत्यमेव जयते

उपभोक्ता मामले, खाद्य और सार्वजनिक वितरण तथा
नवीन और नवीकरणीय ऊर्जा मंत्री
भारत सरकार
MINISTER OF CONSUMER AFFAIRS
FOOD & PUBLIC DISTRIBUTION AND
MINISTER OF NEW & RENEWABLE ENERGY
GOVERNMENT OF INDIA

Message

I congratulate the Indian Federation of Green Energy on the launch of the inaugural edition of magazine titled India Bioenergy Watch. This magazine, dedicated exclusively to the bioenergy sector, comes at a critical juncture as India continues its relentless journey towards sustainable energy solutions and a cleaner, greener future.

As a nation, we have set ambitious goals to reduce our carbon footprint, promote renewable energy, and achieve energy security. The bioenergy sector plays a vital role in this mission by joining the power of organic materials and transforming them into sustainable energy sources.

I am counting on the India Bioenergy Watch to serve as an important platform for sharing insights, innovations, and best practices, while keeping industry professionals, policymakers, and the general public informed about the latest trends and developments in bioenergy. I wish India Bioenergy Watch great success.

Warm regards

(Pralhad Joshi)

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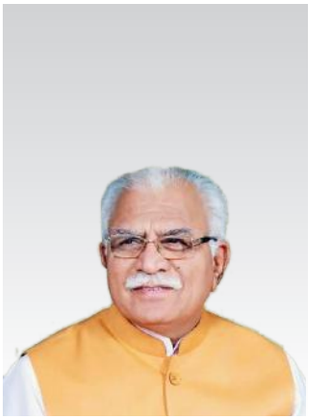
*Previously titled India Bioenergy Watch, the magazine has now been renamed Bharat Bioenergy Horizon.

Message



Manohar Lal Khattar
Hon'bl Minister of Power
& Minister of Housing &
Urban Affairs

मनोहर लाल
MANOHAR LAL

सत्यमेव जयते

विद्युत मंत्री एवं
आवासन और शहरी कार्य मंत्री
भारत सरकार
Minister of Power and
Minister of Housing and Urban Affairs
Government of India

MESSAGE

It is with great pleasure that I extend my heartfelt greetings to IFGE for publishing *India Bioenergy Watch*.

As India continues its journey towards a sustainable energy future, bioenergy plays a pivotal role in enhancing energy security, promoting rural development, and combating climate change. Our government has launched several initiatives to promote the production and utilization of bioenergy, particularly through the generation of energy from agricultural and industrial waste. In my capacity I am committed to ensuring that renewable energy solutions, including bioenergy, are at the forefront of our energy transition strategy.

India Bioenergy Watch provides an important platform to highlight the latest trends, policies, and innovations in the bioenergy sector. It plays a crucial role in facilitating discussions and knowledge-sharing to accelerate the adoption of clean, renewable energy sources across the country. The magazine's efforts to connect policymakers, industry leaders, and experts are commendable, and I am confident that it will continue to inspire positive action toward realizing India's renewable energy goals.

I wish *India Bioenergy Watch* continued success in its mission to advance bioenergy awareness and its contributions to India's energy transition.

(Manohar Lal)

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Talk Time

Nitin Jairam Gadkari
Hon'ble Minister (RT&H)

In your view, how can consumer behaviour be influenced to embrace biofuels, especially in sectors like transportation where adoption has been slow?

As we push for greater adoption of biofuels, especially in transportation, influencing consumer behavior is key. Here's how we can make the shift smoother and more appealing:

- People will embrace biofuels faster if they see cost savings. By reducing taxes on flex-fuel vehicles and ensuring ethanol-blended fuels are priced competitively, we can encourage wider use.
- Many consumers still don't know the benefits of biofuels. A strong awareness campaign highlighting cost savings, reduced pollution, and energy security can make a big difference.
- We are collaborating with OEMs to bring more flex-fuel and ethanol-compatible vehicles to the market. The more options available, the easier the transition will be.
- We have also issued advisories to State Governments to give concessions in Motor Vehicle Tax to incentivize the consumer
- More biofuel pumps mean better accessibility. We are working towards increasing the number of ethanol-dispensing stations nationwide. IOCL has set up 400 ethanol pumps across 4 states, Tamil Nadu, Karnataka, Maharashtra, Uttar Pradesh.

What steps is the government taking to prepare the automobile sector for a transition to biofuels, and how do you see this shift impacting both industry growth and environmental sustainability?

- In an attempt to ensure the feasibility of E-100 fuel, IOCL has set up 100 dispensing stations to dispense 100% ethanol across four states.
- E20 has been officially notified as a mono-fuel. Additionally, the government has notified mass emission standards for Flex Fuel Vehicles, covering multiple ethanol blends such as E10, E12/15, and E20.
- To push the demand for flex-fuel vehicles, an advisory has been issued to all State and UT Governments, recommending exemption or reduction of motor vehicle tax on flex fuel vehicles.
- Also, ethanol fuel vehicles

carrying passengers or goods have been exempted from the requirement of a permit.

- Talking about the impact of this transition, in addition to ensuring energy security by reducing imports by more than Rs. 2 lakh crore annually, bio-energy is expected to contribute 10 lakh jobs.
- Already 12 OEMs have developed flex-fuel vehicles.
- At the Bharat Mobility Expo 2025, a significant shift towards alternate fuel-based vehicles was observed.
- OEMs like Hyundai, Mahindra, Tata, and Suzuki have introduced flex-fuel, electric, and CNG passenger vehicles.
- Two-wheeler manufacturers like TVS, Bajaj, and Honda have launched flex-fuel and electric variants of motorcycles and scooters.
- Biofuel adoption will reduce fossil fuel consumption by 50% in the next five years and significantly reduce greenhouse gas emissions.
- In addition to the growth of the automobile industry, this transition will significantly contribute to rural development. It will result in a 6-8% agricultural growth, converting the farmer from being Annadata to Urjadata.

You have been great proponent of flex fuel in India. While the adoption of flex fuel engines holds great promise for reducing emissions and enhancing energy security, there are concerns about the readiness of automobile industry and availability of ethanol dispensing stations.

What is the plan of your Ministry to address these concerns?

- India has surpassed 18% ethanol blending with petrol (~700 crore litres) and is on track to achieve the 20% target soon.
- IOCL Panipat has developed technology to convert rice straw into ethanol, successfully producing:
  - 1 lakh litres of ethanol
  - 150 tonnes of bio-bitumen
  - 88 thousand tonnes of bio-aviation fuel
- The ethanol dispensing stations are currently selling E-100 at Rs. 100 per litre while it should be close to Rs. 65 per litre.
- I recently met with the Minister of Petroleum and Natural Gas, Shri Hardeep Singh Puri to discuss the issues related to the adoption of ethanol.

The transport sector is the largest consumer of diesel in India, and while the government has introduced several initiatives to replace diesel with greener alternatives, significant progress has yet to be made. What do you consider to be the key challenges in this transition, and how do you envision the future of this sector in terms of adopting sustainable fuels?

- The availability and affordability of alternative fuels like ethanol, CNG, LNG, hydrogen, and electric mobility are still evolving. Expanding production, refining distribution networks, and ensuring competitive pricing are crucial and the government is working steadily to strengthen each of these pillars. We are working on scaling up ethanol pumps, EV charging stations, and LNG corridors across highways.
- The initial cost of alternative fuel vehicles is higher than traditional diesel vehicles, making adoption slower. Financial incentives, tax breaks, and low-interest financing can encourage faster uptake. We have already exempted ethanol fuel vehicles carrying passengers or goods from the requirement of a permit.
- OEMs need to accelerate R&D and production of heavy-duty trucks, buses, and commercial vehicles running on alternative fuels. The government is actively engaging with manufacturers to push for faster innovation. I recently launched 3 hydrogen trucks manufactured by Tata Motors. I have been told that 34 more hydrogen trucks and trailers manufactured by different OEMs are in the pipeline. Additionally, 9 hydrogen dispensing stations will also be set up under the project.

Looking ahead, the future of India's transport sector is green and sustainable. With strong policy interventions, infrastructure expansion, and industry collaboration, we will transition towards ethanol, LNG, hydrogen, and electric mobility, reducing diesel dependency and creating a cleaner, more energy-secure India.

Could you outline the journey of E20 fuel adoption in India, including key milestones and current initiatives, and what do you foresee as the future of E20 in our energy landscape, particularly concerning the challenges the sector faces today?

The journey of E20 fuel adoption in India has been a significant step toward cleaner and more sustainable mobility.

- Initially, we set a target of achieving 20% ethanol blending by 2030, but with our determined efforts, we advanced this goal to 2025.
- In 2021, we released the E20 roadmap, which laid out a structured plan for phased implementation, vehicle compatibility, and infrastructure expansion.
- The first rollout of E20 fuel began in select cities in 2023, marking a major step in making it accessible to consumers.
- Today, we have already crossed 18% ethanol blending, which translates to approximately 700 crore litres, bringing us very close to our target.
- Auto manufacturers have stepped up and are now producing E20-compatible vehicles, and we have officially notified E20 as a mono-fuel.
- To encourage wider adoption, we have advised states and UTs to reduce motor vehicle tax on flex-fuel vehicles, making them more affordable for consumers.

Though, some challenges have been identified:

- We need to ensure sufficient ethanol production to meet demand while maintaining food security.
- Fuel stations across the country must be upgraded to make E20 widely available.
- OEMs and consumers must be encouraged to transition to E20-compatible vehicles at a faster pace.
- Awareness must be built regarding vehicle performance and long-term benefits of ethanol-blended fuels.

With strong policy support, increased investment in ethanol production, and collaboration with the automotive industry, I am confident that E20 will become a mainstream fuel in India, driving us toward a cleaner, greener, and more energy-secure future.

The role of farmers is changing from Annadata to Urjadata, Indhandata and finally Hydrogendata. You have been an inspiring figure in this entire progress. Slowly farmers are becoming the backbone of Bioenergy sector. What is your vision for rural India economy, and how do you see it integrating with the country's broader economic goals, particularly in terms of sustainability, job creation, and enhancing rural livelihoods?

Our farmers are no longer just Annadata; they are now becoming Urjadata, Indhandata, and even Hydrogendata. This is a huge shift, and I truly believe that farmers are now at the heart of India's bioenergy revolution.

- By producing biofuels, they are securing India's energy future while also increasing their own incomes.
- In the last decade, our ethanol blending program has had a tremendous impact. We have saved ₹99,000 crore in foreign exchange, reduced crude oil imports by 173 lakh tonnes, cut carbon emissions by 519 lakh tonnes and most importantly, farmers have earned an additional ₹87,000 crore from ethanol production.
- Biofuels are being produced from agricultural and bio-feedstock, giving new life to farm residues and ensuring that nothing goes to waste.
- Ethanol blending has also given farmers better prices for their crops. Just look at corn—earlier, it was selling at ₹1,200 per quintal, but thanks to ethanol demand, the price has now increased to ₹2,800 per quintal.

At the core of Viksit Bharat is the empowerment of our farmers, and this shift to bioenergy is a major step toward the Hon'ble Prime Minister's

vision of Atmanirbhar Bharat. As we work towards becoming the third-largest economy and achieving our $5 trillion target, rural India will play a crucial role in shaping a self-reliant, sustainable, and prosperous nation.

Our farmers are no longer just growing food; they are fueling the future of India!

Electric Vehicles production and use is increasing at a faster pace than Biofuel based Vehicles. Do you think the growth of EV will not slow down the pace of Biofuel Vehicles. Can both the types of vehicles co-exist?

Absolutely! The growth of Electric Vehicles will not slow down the pace of biofuel-based vehicles. In fact, both technologies can coexist and complement each other in India's journey towards a cleaner and more sustainable future. Both technologies have no conflict of interest.

- India is a vast and diverse country with multiple transportation needs. EVs are ideal for urban mobility, while biofuels are a great solution for long-haul transport, heavy-duty vehicles, and rural areas where charging infrastructure may take longer to develop.
- Flex-fuel and ethanol-powered vehicles are already making a significant impact, reducing fossil fuel dependency and creating new income opportunities for farmers.
- The government is promoting both EVs and biofuels, ensuring that consumers have multiple green alternatives to choose from.
- Biofuels play a crucial role in reducing carbon emissions while utilizing our agricultural resources efficiently. At the same time, EVs help in reducing pollution in cities and are key to achieving net-zero goals.
- Many countries are exploring a multi-fuel approach, and India is leading the way by supporting a balanced mix of EVs, ethanol, compressed biogas (CBG), LNG, hydrogen, and hybrid technologies.
- Our focus is on creating a technology-neutral ecosystem where all sustainable mobility solutions thrive together.

So, rather than competing, EVs and biofuel-based vehicles will grow together, each playing a crucial role in different sectors. The ultimate goal is the same—to make India a global leader in green mobility and energy security.

What is the future of fossil fuel based transport segment as per your assessment?

The future of fossil fuel-based transport is changing fast, and I see its

role gradually declining as we transition to greener alternatives. This shift won't happen overnight, but it will be systematic and well-planned to ensure energy security and economic stability.

Alternative fuels like ethanol, bio-CNG, LNG, and green hydrogen are gaining momentum. Ethanol blending has already reached 18% and will soon hit 20%, directly cutting petrol consumption. Similarly, biofuels and hydrogen-based solutions will help reduce diesel dependency, especially in commercial transport.

Heavy vehicles and long-haul transport may take longer to shift, but we are actively promoting LNG and hydrogen as viable alternatives. At the same time, EV adoption is picking up speed, particularly in cities.

Globally, countries are moving away from fossil fuels, and India is aligning with this transition while ensuring that industries and vehicle manufacturers adapt smoothly. The goal is to create a diverse, and sustainable transport ecosystem.

Fossil fuels won't disappear immediately, but their role will keep shrinking. The future of mobility in India is clean, green, and self-reliant.

You have been a great advocate for Bioenergy in India. Are you satisfied with the current status and growth in this sector so far and where do you see the areas of further improvement?

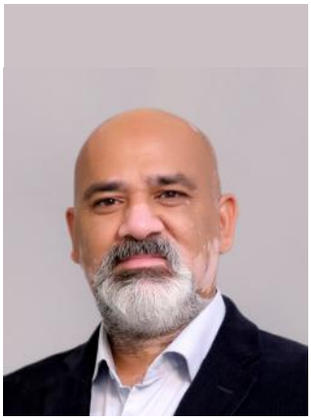
I'm very encouraged by the progress we've made in bioenergy, but there's still a lot more we can do. Ethanol blending, bio-CNG, and green hydrogen are changing the game, reducing our fuel imports and giving farmers new income opportunities.

One big area for improvement is ethanol blending with diesel. While we've reached 13% blending in petrol, diesel consumption is much higher, so the impact could be even greater. ARAI has recommended 7% ethanol blending for heavy commercial vehicles, and it's time for OMCs to push this forward. This will significantly cut imports and reduce costs.

Another key focus is Bio-CNG, which has huge potential but still lacks widespread adoption. It can be a great alternative for public transport, logistics, and agriculture, but we need to scale up production, infrastructure, and awareness to make it a mainstream fuel.

We're on the right track, but by accelerating these initiatives, we can build a cleaner, self-reliant, and more energy-secure India.

Sectoral views
Compressed Biogas



Ashish Kumar
Co-Chairperson, IFGE: CBG Producer Forum (CBGPF)
& Managing Director
– Verbio India.

CBG sector in India kicked off with the launch of SATAT initiative in October 2018 as previously, biogas programs lacked an environmental focus with an industrial scale economic orientation. However, the glorious start of SATAT with the ambitious target of setting up 5,000 CBG plants was completely clouded by mere LoI signing on behalf of oil marketing companies and little progress in terms of capacity build-up was made during 2018 to 2022.

The first industrial-scale plants started getting setup since 2021, based on different waste streams such as press mud and animal waste by Indian Oil and Nirani group, followed by the Agri-residue project by Verbio (German biofuel producer) wherein for the first time a technological solution was demonstrated to solve the problem of stubble burning in Punjab. In addition, the largest MSW project was set up by EverEnviro in Indore These plants marked the true beginning of large-scale CBG production in India and they continue to be the largest in their respective domains of implementing the concept of *Waste to Bio-Energy*.

While policy interventions have encouraged the CBG investment case since 2022 but the very fact that we do not have even 100 optimally functional capacities, reflects that significant policy gaps still persist across the multiple relevant Ministries, highlighting that the CBG investment case is still not a viable one specifically for Agri-residue and MSW based projects.

Objective is not to be overly critical but to state facts and there is no doubt that extremely progressive policies have been introduced such as by MoA&FW (CRM scheme) and MoPNG (BAM scheme) to viably manage the crop residue feedstock, MoA&FW incorporated and amended the FCO for inclusion of Fermented Organic Manure (FOM & LFOM) and DoF introduced the Market Development Assistance (MDA) for monetization of FOM. And then we have had policies which couldn't get effectively

implemented, in addition to still a long list of policies which are required for making a viable investment case for CBG and a brief is as follow:

- CBG pricing revision, establishing CBG offtake via Grid connectivity and having detailed guidelines for implementation of CBG blending obligations (CBO) to be introduced from FY 25-26, provision of injecting CBG into trunk pipeline by MoPNG
- Amend FCO specifications for acceptance of FOM/LFOM as a source for improving soil health by MoA&FW and still being eligible for MDA
- MDA revision for FOM/LFOM so as to become production linked, with regular monthly revenue streams, an upward revision of MDA amount and introduction of subsidies for advanced derivatives of FOM such as PROM from DoF
- Disbursal of CFA for eligible capacities and amend the existing Waste to Energy program by MNRE
- Rationalization of GST to avoid accumulation of input tax credit during capacity build-up stage and operational stage as well, to be implemented by MoF
- Monetization provision of Green Attributes for fulfilment of CBO in domestic market and more importantly open up exports for Green Attributes in compliance to article 6.2 of Paris agreement allowing countries to cooperate on emissions reductions by transferring "Internationally Transferred Mitigation Outcomes" (ITMOs) through bilateral agreements, aiming to achieve Nationally Determined Contributions (NDCs) more effectively

This long wish list summarizes the existing factors responsible for the unviability of the investment case for CBG and its clear that despite a lot of scattered support from the Government of India, there is an evident lag between intent and implementation because its just not possible that if the Indian Government truly wishes to support a sector that such sector continues to struggle even after 6 years of launch of SATAT. To overcome these roadblocks, we can opt for either of the following 2 approaches:

- Consolidate all schemes/benefits offered by all Ministries under single CBG Price and make MoPNG the nodal Ministry for all aspects of the CBG value chain with clear review mechanisms and aligned with global monetary practices for adoption of Renewable Natural Gas
- Continue with the multiple stakeholder approach but with a clearly defined coordination mechanism to monitor effective policy implementation and accomplish the following:
  - o Increase existing provisions for CBG pricing (along with floor price) and MDA for improved monetization of FOM/LFOM
  - o Introduce appropriate revenue streams for waste management specifically for Agri-residue and MSW feedstocks
  - o Implement blending obligations for CBG and introduce obligations for FOM/LFOM with financial instruments/certificates having a market based pricing framework and clarity on penalties for obligated entities
  - o Strengthen financial assistance for CBG capacity build-up (CFA) and for feedstock aggregation (CRM and BAM)
  - o GST rationalization for build-up and operational phases
  - o Provision for exports of Green Attributes to countries with bilateral agreements

This might seem complex and voluminous but with the continued and committed policy development efforts from Government of India over last 2-3 years, gradual technological advancements, improving feedstock accessibility and commercial conditions, CBG investment case has improved and is getting prepared to emerge as a vital pillar of India's green economy, enhancing energy security while promoting sustainable development.

Sectoral views - Biomass

Subodh Kumar
National Advisor IFGE,
Chairperson IFGE:BGAF,
ED-Valpro, & Former ED, IOCL

The biomass briquette and pellet industry is becoming a key pillar in India's bioenergy sector, offering a sustainable alternative to traditional fossil fuels. Made from agricultural residues, forestry by-products, and organic waste, biomass briquettes and pellets help reduce dependence on coal and address environmental concerns like carbon emissions. We must treat biomass as a valuable resource, not waste.

The global biomass market is growing rapidly, and India's market is projected to reach Rs 32,000 crore by FY31, driven by government initiatives and rising investments in green energy. Key policies like the National Bioenergy Programme (NBP) and the Revised Biomass Policy, which mandates biomass co-firing in thermal power plants, are strengthening the sector. The RBI's approval of biomass pellet manufacturing under Priority Sector Lending (PSL) and financial assistance schemes from MNRE and CPCB are also supporting growth.

Technological advancements, including gasification, pyrolysis, and biochemical conversion, are expanding biomass applications. With continued government support and innovation, biomass will play a crucial role in India's renewable energy future.

Col. Rohit Dev
Co-Chairperson, IFGE: BGAF

Bioenergy will play a crucial role in India's 'Just Energy Transition' as we move towards #NetZero2070, offering collective benefits from farm to factory to furnace. It will harness the potential of India's agrarian economy, enhance energy security, and foster economic growth, in line with the vision of the Hon'ble Prime Minister's 'Ann Daata se Urja Daata'.

Densification of biomass within the bioenergy sector supports the entire value chain, driving decentralized energy solutions, circular economy models, and socio-economic impact while adhering to sustainable development goals. Biomass densification is key for industries needing heating, steam, and power solutions, facilitating the shift from fossil fuels to renewable biomass. By 2030, the transition in boiler-based industries will accelerate, supported by refined bioenergy policies and international collaborations to ensure energy security and sustainable growth.

Sectoral views
Bamboo

Anil Mutha
Chairperson, BDF
Director, Mutha Industries Private Limited.

A Promising Bioenergy Resource for India's Green Future

As India embarks on its journey toward a sustainable energy future, the role of bioenergy has become increasingly significant. Among various biomass sources, bamboo stands out as a promising and highly efficient feedstock for bioenergy production. With its rapid growth, high biomass yield, and ability to thrive in diverse climatic conditions, bamboo can play a pivotal role in India's transition to greener, cleaner energy solutions.

Bamboo as an Ideal Biomass Source

Bamboo, often referred to as the 'green gold,' is one of the fastest-growing plants on Earth. Some species can grow up to 1.5 meters per day, making it an ideal biomass resource. Unlike traditional timber, which takes decades to mature, bamboo can be harvested in just three to five years, ensuring a continuous and sustainable supply. Additionally, bamboo has a high calorific value, making it an excellent feedstock for bioenergy applications, including biomass power generation, bioethanol production, and biogas generation.

Bamboo-Based Bioenergy Applications

Bamboo can be utilized in multiple bioenergy forms, including:

Bamboo Biomass for Power Generation: Bamboo can be directly combusted or converted into pellets for use in biomass power plants. Its low moisture content and high energy density make it an efficient fuel source.

Bamboo Charcoal and Briquettes: Bamboo charcoal is a superior alternative to conventional wood charcoal due to its high carbon content and lower emissions. Bamboo briquettes offer a sustainable solution for cooking and heating, reducing dependency on traditional firewood and mitigating deforestation.

Bioethanol Production: Bamboo can be processed into bioethanol, a clean-burning fuel that can be blended with petrol to reduce carbon emissions in the transportation sector. Bamboo's high cellulose content makes it a viable feedstock for second-generation bioethanol production.

Biogas Production: Bamboo residues can be anaerobically digested to produce biogas, which can be used for electricity generation and as a cooking fuel. This presents an excellent opportunity for rural energy security and waste management.

Environmental and Economic Benefits of Bamboo Bioenergy

Carbon Sequestration and Climate Change Mitigation: Bamboo is highly effective in capturing and storing carbon dioxide. Its extensive root system helps stabilize soil, prevent erosion, and improve land productivity. By replacing fossil fuels with bamboo-based bioenergy, India can significantly reduce greenhouse gas emissions and combat climate change.

Sustainable Livelihoods and Rural Development: The cultivation and utilization of bamboo for bioenergy can generate employment opportunities, particularly in rural and tribal areas. The bamboo industry has the potential to create jobs across the entire value chain, from farming and processing to energy production and distribution.

Energy Security and Reduced Dependence on Imports: With India heavily dependent on fossil fuel imports, bamboo-based bioenergy offers a domestic and renewable alternative. By investing in bamboo bioenergy, the country can enhance its energy security and reduce its reliance on volatile global energy markets.

Restoration of Degraded Land: Bamboo can grow in degraded and marginal lands where conventional crops may not thrive. Large-scale bamboo plantations can restore soil fertility, promote biodiversity, and prevent desertification.

Policy intervention by Government of India

Here, it is worth mentioning that The Addendum dated May 3, 2023, to the Revised Policy for Biomass Utilization for Power Generation through Co-firing in Coal-Based Power Plants (issued on October 8, 2021) by the Ministry of Power, Government of India, specifies that biomass pellets used for co-firing in thermal power plants (TPPs) can be produced from bamboo and its by-products, such as bamboo chips, cuttings, bamboo dust, as well as other agricultural residues.

The inclusion of bamboo and its by-products in biomass pellets for co-firing in thermal power plants (TPPs) under the Revised Policy for Biomass Utilization is expected to have a significant impact on bamboo plantations in India.

Challenges and the Way Forward

Despite its immense potential, several challenges need to be addressed to scale up bamboo-based bioenergy in India:

- **Lack of Awareness**: Greater awareness and policy incentives are required to encourage farmers and industries to invest in bamboo-based bioenergy.
- **Efficient Processing Technologies**: Research and development efforts should focus on improving bamboo processing technologies to enhance energy conversion efficiency and reduce costs.
- **Supply Chain and Infrastructure Development**: A well-developed supply chain, including efficient harvesting, transportation, and storage mechanisms, is crucial for the success of bamboo-based bioenergy initiatives.

Conclusion

Bamboo presents a transformative opportunity for India's bioenergy sector, aligning with the nation's goals of sustainability, energy security, and rural development. By leveraging its potential through supportive policies, research advancements, and strategic investments, India can position bamboo as a key driver of its green energy transition. As the country moves toward a cleaner and more resilient energy future, bamboo bioenergy can serve as a cornerstone in achieving environmental and economic sustainability.

Sectoral views
Bamboo

BB Singh
Co-Chairperson IFGE:BDF,
Former CEO PCCF, Govt. of MP

Bamboo as an Alternative Source of Green Energy

India's energy demand grows at 4.5% annually, with 80% of fossil fuel needs met through imports, posing economic and geopolitical challenges. Biomass and solar are the most viable clean energy sources.

Bamboo, with high chlorophyll content and rapid biomass generation, efficiently captures and stores solar energy as solid biomass, which can be converted into thermal, chemical, or electrical energy using local technologies.

For comparison, sugarcane yields 70–80 metric tons per hectare per year and plays a key role in India's bioethanol production. With a 20% ethanol blending target, India needs 300 million barrels annually, but current production meets only half of its demand, relying on water-intensive crops like sugarcane, maize, and barley. Bamboo, however, thrives in semi-moist to dry conditions with minimal input, making it a superior long-term solution.

Bamboo biomass can also produce methane gas via enzymatic reactions using cow dung bacteria. A 1:10 ratio of bamboo chips to water generates 10–12 kg of methane per quintal of biomass, producing CNG alongside dry bamboo waste. Establishing village-based CNG units can create a bamboo-driven industry, boosting farmers' incomes while reducing fuel imports and strengthening energy security.

Sectoral views
CCUS

India's CCUS Opportunity—Fuelling Sustainable Growth in Key Hard-to-Abate Sectors

Keshav Goela
Director, GAS LAB Asia &
Co-Chair IFGE : CCUS

India's net-zero ambition hinges on decarbonizing hard-to-abate sectors like cement, steel, power, and oil & gas. Carbon Capture, Utilization, and Storage (CCUS) is a pivotal solution—capturing CO_2 in real-time for storage or reuse in industries such as cement (low-carbon materials), refineries (enhanced oil recovery), and power plants (retrofitting aging assets).

Policy momentum, including NITI Aayog's CCUS Framework, highlights the need for fiscal incentives like tax credits, carbon pricing, and subsidies to offset high capital costs. Global models such as the U.S. 45Q tax credit and Norway's Northern Lights Project showcase the role of regulatory clarity, financing mechanisms, and shared infrastructure in scaling CCUS. Success in India will require synergy between policy, private-sector innovation, and state-level initiatives. The CCUS Forum at IFGE plays a key role in aligning stakeholders—advancing R&D, financing, and regulations to drive industrial adoption. With coordinated action, CCUS can balance economic growth with climate goals, making India a global leader in decarbonization.

Sectoral views

Grain-Based Ethanol

Grain-Based Ethanol: Strengthening India's Bio-Energy Ecosystem

Naresh Goel
Chairperson, IFGE: GEDA,
Director, Pingaksh Beverages Pvt. Ltd.

India's ethanol sector is a key pillar of the nation's energy transition, propelled by government support under the Ethanol Blended Petrol (EBP) program. Among various feedstocks, grain-based ethanol has emerged as a dominant force, utilizing surplus food grains like maize and broken rice to enhance energy security, reduce carbon emissions, and boost rural incomes.

The rise of Flex Fuel Vehicles (FFVs) will drive ethanol demand as automakers adopt E85-compatible technologies. Simultaneously, Sustainable Aviation Fuel (SAF) is gaining traction, with ethanol playing a vital role in reducing aviation emissions. This growing demand across transportation and aviation strengthens ethanol's strategic significance.

By leveraging surplus grains, grain-based ethanol ensures a stable domestic supply while supporting farmers and mitigating crude oil imports. It contributes significantly to India's energy independence and climate goals, reinforcing its role in the renewable energy ecosystem.

With strong policy backing, technological advancements, and industry participation, grain-based ethanol is set to play a crucial role in India's bio-energy landscape. As demand rises, sustained investment and infrastructure expansion will be key to unlocking its full potential, ensuring long-term growth and resilience in India's renewable energy sector.

Sectoral views
Sugar-Based Ethanol

Ravi Gupta
Chairperson, IFGE: SBF
Executive Director, Shree Renuka Sugars

India's Ethanol Blending Program: A Model for Sustainable Energy and Economic Growth

India's ethanol blending program has transformed the country's energy landscape, enhancing energy security, increasing farmer incomes, and reducing carbon emissions. Once considered an impossible dream, the initiative has propelled India from negligible ethanol blending in 2013-14 to an expected 18% ethanol blending by 2025. This policy shift has saved ₹1,13,000 crore in foreign exchange, generated ₹88,000 crore in additional income for farmers, and reduced 55 million tonnes of CO_2 emissions over the past five years.

The success of this program lies in its innovative policy framework. The government adopted a unique pricing mechanism, linking ethanol prices to feedstock costs. Sugarcane ethanol prices were aligned with the Fair and Remunerative Price (FRP), rice ethanol with Food Corporation of India (FCI) issue prices, and corn ethanol with the Minimum Support Price (MSP). This strategy created price stability, encouraged investment, and incentivized farmers to contribute to ethanol production. To address capacity constraints, the government provided interest subvention for ethanol plants and mandated long-term purchase agreements with oil marketing companies, ensuring a stable market.

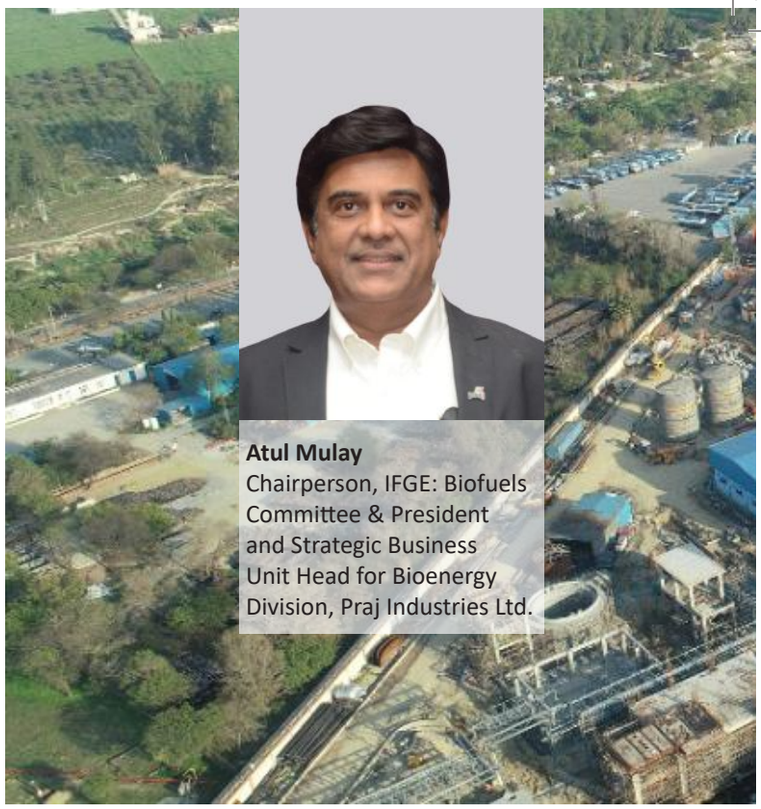
Thinking globally, acting locally, the country played a key role in launching the Global Biofuel Alliance, reinforcing its commitment to sustainable energy.

India has a few learnings from this great achievement. India's roadmap to ethanol blending unveiled in 2019 projected a demand of 1,016 crore liters of ethanol by 2025, to be met using 7.5 million tonnes of sugar and 15 million tonnes of grains. However, policy adjustments skewed production toward grain-based ethanol, leading to an unintended consequence—while India exported 1 million tonnes of sugar in 2025, it simultaneously may have to import 3 million tonnes of corn. Given that sugarcane ethanol is more energy-efficient and water-efficient than corn ethanol, a recalibration is necessary to ensure long-term sustainability.

The next challenge is looking beyond the 20% ethanol blending target. The logical progression is to increase blending to 25%, similar to Brazil, which already blends at 27%. A more transformative step would be the widespread adoption of flex-fuel vehicles (FFVs), which can run on both ethanol and gasoline. In Brazil, 95% of vehicles are flex-fuel, giving consumers the flexibility to switch fuels based on price and efficiency. India must take decisive steps to promote FFVs by rationalizing taxes—while electric vehicles benefit from a reduced GST of 5%, ethanol vehicles still face a 28% GST, a disparity that needs correction. Furthermore, expanding E100 fuel pumps beyond the current 400 will enable direct ethanol distribution at production sites, reducing transportation costs and carbon footprints.

India's ethanol blending program has been an undisputed success, proving that well-structured policies can simultaneously address economic, environmental, and energy challenges. However, the real test lies in what comes next. To maintain momentum, the country must refine its strategy, encourage flex-fuel technology, and prioritize sustainable ethanol sources. If history is any indication, India will continue to push boundaries, setting new global benchmarks in renewable energy and sustainability.

The Bioeconomy of India: Driving Sustainable Progress alongside Inclusive Growth



Atul Mulay
Chairperson, IFGE: Biofuels Committee & President and Strategic Business Unit Head for Bioenergy Division, Praj Industries Ltd.

India faces significant environmental and economic challenges due to its heavy reliance on fossil fuels. In 2023-24, the country imported 232.5 MMT of crude oil, costing ₹13,240 crore and contributing substantially to its 2.8 gigatonnes of GHG emissions. Reducing this dependency through biofuels, renewable energy, and efficiency measures are essential.

The bioeconomy has emerged as a crucial driver of sustainable growth. India's bioeconomy has grown from ₹1000 crore in 2014 to ₹15100 crore in 2023, with projections of ₹30,000 crore by 2030. Industrial biotechnology is gaining momentum through advancements in biofuels, biomass utilization, and biogas production.

Industrial Biotechnology: The Engine of India's Bioeconomy

A. Biofuels: Transforming Energy Landscapes

Bioethanol

Bioethanol, derived from biomass such as corn and sugarcane, is a renewable, high-octane fuel that improves engine efficiency and blends well with petrol. It reduces pollutants and particulate matter while significantly cutting GHG emissions.

The Ethanol Blended Petrol (EBP) Program launched by Government of India aims to increase the use of domestically generated bioethanol as transportation fuel along with Gasoline (Motor Spirit or Petrol) to reduce CO_2 emissions and fossil fuel imports.

In India, ethanol blending with petrol has significantly increased from 188.6 crore liters in 2018-19 to over 700 crore liters in 2023-24, with blending percentage reaching approximately 14.6% in ESY 2023-24. Over the past decade, the initiative has saved ₹1,06,072 crore in foreign exchange, reduced CO_2 emissions by 544 lakh metric tonnes, and replaced 181 lakh metric tonnes of crude oil. Additionally, the program has had a significant economic impact, with Oil Marketing Companies disbursing ₹1,45,930 crore to distillers and ₹87,558 crore to farmers. Looking ahead, India aims to blend 988 crore liters of ethanol in 2024-25 and 1016 crore liters in 2025-26, as outlined by NITI Aayog.

Compressed Biogas (CBG)

Compressed Biogas (CBG), derived from agricultural waste and industrial byproducts, serves as a sustainable substitute for diesel in transportation and an alternative to natural gas in industries. Under the Sustainable Alternative Towards Affordable Transportation (SATAT) policy, launched in 2018, India aims to establish 5,000 CBG plants by 2025, to produce 15 million metric tonnes (MMT) of biogas annually. By 2023, over 50 CBG plants were operational, with the sector projected to grow at a CAGR of 10.3% until 2030. Additionally, the Indian Government's Compressed Biogas Obligation (CBO) mandates the blending of CBG with natural gas in city gas distribution networks, with a target of developing 750 CBG projects by 2028-29, supported by an estimated investment of ₹37,500 crore.

Sustainable Aviation Fuel (SAF)

With aviation contributing 2-3% of global emissions, sustainable aviation fuel (SAF) is a crucial solution.

SAF has the potential to reduce emissions by up to 65%, requiring production of 350 million tons annually to achieve the International Civil Aviation Organization's (ICAO) net-zero targets by 2050. India, leveraging its abundant agricultural feedstocks, has the capacity to produce 19-24 million tons of SAF annually. Widespread adoption of SAF would not only lower emissions but also boost India's GDP by $2.8 billion, strengthen energy security, generate rural employment, and enhance waste management.

B. Socioeconomic and Environmental Benefits

India's bioeconomy plays a crucial role in fostering inclusive growth by generating employment, supporting rural development, and promoting sustainability. In 2023, the sector employed over 4 million people, with job creation projected to reach 35 million by 2030. Establishing biofuel facilities in rural areas strengthens local economies, curbs migration to urban centers, and enhances infrastructure development. Additionally, biofuels align with the UN Sustainable Development Goals (SDGs), contributing to clean energy, sustainable cities, and improved public health. The use of agricultural residues in biofuel production helps to reduce air pollution while providing farmers with an additional source of income. Furthermore, biofuels bolster energy security by minimizing dependence on imported fossil fuels, reinforcing India's commitment to a sustainable and self-reliant energy future.

C. Policy and Global Leadership

India's bioeconomy is driven by robust policies such as the National Policy on Biofuels and the BioE3 (Biotechnology for Economy, Environment & Employment) initiative, which support sustainable energy development. International collaborations through the Global Biofuel Alliance further reinforce India's leadership in this sector. Strategic partnerships with countries like Brazil and the U.S. accelerate innovation and enhance India's position in the global bioeconomy.

D. Building a Resilient Ecosystem

The bioeconomy's success depends on innovation, infrastructure, and skill development. Initiatives like investments in R&D, focus on academia-industry collaboration, and establishing bio manufacturing hubs will ensure a steady pipeline of scalable solutions.

Conclusion: A Sustainable Vision for the Future

India's bioeconomy offers a transformative path to sustainable growth, blending innovation, environmental responsibility, and socio-economic benefits. Advancements in biofuels, biogas, and SAF reduce carbon footprints, enhance energy security, and empower rural communities. With strong policies, global partnerships, investments in innovation, and fostering inclusivity, India is poised to lead the global bioeconomy.

References: Statistic figures/numbers: PBI, MoPNG, BIRAC

Decoding SATAT: India's Bioenergy Revolution

Subhodh Kumar
Chairperson, IFGE: Biomass Global Associates Forum (BGAF) & ED- Valpro, Former ED, IOCL.

India, home to 18% of the global population, relies heavily on carbon imports to meet its energy demands. In 2023-24 alone, the country imported 232.5 Million Metric Ton of crude oil, 48.1 MMT of LPG, 27 MMT of LNG, and 261 MMT of coal. However, much of this can be substituted with domestic biomass sources, including agricultural waste, animal waste, municipal solid waste (MSW), and energy crops.

As the world's fourth most attractive clean energy market, India derives 42% of its total installed capacity from renewables, including 10.94 GW from bioenergy. Biomass availability stands at 754 MMT annually, with 230 MMT available as surplus. Major biomass-producing states include Uttar Pradesh, Madhya Pradesh, Rajasthan, Punjab, Maharashtra, Tamil Nadu, Gujarat, and West Bengal.

To promote bioenergy, the MoPNG launched the Sustainable Alternative Towards Affordable Transportation (SATAT) initiative in 2018. The program aims to establish 5,000 Compressed Bio Gas (CBG) plants by 2024-25, targeting an annual production of 15 MMT. As of December 2024, 115 CBG plants have been commissioned, producing 22,097 tonnes of CBG in 2023-24.

To further boost demand, the government has introduced a phased CBG blending obligation in CNG (Transport) and PNG (Domestic) segments, starting with 1% in 2025-26 and increasing to 5% by 2028-29. Additionally, Ministry of Chemicals and Fertilizers recently announced a market development assistance of INR 1500/MT of sale of Fermented Organic Manure (FOM) / Liquid Fermented Organic Manure (LFOM) / Phosphate Rich Organic Manure (PROM) produced at biogas/CBG plants established under the GOBARdhan (Galvanizing Organic Bio Agro Resources dhan) initiative.

Several states, including Uttar Pradesh, Bihar, and Haryana, have independent bioenergy policies, while others like Maharashtra, Punjab, and Gujarat offer incentives and subsidies in this area. Private sector participation is growing, with companies such as Reliance Industries planning 100 CBG plants in five years, reducing CO_2 emissions by 2 million tonnes annually. Other players like Adani Total Gas, Thermax, and Ever Enviro are also investing, alongside Oil and Gas Marketing Companies such as Indian Oil, BPCL, HPCL, and GAIL.

CBG Production and Applications

A CBG plant operates by utilizing various feedstocks such as agricultural residue, press mud, organic municipal solid waste (MSW), and animal waste. These feedstocks undergo decomposition in an anaerobic digester, generating biogas composed of 55-65% methane, 35-45% carbon dioxide, 0-10% nitrogen, 0-1% hydrogen, and 0-3% hydrogen sulfide. The resulting biogas is then upgraded and compressed at 250 bar to produce CBG with a methane content exceeding 90%, in accordance with IS 16087 specifications set by Bureau of Indian Standard.

Plant locations must be strategically chosen based on feedstock proximity—within 50 km for agri-residue-based plants, near sugar mills for press mud-based plants, and in cities for MSW-based plants. Feedstock supply is secured through long-term contracts with aggregators and farmers. Efficient MSW segregation, as seen in Indore, simplifies organic waste processing, enhancing plant efficiency.

CBG plants utilize various anaerobic digesters, with Continuous Stirred Tank Reactors (CSTR) and Plug Flow reactors being the most common. Biogas upgrading technologies include scrubbing, pressure swing adsorption, membrane separation, and cryogenic techniques. The process also yields bio-manure, enriched with Phosphate Rich Organic Manure (PROM), which is sold to farmers at INR 3-9/kg.

CBG Market and Financial Viability

CBG is procured by Oil Marketing Companies (OMCs) at INR 56-78/kg under SATAT pricing. It is also supplied to City Gas Distribution (CGD) companies under CBG-CGD synchronization, facilitated by GAIL. Additional incentives include INR 2/kg for pipeline compression and INR 8/kg for cascade compression. Some producers also establish private retail outlets to sell CBG at higher prices.

Economic viability depends on diverse revenue streams, including CBG sales, bio-manure, and industrial CO_2 utilization for greenhouse farming and dry ice production. Carbon credits further enhance profitability, with each credit valued between USD 5-15. Methane capture contributes to emissions reduction, with Green Energy Certificates (GEC) under proposal by the Indian Gas Exchange, potentially adding another revenue stream.

Environmental and Social Impact

CBG plants align with environmental and social sustainability goals. Required regulatory approvals include pollution control board clearances, fire safety permits, and industry licenses. Till August 2022, the bioenergy sector has generated 0.43 million direct and 0.66 million indirect jobs, with 0.25 million positions occupied by women.

Farmers in North India traditionally burn crop residues, degrading soil and polluting the air. By supplying feedstock to CBG plants, they gain economic benefits, earning INR 1,000-3,500 per tonne. Haryana offers INR 1,000 per acre as an incentive to prevent stubble burning, along with 50% subsidies on crop residue management equipment.

Future Prospects and Challenges

With strong government backing and growing private sector interest, India's CBG industry is expanding rapidly. However, challenges such as feedstock availability, financing, and infrastructure gaps remain significant obstacles. Solutions include ensuring guaranteed offtake, providing competitive financing, and classifying CBG projects under priority sector lending.

Public-Private Partnerships (PPP) can accelerate investments and risk mitigation. Additionally, biogas projects offer unique environmental and social benefits, making them more sustainable than other renewable energy sources. By reducing fossil fuel dependence, CBG supports India's clean energy transition and net-zero targets, positioning it as a critical player in the global bioenergy sector.

India's Transition from Biogas to Compressed Biogas (CBG) market : A Journey from the Past to the future

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Indian Institute of Technology Delhi

Prof (Retd) Deepak Sharma
CTAE, MPUAT Udaipur (Raj)

India, with over 1.4 billion people and a cattle population of nearly 300 million, has vast organic resources for biogas production. This can benefit both rural and urban populations. As per livestock census of 1981-82, India has the potential for 12 million small family-type biogas plants. As of March 2024, approximately 5.1 million such plants have been installed, making India the second-largest adopter of biogas technology worldwide. Cattle farms, dairies, and industries like distilleries and food processing offer large- scale biogas production opportunities, as do sewage treatment plants and landfills in urban areas for Compressed Biogas (CBG) production. India has the potential to generate 6.38x1010 cubic meters of biogas annually from 980 million tons of cattle dung, equivalent to 36 million tonnes of coal or 68 million tonnes of wood.

In India, the history of biogas plants using cow dung (gobar gas plants) dates back to 1859 when the first anaerobic digesters were installed for biogas illumination. First Organic waste based biogas plant was setup in 1900 in Leprocy Centre Matunga Bombay for methane recovery. In 1910s, digestion of cellulosic materials were tried to address nitrogen shortfall in agriculture and waste sanitation. In 1946 Indian Agricultural Research Institute (IARI) developed a batch- type cattle dung digester, but its high cost hindered widespread adoption however research continued to improve cost-effectiveness and gas production.

The second phase (1950-1960) saw contributions from Jasbhai J. Patel and the IARI group. Patel designed the Gram Laxmi gas plant, patented in 1951, featuring a rotating gasholder and continuous digestion system. Fresh

slurry was fed daily, with an equal amount of digested slurry discharged, combining the gasholder and digester in one unit.

The third phase (1960 onwards) focused on the extension of biogas technology. Jasbhai J. Patel's Gram Laxmi III model improved upon previous designs with a brickwork digester and a gasholder. In the 1960s, the Gobar Gas Institute developed the KVIC model (Khadi and Village Industries Commission Model), and by 1973, over 6,000 plants were commissioned.

In 1978, the Planning Research and Action Division (PRAD) developed the low-cost fixed dome Janta biogas plant, which was extended with the help of KVIC, AFPRO, and state agencies, leading to the installation of 100,000 plants by 1980. Recognizing the significance of biogas technology, the GoI launched the National Project on Biogas Development (NPBD) in 1981-82 to accelerate the growth. In the 1980s, the Department of New Energy Sources (DNES) promoted biogas technology, eventually becoming an independent ministry that established a comprehensive National Program on Biogas Development.

Basic research and training components were also initiated in this area at many leading institutions in the country. Many appropriate models/designs and R&D efforts came to fruition between 1973-1988 including the Janata Biogas plant by the Planning Research and Action Institute, Lucknow; fixed dome biogas plant by Tamil Nadu Agricultural University, Coimbatore, Deenbandhu design by Action for Food Production (AFPRO), New Delhi.

MNRE Sources, since then, has been providing central financial assistance through nodal agencies for the construction of biogas plants throughout the country, encouraging R & D through sanctioning research projects and extension through eight Biogas Development and Training Centers (BDTCs).

In 2002-03, the NPBD was renamed the National Biogas and Manure Management Programme (NBMMP). From 2005-06, biogas plants were disseminated through the Biogas-based Distributed/Grid Power Generation Programme and Energy Recovery from Urban and Industrial Waste Programs. In 2008-09, the government launched a new initiative for an Integrated Technology Package on medium-size Biogas-Fertilizer Plants (BGFP), focusing on biogas generation, purification, bottling, and distribution. A 50% subsidy and 30% loan support were provided for compressed biogas plants. These plants produced CBG, to be used as vehicle fuel and meeting other needs. This initiative, supported by IIT Delhi, laid the foundation for the commercialization of CBG in India's bio-fuel policy (2018) through SATAT (Sustainable Alternative Towards Affordable Transportation).

Since 2014, India has shifted from traditional biogas to compressed biogas (CBG), driven by a focus on renewable energy and sustainability. Initiatives like the SATAT program, GOBARdhan (Galvanizing Organice Bio-Agro Resources Dhan) scheme, and National Bio-Energy Policy (2018) have accelerated CBG adoption. State governments also implemented policies to encourage investment in CBG production. IIT Delhi has been instrumental in advancing CBG technology with cost-effective Water Scrubbing Technology to enhance methane content (Patent No 284588), making it suitable for CBG production. The technology has been transferred to 11 industries, and IIT Delhi's

biogas car has covered over 140,000 km since 2011, promoting CBG use in transportation.
Historically, biogas in India was limited to small-scale applications, but the shift to CBG enables its use for commercial-grade applications like transport and industry. The government's push for biogas and CBG adoption continues to grow.

Launched in 2018, the SATAT initiative aimed to set up 5,000 CBG plants by 2025, producing 15 million metric tons of CBG annually. While progress has been slow, with only 82 plants commissioned by January 2025, 2026 numbers of Letters of Intent have been issued to entrepreneurs. The RBI has prioritized C B G plant financing, with major banks offering tailored loans.

In 2018, the GOBARdhan scheme was launched to promote waste-to-energy projects by managing cattle dung and agricultural waste. It supports biogas and CBG plants, enhancing rural economies and farmers' income. In the 2023-24 Budget, ₹10,000 crore was allocated for 500 new plants. Over 2,200 plants are registered, including 851 CBG plants under this scheme.

The Indian Biofuel Policy 2018 supports biofuels, including CBG, ethanol, and biodiesel, offering financial incentives for large-scale adoption. States like Uttar Pradesh and Punjab have developed their own bioenergy policies to promote CBG production. Uttar Pradesh offers subsidies, tax exemptions, and has partnered with private investors to Establish large scale CBG plants to b o o s t biogas production, P u n j a b focuses incentives and streamlined approvals. Additionally, the MNRE launched the New National Biogas

and Organic Manure Programme (NNBOMP) for small biogas plants in rural areas from 2018.

The MNRE has refined its biogas program, introducing a subsidy scheme and strengthening the institutional framework at the state and district levels. Approved biogas models, including fixed and floating dome ty pes, are eligible for subsidies under the New National Biogas and Organic Manure Programme (NNBOMP). The program also includes specifications for biogas stoves and parts, ensuring safe and efficient us e. Additionally, the maximum size for family-type biogas plants has increased from 6 to 25 cubic meters to tap into untapped potential in rural and semi-urban areas. Central Financial Assistance (CFA) has been raised, ranging from ₹7,500 to ₹35,000 per plant.

The GoI is prioritizing renewable energy, with biogas production set to expand across households, municipalities, and industries for heating and electricity. Growing public awareness will further promote biogas use, and biogas-based power can earn carbon credits, as demonstrated in Kerala. India's transition from **biogas to compressed biogas (CBG)** marks a significant milestone in the country's renewable energy journey in past 50 years. Government initiatives like NBMMP, NNBOMP, **SATAT**, **GOBARDHAN**, and the **Bio- Energy Policy 2018** have laid a strong foundation for the growth of the Biogas and **CBG sector**. India's transition to CBG will reduce fossil fuel dependency, create rural jobs, and contribute to the 2070 net- zero emissions goal. For sustainability and profitable CBG program, there is need to have proper multi-feed biogas digesters which can take care of locally available different organic wastes ensuring round the year feed availability, efficient indigenous biogas upgrading technologies, a mechanism to store upgraded methane and carbon dioxide both and their commercialization and finally, able to create market for Fermented Organic Manure (FOM) and Liquid Fermented Organic Manure (LFOM) for agricultural applications.

CBG-CGD Synchronization Scheme: a transformative shift for Biogas in India

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Energy is the backbone of any economy, driving trade, industry, education, and social progress. Access to clean and affordable energy is essential for improving quality of life and fostering economic growth. For India, the world's third-largest energy consumer, ensuring reliable energy for its growing population is critical to sustaining development and social stability.

Since 2008, India's energy consumption has doubled, with over 83% of its primary energy needs still met by coal and oil. This heavy reliance on fossil fuels increases import dependency, financial strain, and carbon emissions, making a transition to locally available and greener energy sources imperative.

Natural gas, the cleanest fossil fuel, is gaining global traction as a bridge to renewable energy. The GoI aims to increase its share to 15% by 2030, with City Gas Distribution (CGD) playing a crucial role in achieving this target. The regulatory body is actively expanding CGD networks across India through new bidding rounds.

India's shift toward sustainable energy is accelerating, with biogas emerging

as a key contributor. Abundant biomass and organic waste offer immense potential for large-scale biogas production, enhancing energy security by reducing LNG imports and supporting the AatmaNirbhar Bharat mission.

Biogas supports multiple objectives, including increasing India's green energy mix, reducing import dependence, fostering entrepreneurship, and boosting rural employment. It also mitigates pollution from vehicles and agricultural waste while promoting efficient urban waste management. Additionally, biogas contributes to India's climate commitments, by making it a key renewable energy source.

As a developing nation, India must meet its growing energy demands responsibly by integrating biofuels and renewable energy into its energy mix. The Ministry of Petroleum and Natural Gas has implemented several initiatives to develop a strong biogas ecosystem. The National Policy on Biofuels 2018 promotes biofuel usage as an alternative or blend for conventional fuels. The Galvanizing Bio- Agro Resources Dhan (GOBARdhan) initiative, also launched in 2018, supports converting organic waste into biogas, CBG, and Bio-CNG.

Recently, MoPNG announced plans to set up 195 model biogas plants across India by organizations under MoPNG such as IOCL, GAIL, BPCL, HPCL, ONGC, PLL, OIL, IGL, and EIL, either through their own investment or through private partnership. These plants will create employment opportunities in construction, operations, and supply chain management, benefiting rural communities.

On the offtake side, the Sustainable Alternative Towards Affordable Transportation (SATAT) scheme, launched in 2018, targets production of 15 Million Metric Ton Per Annum (MMTPA) of CBG production through Oil & Gas Marketing Companies. Additionally, in April 2021, MoPNG introduced the CBG-CGD Synchronization Scheme to integrate biogas with domestic natural gas for CNG (Transport) and PNG (Domestic) segments in the CGD sector. GAIL has been tasked with implementing this scheme nationwide.

Connecting biogas production to CGD networks via pipelines ensures cost-effective, seamless distribution, marking a significant step in India's transition to sustainable energy.

Aligning biogas production with gas distribution infrastructure minimizes transportation costs and ensures a seamless supply of green gas to end consumers. The CBG-CGD Synchronization Scheme has the potential to revolutionize the biogas sector. It focuses on integrating CBG into the existing CGD network, ensuring a seamless supply of green fuel for domestic and transport use. This decentralized system also provides a huge opportunity to supply CBG in remote locations where the affordability and access to modern energy is still a major challenge.

GAIL has already implemented the operational modalities for supply of CBG co-mingled with domestic gas at uniform base price across all CGD entities for CNG (T) and PNG (D) segment of CGD network.

GAIL commenced the first supplies of Biogas/Compressed Biogas (CBG) under the Synchronization scheme on 19th April 2021 at Nadiad District in Gujarat. The following statistics highlight how the Synchro Scheme is already beginning to shape the Biogas ecosystem in India.

- ✓ Total 123 Ton Per Annum signed all over India

- ✓ ~1,50,000 Standard Cubic Metres Per Day of Biogas sale is being made at present country-wide.
- ✓ Supplying to 57 CGD Geographical Areas
- ✓ 90 CBG producers tied-up under Synchro Scheme
- ✓ 32 CGD entities tied-up under Synchro Scheme

Further, MoPNG has also announced mandatory CBG Blending Obligation (CBO) for CGD entities wef 2025-26. The CBO is mandatory @ 1%, 3% and 4% of total CNG/PNG consumption for FY 2025-26, 2026-27 and 2027-28 respectively and 5% from FY 2028 –29 onwards. This guarantees a market for CBG producers, reducing investment risks and encouraging more waste-to-energy projects.

In addition, MoPNG has announced the Development of Pipeline Infrastructure (DPI) scheme to provide Subsidy of upto 50% for connecting CBG plants with CGD networks through pipeline.

These measures are in addition to several policies, and fiscal incentives announced by other ministries like Ministry of New and Renewable Energy, Department of Fertilizers, Ministry of Finance etc.

Now the stage is set for roll-out of Biogas and CBG as a clean and local solution to meeting India's rising energy needs at the local level.

The CBG-CGD Synchronization Scheme represents a transformative shift in India's biogas sector. It is unlocking new opportunities for waste-to-energy projects and supporting the shift towards a sustainable, self-reliant, and low-carbon energy economy. With the evolving policy measures, financial incentives, and infrastructure investments, Biogas can revolutionize India's energy landscape, reducing waste, lowering emissions, and strengthening India's energy security.

Unlocking India's Bioenergy Potential

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India's bioenergy sector is on the brink of transformation, playing a crucial role in the country's energy transition and sustainability goals. As India strives for net-zero emissions by 2070, bioenergy emerges as a critical contributor to energy security, rural economy, and emissions reduction. The National Policy on Biofuels promotes biofuels to enhance energy security, reduce oil imports, and mitigate environmental impact.

NITI Aayog, the government's leading think tank, is driving policies and strategies to unlock the sector's potential. It facilitates stakeholder consultations and research to align strategies with sustainability goals, advocating higher blending targets like 20% ethanol blending by 2025 and the development of advanced biofuels such as 2G ethanol and bio-methanol.

The "Roadmap for Ethanol Blending in India 2020-25," released by NITI Aayog and the Ministry of Petroleum and Natural Gas, outlines the strategy to achieve 20% ethanol blending (E20) in petrol by 2025, and highlights its benefits like energy security, lower vehicular emissions, and increased agricultural demand for ethanol feedstocks. The roadmap provides plans for ethanol production & supply and addresses challenges such as vehicle compatibility, infrastructure, and stakeholder coordination to ensure successful implementation of blending targets.

The Ethanol Blending Program has driven a sharp rise in bio-ethanol production in India, increasing the ethanol blending rates from 1.53% in 2014 to 15% by October 2024, with a target of 20% by 2025. Primarily derived from sugarcane, 1G ethanol cuts fossil fuel use and carbon emissions, contributing to sustainability. So far, it has reduced CO_2 emissions by 544 lakh metric tons, replaced 181 lakh metric tons of crude oil, and significantly curbed import dependency. [1]

India aims to advance bio-ethanol-based transport fuels and has set up an inter-ministerial committee to assess the feasibility of blending beyond 20% (E20+) while focusing on feedstock sustainability, supply chain efficiency, and vehicle compatibility.

NITI Aayog conducts comprehensive studies to provide strategic insights that shape policy decisions. The ongoing Life Cycle Assessment (LCA) of first-generation (1G) ethanol-study highlights that while bioethanol is cleaner than fossil fuels, it is not entirely carbon neutral. Emissions vary by feedstock, with sugarcane-based ethanol having the lowest emission due to bagasse use, while molasses and food grain-based ethanol produce higher emissions due to energy-intensive fermentation and distillation processes. The Net Energy Ratio (NER) confirms sugarcane as the most efficient feedstock, whereas food grain-based ethanol is less favourable, emphasizing the need for advancements in energy-efficient production technologies. The study also deep dives into ethanol's True Cost of Production without subsidies, to gauge its financial viability.

Methanol Economy program of NITI Aayog aims to reduce India's methanol imports, cut greenhouse gas emissions, and convert domestic resources like high-ash coal, agricultural residue, CO_2 from thermal plants, and natural gas into methanol. Methanol is promoted as a low-carbon fuel for transport (road, rail, marine), energy (DG sets, boilers), and cooking (replacing LPG, kerosene, wood charcoal). Blending methanol in gasoline can reduce imports and

1 India's Ethanol Push: A Path to Energy Security https://pib.gov.in/PressNoteDetails.

emissions, while adding 20% Di-Methyl Ether (DME) to LPG could save Rs 6000 crore annually and reduce consumer costs by Rs 50-100 per cylinder[2].

The Methanol Economy program is set to generate 5 million jobs in production, application, and distribution with initiatives like Asia's first canister-based methanol cooking fuel program in Assam. NITI Aayog is also developing five high ash coal-based methanol plants, five DME plants, and a natural gas-based methanol plant with a combined 20 MMT annual capacity. Additional innovations include methanol-powered boats for inland waterways and generator sets running on 100% methanol. R&D efforts, led by BHEL, Thermax, IIT Delhi, and the Department of Biotechnology, focus on indigenous coal-to-methanol and biomass-based methanol technologies. [3]

In October 2024, NITI Aayog hosted the Second International Methanol Seminar and Expo as part of the Methanol Economy Programme, reinforcing India's commitment to methanol as a sustainable, low-carbon fuel. It brought together global experts, industry leaders, and policymakers to discuss advancements in methanol production, technology, and applications in transport, energy, and industry.

To advance the Methanol Economy, NITI Aayog has placed bio-methanol at the forefront of India's clean energy transition. Derived from various biomass sources like agricultural residues and municipal waste, bio-methanol is a cost-effective alternative that

reduces reliance on energy imports. However, bio-methanol production faces challenges related to feedstock availability, technology scalability, and infrastructure development.

With multiple competing fuels for biomass as raw materials like bioethanol, bio-methanol, green hydrogen, CBG, and biomass power, etc., assessing biomass potential and feedstock availability is crucial. NITI Aayog's study, *Bioenergy Potential Estimation and Feedstock Availability for Competing Uses*, will help in understanding the potential of bioenergy in meeting India's Nationally Determined Contributions (NDCs) for emission reduction and the goal of achieving net-zero emissions by 2070. The study will assess agricultural residues, municipal solid waste, crop biomass, and food grains, addressing challenges in feedstock allocation, pricing impact, and sectoral demand. Its findings will guide strategies for optimizing bioenergy production, supply chains, and renewable energy goals.

The government, through Ministry of New and Renewable Energy and Indian Renewable Energy Development Agency Limited, is strengthening bioenergy by conducting awareness campaigns and training programs to integrate farmers and entrepreneurs into the value chain. These efforts address sectoral challenges and drive growth, making bioenergy a key part of India's 2070 NetZero strategy. With its potential to cut emissions, create rural jobs, and enhance energy security, bioenergy is crucial to India's sustainable energy future.

The Global Biofuel Alliance (GBA), launched during India's G20 Presidency in 2023, reinforces this vision by promoting global biofuel collaboration. Endorsed by over 25 countries and 12 international organizations, GBA supports innovation and standardization.

NITI Aayog, in coordination with ministries, drives bioenergy growth through policies, technology advancements, and inclusive development. By leveraging biomass resources and fostering global cooperation, India is not just meeting domestic goals but setting a global benchmark for sustainable energy transitions.

2 Methanol Economy (https://www.niti.gov.in/ methanol-economy)
3 Methanol Economy (https://www.niti.gov.in/ methanol-economy)

Biomass Co-firing in the Indian Power Sector: Persisting Challenges and Way Forward

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Biomass co-firing assumes a critical role in energy transition for decarbonization of coal power plants. National Thermal Power Corporation's (NTPC) journey of biomass co-firing started in 2017 with the first co-firing trial in a 210 MW Unit at NTPC Dadri with aim of mitigation of carbon emission from power plant as well as mitigation of air pollution caused by stubble burning. Availability of biomass pellet in adequate quantity was the major challenge during those times to carry out biomass co-firing on a regular basis. Series of direct and indirect efforts were made by NTPC for creating momentum, right from stakeholder engagement to vendor development coupled with favorable procurement model and less stringent technical specification of biomass pellet to enable larger participation and kick start the sector. The endeavor enabled gradual improvement in biomass pellet supply position over the years and now some of NTPC plants have started to receive adequate quantity of biomass pellet for biomass co-firing on regular basis and same trend is expected to continue in future for the rest of the plants of NTPC. Policy for mandatory biomass co-firing is in place as an obligatory measure for Generation Companies (GENCOs) to undertake biomass co-firing. Nevertheless, there are several challenges which are required to be resolved for round the year co-firing on a sustainable basis. The article highlights the persisting challenges in biomass co-firing sector and suggests resolution plan to scale up biomass co-firing.

Persisting challenges in biomass co-firing sector

There are several persisting challenges in the biomass co-firing sector which is required to be overcome for rapid scale up of biomass co-firing across country. The challenges are enumerated as follows-

Biomass supply chain

Challenges

A sustainable biomass supply chain with long term supply contract is the key to enable round the year biomass co-firing. The following are the key obstacles associated with biomass supply chain-

- Price volatility and supply of raw biomass round the year for pellet manufacturing
- Least preference towards paddy straw & raw material verification
- Unsustainable growth of supply-demand chain and sector regulation
- Bankability of biomass collection, storage and pellet manufacturing projects

- Handling multiple numbers of small capacity suppliers & rapid capacity development
- The limited engagement of GENCO's in fostering investor confidence within the biomass pellet manufacturing sector poses a significant challenge

Resolution plan

The above challenges may be tackled by changing model for procurement of biomass pellet. The current model of procurement is a free market where demand is floated in the market to get the supply of biomass pellet. The present model can cater for short term demand of biomass pellet to the power plants. However, to cater long term demand on sustainable basis, Built Own Operate (BOO) model and Aggregator (AGG) model is proposed. Under both of above model, bid may be invited for an identified biomass rich zone nearest to the plant in concurrence with the state agencies which will demarcate and allocate the biomass rich zone for pellet manufacturing. Assessment of surplus availability of biomass in that area by state agencies will ensure stable supply against pre-determined consumption which is important to get the raw material round the year at stable price. If a bid is invited for paddy rich zone, it will encourage utilization of paddy which is least preferred raw material due to high input cost and low output leading to shrink profit margin and causing uneven competition between paddy straw vs rest of agricultural residue. Demand projection by GENCOs in a phased manner after assessment of market is important for sustainable growth of supply chain. Flow of finance into the sector is the most important part, however, banks are yet to get the required level of confidence in the sector. The following steps need to be taken to enhance bankability-

- Formulation of long-term contracts (5-7 years)
- Benchmarking of proven and reliable technologies
- Assuring of the offtake of biomass pellet by GENCOs
- Incorporation of financial QR for vendor selection in concurrence with banking institution
- Incorporation of technical QR for vendor selection with due emphasis on experience in biomass or allied sector or collaboration with experienced players

Biomass pellet minimum lot size may be enhanced from current 20 TPD to e.g. 100 TPD to reduce handling multiple numbers of small capacity suppliers while promoting rapid capacity development through collaboration between experienced players with sector knowledge and new players with financial strength.

In BOO model, bid may be invited directly from manufacturers (single or consortium) having cumulative production and supply capacity (say minimum 100 TPD). In AGG model, bid may be invited from biomass aggregator who may be a Govt. or private company with enough financial strength to enable biomass collection and round the year storage. This also requires working capital support (collection by self or third party), to get it converted into biomass pellet, from multiple numbers of pellet manufacturers with cumulative production capacity (e.g. minimum 100 TPD), and then supply it to NTPC. Aggregator models shall resolve working capital challenges in the sector.

Biomass pellet specification and quality

Challenges

Initially biomass pellet specification

was kept less stringent with primary objective to encourage larger numbers of participation and to kick start the sector with an aim to gradually finetune it in the longer run. The present supply of biomass pellet has large and loosely bonded constituent particles which makes it less durable and easily breakable while unloading and conveying. This creates huge dust while unloading and conveying which leads to deposition of dust in conveyor areas causing fire hazards and loss of biomass causing financial implication. Fugitive dust causes health hazard. Furthermore, coal mills are not designed to pulverize larger, fibrous particles found in biomass pellets. These larger particles can easily pass through the classifier due to their light weight, resulting in poor mill fineness. This leads to high levels of unburnt carbon in the bottom ash, fly ash, and FGD slurry, especially at higher co-firing ratios (10 wt.%) when biomass is fed into all mills, including those at upper elevations. Coarser biomass particles in fly ash is also affecting ash utilization. It is observed that supplied pellets often contains undesired base material or binder, reeking foul smell. Press mud used as a binder but it has an issue associated with foul smell and high sulfur content leading to high SOx emission. High chlorine in biomass is also linked to the corrosion which is yet to be the part of technical specification. Density of biomass pellet was also observed on lower side which makes it less compact.

Resolution plan

ISO Standard 17225-6: 2021 may be adopted in long term contract. A long-term contract may be floated parallelly to allow new investment in the sector. Pellet specification may include limits on diameter and length to ensure better flowability, as well as density and durability indices for strength. Additionally, setting limits on constituent particle fineness can help eliminate unburnt carbon in fly ash and FGD. Finally, imposing limits on sulfur and chlorine content can prevent the use of unwanted binders or raw materials, such as press mud and high-chlorine materials, which can cause corrosion. Heavy metals such as Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel and Zinc limits may also be specified in line with ISO standard after testing several kinds of biomass pellet to ensure practical limits. This will prevent the mixing of any undesired material in biomass which may lead to pollution.

Biomass storage and handling

Challenge:

Existing shed-based biomass storage and handling infrastructure has limitations with respect to precise blending and ensuring round the clock biomass co-firing to achieve required mandate. It also involves significant financial loss from damage of biomass pellet during storage and handling by action of dozer. It poses fire and health hazard due to high dust while unloading, handling and conveying. Further, it doesn't provide water proofing to the stored biomass pellet. With present storage and handling infrastructure, round the clock biomass co-firing is not feasible to achieve the required mandate.

Resolution Plan

As a long-term measure, a truck tippler cum bulk receiving unit and Silo based biomass storage and handling system equipped with fire detection and protection system is under conceptualization for future to enable round the year biomass co-firing. Advantages of silo-based system includes-

- Waterproof storage in silo
- Easy and quick material displacement after tippling truck when nos. of trucks are more
- Fully Automatic and metered feeding can work 24 hours with small manpower
- Dust extraction system in place.
- No dusting, No unhealthy environment, No material loss.
- Reduced fire risk.
- No Material breakage or loss

due to handling of material.

- Nitrogen based firefighting system installed with early warning fire detection system.

The above logistics at plant side shall enable round the clock biomass pellet blending in precise limit without causing damage to the pellets (and financial loss) which is important to achieve safe and sustainable biomass co-firing to achieve the required mandate of 5-7%.

Biomass co-firing standard operating procedure

Challenges

Mill primary air inlet temperature restriction of 180^{0}C in existing standard operating procedure (SOP) of biomass co-firing leads to significant mill capacity decreasing. Furthermore, the feeder must be kept in manual mode in mills co-firing biomass. In these mills, the mill outlet temperature is controlled by manually adjusting the feeder speed. As a result, mills set to biomass co-firing mode remain in manual mode, preventing the unit from operating in coordinated master control (CMC) mode. Therefore, with the current standard operating procedure (SOP), it is not possible to achieve the mandated 5-7% biomass co-firing. The current SOP was designed for a first-time, safe trial in a single mill, considering the worst-case scenario of 100% biomass entry into the mills due to poor blending with coal.

Resolution Plan

The purpose of existing SOP has been met, and SOP has been revised to enable 5-10% biomass co-firing which is under trial. In revised SOP, mill inlet temperature restriction has been enhanced to 240^{0}C while incorporating additional safety measures like implementation of blending logic and auto mill steam inerting logic to ensure fire safety. With revised SOP, feeder can now run in auto mode and unit can run in CMC. Mill inlet temperature limit is again under review and may be enhanced further to reduce mill derating where coal moisture is high. With the revised SOP, units are capable to achieve up to 10 wt.% biomass co-firing. However, with present biomass pellet specification, restriction has been kept up to 5 wt.% to avoid unburnt carbon in fly ash and FGD. After introducing constituent particle fineness in pellet specification, biomass co-firing limit may further be enhanced up to 10 wt.%.

Biomass co-firing policy

Challenges

Biomass co-firing involves reduced mill outlet temperature (65^{0}C instead of 80^{0}C during normal operation) to ensure fire safety. This 15 ^{0}C reduction in mill outlet temperature leads to an increase in flue gas exist temperature and specific ID fan current. Specific mills current also increases due to reduced grindability at low mill outlet temperature. Specific PA fan current also increases due to high PA header pressure requirement during biomass co-firing to prevent settling of biomass inside mills. High hydrogen content in biomass also leads to related loss during biomass co- firing.

GENCOs, despite being the first movers, are incurring monetary loss due to deterioration in heat rate and APC during biomass co-firing. There is no incentive for carbon mitigation and active engagement in supply chain development. A regulatory framework driven business model is the need of the hour to scale up biomass co-firing at rapid pace across the country.

Resolution Plan

Tests at Dadri 210 MW and 490 MW units established that cumulative loss in net heat rate during biomass co-firing is in range of 22/20 kCal/kWh at 10 wt.% co-firing ratios respectively which increases or decreases proportional to ratio of biomass co-firing which is significant value and cause financial loss to GENCO's in case it is not recovered with appropriate mechanism. Accordingly, normative compensation has been proposed to be given per ton of biomass co-fired as per following formula.

- **Normative compensation:**

Normative for deterioration in net heat rate for compensation Δ NHR(x)= (x/10%). Δ NHR (10%)

where x is co-firing percentage, Δ NHR (x) is normative deterioration in heat rate at x co-firing percentage and Δ NHR (10%) is normative figure: 20 kCal/kWh for 500 MW and 22 kCal/kWh for 210 MW power plant. The compensation formula proposed is as follows-

Compensation per ton of biomass co-fired

$$= \frac{\text{Gross Monthly generation (MWH)} \times \Delta \text{ NHR (x)} \times \text{Wt.avg.cost per ton of blended fuel}}{\text{wt.avg.GCV of blended fuel} \times \text{Total biomass fired in the month (T)}}$$

- **Incentive for carbon mitigation**

An incentive at the market rate of CO_2 mitigation (say with market rate of 6 USD per ton of CO_2, average incentive of Rs. 650 per ton of biomass pellet co-fired is calculated assuming coal and biomass GCV equal and 1 ton biomass mitigates almost 1.266 tons of CO_2 by replacing 1 ton of coal having carbon content of 34.5%) is proposed to be given per ton of biomass co-fired over and above mandatory co-firing limit. Incentives may vary with the market rate of CO_2 mitigation. Mandated quantity is proposed to be set at zero for the initial two years which may be reviewed and revised every year based on the status of biomass co-firing at national level and minimum level achieved by all GENCOs.

- **Prioritizing Merit Order Dispatch (MOD) of Co-Firing Plants**

Policy has provision that MOD of power plant shall not be affected due to biomass co-firing. In line with the intent of policy, it is proposed to make two parts of variable charge - black part (due to coal) + Green part (due to biomass). When GENCOs will co-fire more biomass, black part variable charge shall reduce, and merit order may be decided on that black part. Thus, biomass co-firing plants shall have better MOD. GENCOs shall be encouraged for biomass co-firing by giving better MOD and at least technical minimum schedule in any case during period of biomass co-firing irrespective of % of biomass co-firing.

A regulatory framework for compensation and incentive may go a long way towards enabling business model driven biomass co-firing while ensuring active involvement and willful adoption of biomass co-firing by GENCO's which shall help in rapid scale up of biomass co-firing across country.

c) Conclusion

Effort made over the years has created an ecosystem for biomass co-firing in the country. Mandatory biomass co-firing limit and penalty mechanisms are in place to enable biomass co-firing. However, a good business model is yet to be in place to encourage GENCOs to resort to biomass co- firing as a commercial proposition. As biomass co-firing involves loss in net heat rate, it is required to be compensated with an appropriate mechanism to make it commercially viable in the first place. Further, biomass co-firing also increases the Energy Charge Rate (ECR) of such plants, so such plants shall be required to be given preferential merit order to make it commercially viable. Further, Incentives for carbon mitigation shall further help in formulating a good business model. With revised SOP of biomass co-firing, significant mill derating issue during biomass co-firing has been resolved and up to 10 wt.% biomass co-firing has been achieved safely, but it is recommended to restrict biomass co-firing to 5 wt.% in present condition and specify constituent particle size in biomass pellet to further enhance co-firing ratio. Other technical issues such as implementation of steam interting and blending logic are also required to ensure fire safety. Modification of biomass pellet specification is needed to enhance flowability, durability and density and to prevent dusting, foul odour and mixing of undesired material at source. In addition, silo-based biomass storage and handling infrastructure is needed to enable round the clock biomass co-firing to achieve mandate as well as to prevent material loss (and financial loss), health and fire hazard during unloading, storage and conveying of biomass co-firing within plant premises. Furthermore, a bankable and long-term supply contract with revised technical specification of biomass pellet is enabler for sustainable biomass co-firing round the year at commercial scale.

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Bioenergy Space : Recommendations to Enable Upstream Value Chain

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India is on a mission to achieve Net Zero by 2070, aligned with the vision for *Aatmanirbhar Bharat* and *Viksit Bharat*. It is also leading the International Solar Alliance and Global Biofuels Alliance with the aim to promote solar energy and biofuels. However, several barriers like farmer enablement, financing, infrastructure, skill development, R&D, and technology adoption hinder progress.

Challenges in the Upstream segment

National Biomass Mission, a key bioenergy initiative, faces substantial challenges, particularly in the Upstream Segment resulting in projects like Ethanol to Gasoline (E2G), Compressed Biogas (CBG) and NTPC's Boiler Applications are progressing slowly. Similarly, the Sustainable Alternative Towards Affordable Transportation (SATAT) Scheme, launched in 2015 to establish 5,000 CBG plants by 2023 and reduce fossil fuel imports by 10%, has seen sluggish progress due to multiple constraints.

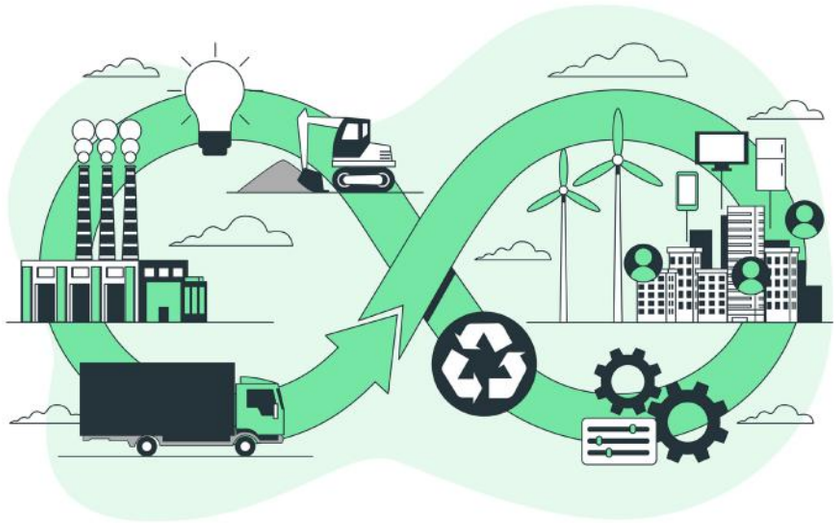
A primary bottleneck is Biomass Supply Chain Management (SCM), which comprises nearly 80% of project costs but receives limited attention. Key SCM issues include produce handling, post-harvest processing, transportation, warehousing, insurance, workforce skilling, manpower hiring, and overall upkeep. The lack of SCM focus deters investments and slows sector growth.

Moreover, SCM remains non-bankable, making financing difficult for both private and nationalized banks. While institutions like Indian Renewable Energy Development Agency Limited and some foreign financial bodies have initiated funding, issues like credibility ratings and high interest rates continue to hinder investment.

Despite central government efforts, state-level policy implementation is weak, increasing risks and discouraging investors and project developers. Political complexities and India's federal structure further hinder the ease of doing business. Additionally, lack of inter-ministerial coordination results in inefficient biomass resource allocation, increasing the risk of future shortages.

The absence of long-term zoning strategies for large-scale bioenergy projects has impeded structured growth. Further, stakeholder misalignment and financial markups create partnership challenges, making projects unviable. Technological constraints also limit biomass utilization, with CBG sector Plant Load Factors (PLFs) averaging only 25-30%.

Farmers remain underrepresented in the biomass value chain, leading to flawed SCM financial models and project failures. Cartel formations in Punjab's balers, and West Bengal's rice husk SCM have further disrupted market dynamics. Additionally, the absence of R&D and Technology Innovation Consortiums hinders the development of efficient solutions, while skill shortages limit sector growth. Addressing these challenges is critical for scaling India's bioenergy sector.



Recommendations to mitigate Upstream challenges

A sustainable bioenergy framework requires integrating farmers as key stakeholders and establishing low-risk financing mechanisms. Energy security should be centrally managed under the Union List, ensuring a unified national policy free from federal-level disruptions.

An Inter-Ministerial Coordination Cell under MNRE/MoPNG and NITI Aayog should streamline biomass utilization planning for the next 50 years, phasing out fossil fuels. Collaboration among key ministries—Agriculture, Petroleum & Natural Gas, Finance, Science & Technology, and others—should drive the creation of a Biomass Consumption Matrix and a structured Energy Transition Plan for 2070. Zoning strategies for biomass projects must align with Sustainable Development Goals (SDGs), ensuring clear implementation strategies and periodic audits.

Policy measures should support SCM infrastructure financing, covering working capital, debt funding, transportation, warehousing, and skill development. A structured EXIM policy should permit limited biomass exports while prioritizing domestic energy security.

Coal imports should be minimized, with fossil fuels used only in large thermal plant boilers during industrialization. Mid- and small-sized boilers must fully transition to biofuels.

New energy projects should rely on biomass for power, steam, heating, and cooling, with defined biofuel allocations. Industries should be incentivized to adopt clean energy through carbon credits and green fuel incentives. Renewable Purchase Obligations (RPO) must include all bioenergy forms, including upstream processes, to enhance risk mitigation and offer offtake guarantees for farmers.

A joint Energy Plantation Scheme with National Bank for Agriculture and Rural Development (NABARD), Compensatory Afforestation Fund Management and Planning Authority (CAMPA) Funds, and financial institutions should support decentralized bioenergy projects.

All bioenergy forms, including briquetting, pelleting, steam, heating, and

cooling, should be recognized under Renewable Energy Certificate (REC).

A single-window clearance under MNRE/MoPNG and state agencies should streamline Consent to Establish (CTE) and Consent to Operate (CTO) approvals. States must implement central policies under Central Electricity Regulatory Commission (CERC)/ Solar Energy Corporation of India (SECI) oversight, addressing delays in policy execution and recognizing steam generation as part of Renewable Energy (RE).

The Bioenergy sector should be designated 'Priority Sector' for faster growth. To ensure financial viability, borrowing costs must be reduced to 4-6% through NBFCs, banks, and government financial institutions. Funding models should include term loans covering 70%-75% of renewable energy project costs. The biomass supply chain, especially upstream, should be GST-exempt to benefit farmers directly.

An allocation of INR 50,000 Crores should be made for biomass energy projects, with 60% directed to biofuels. This should include government-backed guarantees for private companies, focusing on the Public Private People Partnership (PPPP) pilot project. Subsidies for technological collaboration and machinery imports will create an attractive investment climate, with FDI relaxations and import incentives for developers and stakeholders.

Credit rating and collateral requirements should be relaxed, especially for private companies, with a three-year moratorium and removal of collateral for credit guarantee schemes. Bioenergy projects should benefit from a 3-5 year income tax holiday. Equity funding from IREDA, NIIF, private equity, and AIFs should be encouraged.

Profits from offtake companies should be reinvested in rural communities to support farmers and the rural economy. A portion of CSR funds should be allocated to rural development through developers and distributors.

Biomass depots should be established for efficient supply by farmers, with warehousing developed by NABARD, NAFED, and other units, offered at low costs. Public-private partnerships should help optimize warehousing use.

A multi-channel awareness campaign, involving MNRE, MoPNG, NITI Aayog, and others, should promote bioenergy. An annual bioenergy conclave should foster investment and knowledge-sharing.

Technological collaboration and domestic manufacturing under the 'Make in Bharat' initiative will drive technology transfer, job creation, and expertise development.

The PMO should oversee Phase 1 pilot projects within three years. An inter-ministerial core group, including MNRE, MoPNG, Agriculture, Power, DST, MoHFW, MoEFCC, NITI Aayog, and Rural Development ministries, should facilitate project execution. State governments must provide land at no cost to boost development and employment, contributing to SDGs.

A national digital platform should be developed to improve biomass bioenergy services' efficiency, integration, transparency, and reach.

A Bioenergy Commission of Bharat (BECI) under MNRE should lead bioenergy initiatives, with a dedicated biofuels chapter for CBG, E2G, SAF, and related technologies, coordinated by MoPNG. It should include sector experts and follow a structured governance model.

A special package for biomass-based CBG and renewable energy projects should target the North-East to promote growth and employment, with support from National Investment and Infrastructure Fund NIIF-loaned institutions and DoNER.

Designated biomass command areas and large-scale energy plantations should be developed with water management strategies for long-term biomass supply.

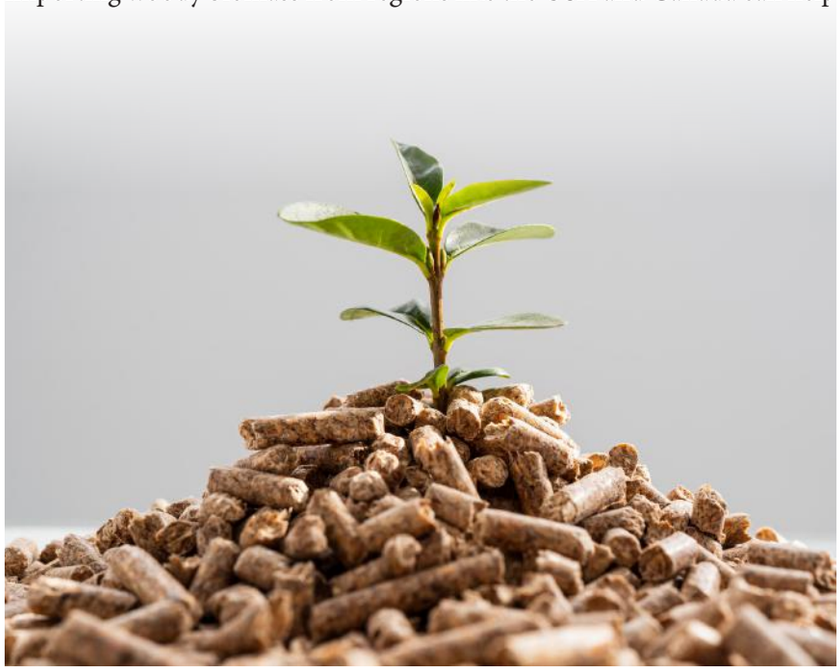
Domestic manufacturing of pre-harvest, harvest, and post-harvest machinery should be prioritized to scale up bioenergy, boost productivity, create jobs, and make Bharat a leader in bioenergy exports, especially to Africa.

R&D in the CBG sector should involve global agencies like the World Bank, USAID, UNIDO, JICA, IFC, and DFC, with government funding to support innovation in agriculture and supply chains.

Collaborations with Japan, the UK, the USA, Israel, and Europe should promote technology transfer, business opportunities, and funding for bioenergy, reducing fossil fuel reliance.

Consumer financing should be encouraged to reduce costs, and biomass by-product optimization should focus on sustainable use. The 'Village as a Hub' model should integrate rural communities into the bioenergy sector, creating extra revenue for farmers.

Financial institutions must adapt to the cash flow patterns of agricultural residue-based supply chains. Costing models should account for energy cost fluctuations and operational expenses to ensure sustainable pricing. Importing woody biomass from regions like the USA and Canada can help allocate more agricultural biomass for biofuels and other uses.



'Sustainable Bioenergy Parks,' driven by sugar companies and large conglomerates, should be promoted. These parks would combine energy plantations and bioenergy projects, creating jobs and fostering local economic growth.

Emerging technologies such as IoT, AI, blockchain, and automation should be integrated into bioenergy operations to boost efficiency and productivity.

Biomass exports like briquettes and pellets should be removed from the 'Free Category' to ensure domestic supply. Export conditions should require companies to use biomass for bioenergy projects within Bharat before allowing a set percentage for export.

A national skilling initiative, supported by central and state governments, should be developed under a PPP model to train a workforce for bioenergy projects, addressing labor shortages and creating structured employment opportunities.

Conclusion

The vision of transforming farmers into 'Oorja Daata' (energy providers) as envisioned by the Prime Minister requires a comprehensive effort across the bioenergy value chain. Challenges in the upstream sector must be turned into opportunities for all the stakeholders.

Bharat is on the verge of a 'Green Energy Revolution,' where bioenergy and biofuels will play a pivotal role in not only achieving goal set during COP25 but will also pave the way for a sustainable future toward COP30 and beyond.

Emerging Biomass Market in India & MSME's Readiness - Featuring Livgreen

Sanjay Jain
Business Head, Livgreen

India is rapidly emerging as a global leader in biomass energy, driven by the need to diversify energy sources and reduce reliance on fossil fuels. The biomass industry promotes rural economic development, creates jobs, and mitigates environmental pollution. Government support and policies further accelerate the growth and impact of this sector.

Livgreen Cleantech Private Ltd, part of the SAR Group of companies founded by Mr. Rakesh Malhotra and Mr. Navneet Kapoor, is at the forefront of this transformation. Established in 2013, Livgreen has been delivering eco-friendly clean energy solutions across India. The company manufactures and supplies premium quality biomass pellets and biomass-based equipment (by Navshakti), which are used to replace fossil fuels like diesel, PNG, LPG, furnace oil, and LDO in various industrial applications. Livgreen's biomass pellets provide fuel cost savings of approximately 30% to 50% without compromising on production output and quality. Their solutions benefit all MSME industries, including food (bakery, namkeen, roasters, noodles, confectionaries), packaging (tape, coating, and rotogravure), aluminum melting, forging, roto-moulding, tea processing, and paint shops. Pellet burners are used in heat exchangers, dryers, steam boilers, and hot air and hot water generators.

Current Scenario of Biomass Pellets

Biomass pellets, derived from organic materials like agricultural residues and wood waste (sawdust, wood chips, branches, leaves), are gaining momentum as a sustainable energy alternative. The market for biomass pellets is growing rapidly, driven by the rising demand for renewable energy and the potential for significant cost savings.

Biomass Pellets Classification

- **Agricultural Residues:** Includes crop residues like straw, husks, and stalks. These are abundant and renewable, making them a primary source for biomass pellets.
- **Agro & Forestry By-products:** Includes sawdust, wood chips, and other forestry waste. These materials are also renewable and provide a sustainable source of biomass.

Biomass Pellet End Use Application

- **Power Generation:** Agricultural residues pellets co-fired with coal in thermal power plants.
- **Processing and Manufacturing:** Agricultural residues pellets used in boilers, furnaces, and kilns for replacing coal, pet coke, and loose biomass.
- **MSME Industry:** Premium wood pellets used in heat exchangers, hot air and hot water generators, and baby boilers by replacing fossil fuels like diesel, PNG, LPG, furnace oil, and LDO burners.

Biomass pellet burners work similarly to diesel, LPG, and PNG burners. They are compact, have auto-ignition and controlling systems, and can be replaced with existing diesel and gas burners by simple on-site modification. Besides significant fuel cost savings, these burners can help reduce CO_2 emissions by almost 60% to 90% and sulfur oxide (SOx) emissions by almost 100%. Wood pellets are sulfur-free fuel.

Environmental Benefits: GHG Emissions Reduction

Biomass pellets with pellet-based burners and equipment offer several environmental benefits, particularly in reducing greenhouse gas (GHG) emissions:

- Negligible SOx emissions in wood pellets.
- Carbon neutral.
- NOx emission reduction.
- Lower emissions.
- Sustainable resource.

Lifecycle benefits: The entire lifecycle of biomass pellets, from production to combustion, generally results in lower GHG emissions compared to fossil fuels. This includes the processes of harvesting, processing, and transportation. Biomass pellets can also help in waste management by utilizing agricultural and forestry residues that would otherwise decompose and release methane, a potent GHG.

Navshakti Biomass Pellet-Based Equipment Range

- Aluminum Furnace
- Pellet Burner
- Namkeen Kadhai Bhatti
- Hot Air Generator

MSME Industries Benefited by Navshakti's Biomass-Based Equipment

Navshakti's innovative approach to integrating biomass-based equipment has significantly impacted several key industries. By utilizing pellet burners, namkeen kadhai fryers, hot air and hot water generators, and aluminum furnaces. Powered by Livgreen biomass pellets, these industries have experienced enhanced efficiency, cost savings, and environmental benefits.

Namkeen Manufacturing

Navshakti's Namkeen Kadhai Fryer stands out as the best solution for namkeen industry, offering uniform frying and superior product quality. Besides ensuring significant cost savings on fuel, Livgreen biomass pellets' user-friendly and customizable design and high efficiency make it a valuable asset for anyone looking to enhance their namkeen production sustainably.

Aluminum Melting

Aluminum melting is a critical process in various manufacturing industries, requiring high temperatures and efficient heat sources. Navshakti's innovative aluminum melting solution, powered by Livgreen biomass pellets, provides the necessary high temperatures for efficient aluminum melting while significantly reducing fuel costs. Small manufacturers, in particular, benefit from this cost-effective and eco-friendly solution, as it ensures consistent performance and substantial savings on energy expenses.

Forging

Like aluminium melting, forging is a demanding process that requires consistent and high-temperature heat sources to shape and strengthen metals. Navshakti's pellet burner, powered by Livgreen biomass pellets, is an ideal solution particularly for small manufacturers. The use of biomass pellets ensures substantial savings on energy expenses, making the forging process more economical. Additionally, the pellet burner is designed for reliability and high performance, enhancing the overall efficiency of small-scale forging operations.

Packaging

Navshakti's hot air generator, paired with a pellet burner powered by Livgreen biomass pellets, is an excellent solution for drying processes such as tape production, coating etc. This system ensures efficient and consistent drying while providing significant fuel cost savings, with reductions ranging from 30% to 50%, making it an ideal solution for small-scale packaging operations.

Bio-Energy from Sugar Industry: Latest Trends and Future Prospects

Prof. Narendra Mohan
Ex-director, National Sugar Institute, Kanpur, India

The depletion of oil reserves and volatility in fuel prices have intensified the need for plant derived renewable energy sources. To avoid the food vs. fuel conflict, non-food biomass sources have gained prominence. Sugarcane is a potential source of alternative green energy as it can guarantee an efficient production of sugar-derived ethanol. The sugar industry's by-products offer a solution for energy generation, waste management, and value addition. Advances in bioethanol production, bagasse-based power, compressed biogas, sustainable aviation fuel (SAF), and green hydrogen highlight the sector's future potential.

Global Bioenergy Trends and its potential in emerging economies

Bioenergy contributes about 10% to global energy consumption, with modern bioenergy technologies gaining traction in high-energy-demand regions such as Brazil, India, and China. Biomass energy is an effective alternative to fossil fuels, particularly in emerging economies. It is not just limited to heating or transportation but also plays a role in global power generation.

Emerging economies like India and China are investing in biomass for heat generation power generation and for biofuels. They also have substantial agricultural residues and organic waste that can be used as feedstock for bioenergy production. The Indian sugar

industry, processing over 300 million metric tonnes of sugarcane annually, generates substantial biomass for energy production.

The Indian sugar industry also has the potential to export about 1600 MW of bagasse-based bioelectricity to the national grid[1].

Latest Trends in Bioenergy from Sugar Industry

Bagasse-Based Bioelectricity

Bagasse, the fibrous residue from sugarcane juice extraction, is widely used in the sugar industry for bioelectricity production. Many sugar mills adopt cogeneration systems to meet their energy needs and sell surplus power to the grid. While issues with power tariffs and purchase agreements have reduced its appeal, Sugar mills still export surplus power during the season. Technological advances in boilers, turbines, and power systems are making the process more efficient, with some factories upgrading to high-pressure, high-temperature boilers to lower costs and emissions.

Bioethanol Production

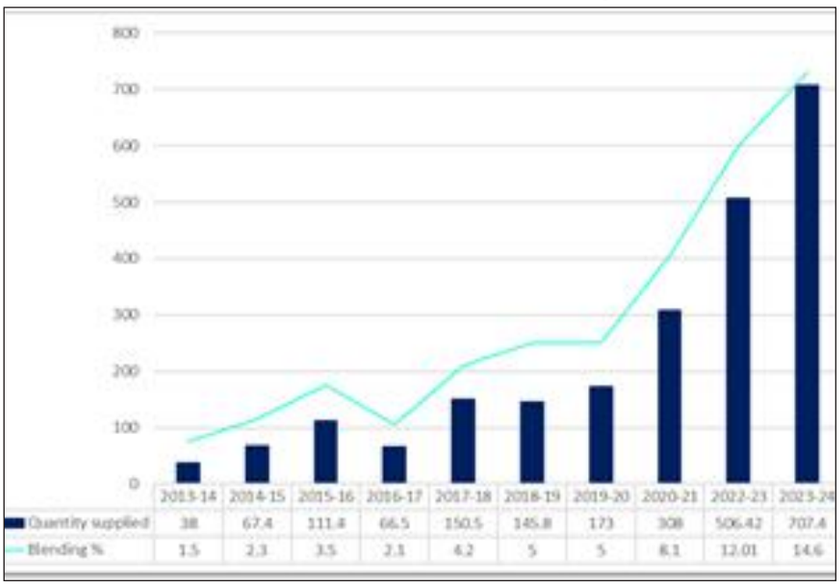
Molasses, a sugar industry by-product, is increasingly used for ethanol production. Ethanol blending with gasoline has gained momentum in India and Brazil to reduce fossil fuel dependency. India has set a target of 20% ethanol blending in petrol by 2025-26. Figure 1 below shows India's success in ethanol blending over the years.

Figure 1: Ethanol blending levels achieved from 2013-14 to 2023-24

Ethanol from sugarcane has a lower carbon footprint compared to corn-based ethanol due to its higher yield per hectare. It strengthens energy security by reducing reliance on imported oil and promoting sustainable, local fuel production. Emerging technologies are also developing second-generation bioethanol from lignocellulosic biomass, such as agricultural and industrial waste, avoiding food-versus-fuel conflicts.

Integration with sustainable practices

Sugar mills are increasingly adopting sustainable production practices to minimize environmental impact. They are also exploring the use of other biomass residues and waste streams to generate energy, fostering a circular economy around sugar production and reducing the industry's carbon footprint while boosting economic viability. Additionally, some mills are integrating solar and wind energy with bioenergy systems, such as bagasse-based power generation, creating hybrid energy solutions that address the variability of renewable sources and enhance energy security and reliability



	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2022-23	2023-24
Quantity supplied	38	67.4	111.4	66.5	150.5	145.8	173	308	506.42	707.4
Blending %	1.5	2.3	3.5	2.1	4.2	5	5	8.1	12.01	14.6

Future Prospects for Bioenergy from the Sugar Industry

The sugar industry is poised to expand bioethanol production, meeting growing global demand for clean fuels by diversifying feedstocks beyond sugarcane to include crops like sweet sorghum, cassava, and sugar beet residues. Sustainable Aviation Fuel (SAF), a promising alternative to fossil fuels, is being developed, with initiatives like Summit Next Gen's SAF facility in Texas and TruAlt Bioenergy's large-scale plant in India. Green hydrogen production using renewable bioenergy sources like bagasse is gaining traction, aligning with India's National Green Hydrogen Mission to promote clean energy and reduce fossil fuel dependence. Carbon capture and utilization (CCU) technologies in sugar mills could further cut emissions, with captured CO2 being used for biofuel production and algae farming. Advancements in waste-to-energy technologies, such as biogas from anaerobic digestion, will help sugar mills contribute to a circular economy while generating additional revenue. Policy support, including financial incentives and carbon credit schemes, will drive growth in bioenergy production, supporting net-zero targets

and strengthening the sector's sustainability.

Bioenergy Demand Across Various Sectors

The bioenergy market is expected to grow across various sectors, driven by government emissions restrictions and other factors discussed earlier. In the industrial sector, bioenergy will see the fastest growth through 2030, with biomass being used for heating, power generation, and as feedstock in industrial processes. Its cost competitiveness makes it a compelling choice for decarbonization, particularly in sectors like cement, steel, and chemicals. Additionally, biomass is commonly used in waste-to-energy plants, converting municipal and industrial waste into valuable energy.

Transport biofuels, such as ethanol and biodiesel, will remain the dominant form of bioenergy, supported by strong policies. Demand for biofuels will also increase in the aviation and maritime sectors. Biofuels in aviation are expected to make up nearly 2% of total fuel demand by 2030, up from almost zero in 2023. In the shipping industry, biofuel use is projected to reach about 0.5% of total international demand by 2030.

Biomass heating systems are becoming increasingly common in buildings, especially in countries with cold climates like the Nordic region and Central Europe. Figure 2 gives scenario of renewable fuel growth across sectors during 2023-2030.

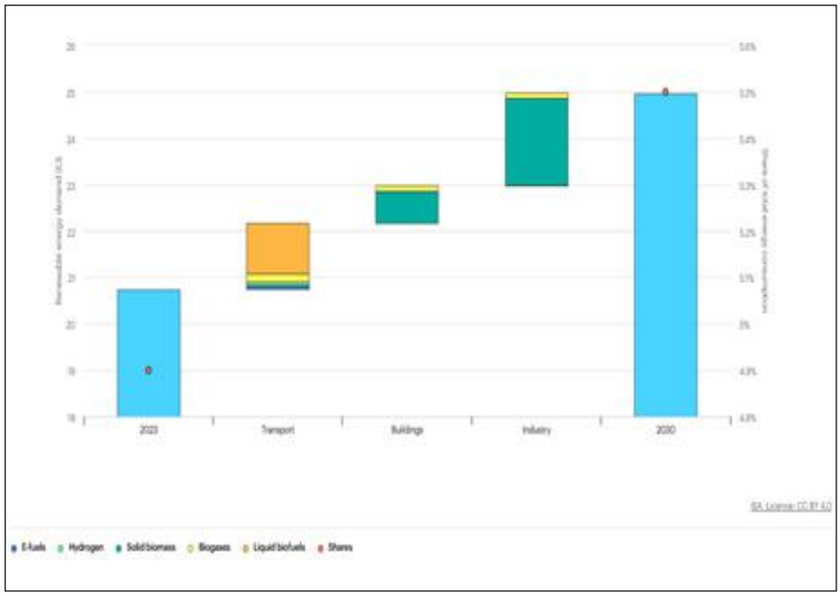


Figure 2 Renewable fuel growth by fuel type

Sources: Hydrogen estimates from IEA Global Hydrogen Review (2024) (https://www.iea.org/reports/global-hydrogen-review-2024), IEA (forthcoming), World Energy Outlook 2023

Challenges and Considerations

The challenges associated with bioenergy production in the sugar industry primarily revolve around feedstock availability, environmental impact, shifting government policies and economic viability. Dependence on sugarcane as a raw material makes bioenergy production vulnerable to climate change and land-use. Additionally, sugarcane is a water-intensive crop, necessitating sustainable resource management to prevent ecological degradation. Economic factors also play a critical role, as fluctuations in raw material prices and policy changes can significantly impact the profitability of bioenergy projects. To ensure long-term sustainability, continuous investment in advanced technologies and diversification of feedstocks is essential.

Conclusion

Bioenergy from the sugar industry offers sustainable solutions for energy production and waste management. Advances in ethanol production, bagasse power, compressed biogas, SAF, and green hydrogen present promising opportunities. However, overcoming challenges related to feedstock supply, environmental sustainability, and economic feasibility is crucial. With strong policies, technological advancements, and sustainable practices, the sugar industry can play a pivotal role in the renewable energy transition.

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India's Green Steel Taxonomy and CBAM: The Role of Carbon Capture in Steel Decarbonization

Keshav Goela
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The global steel industry is undergoing significant change as sustainability and emission reductions become key to remaining competitive. As one of the world's largest steel producers, India is navigating this transition shaped by international carbon regulations and domestic sustainability mandate. The European Union's Carbon Border Adjustment Mechanism (CBAM) and India's Green Steel Taxonomy are central to this shift, presenting both challenges and opportunities for Indian steelmakers.

On December 12, 2024, India's Union Minister of Steel, Shri H.D. Kumaraswamy, introduced India's Green Steel Taxonomy, becoming the first country globally to define green steel. This landmark step not only supports India's goal of achieving net-zero emissions by 2070 but also highlights the urgency of decarbonizing the steel sector to ensure global competitiveness.

The EU's CBAM, set for full implementation by January 2026, introduces carbon tariffs on imports to ensure a level playing field for domestic producers adhering to stringent emissions regulations. Indian steelmakers to EU, face a major challenge as non-compliant steel will incur steep tariffs, impacting profit margins and reducing competitiveness. Redirecting exports to less regulated markets is unsustainable in the long term. As carbon pricing expands globally, India must decarbonize its production to secure access to international buyers who are increasingly prioritizing low-carbon supply chains.

India's Green Steel Taxonomy introduces emission intensity thresholds to define "green" steel. Steel with emissions below 2.2 tonnes of CO_2 per tonne of finished steel (tfs) qualifies for a green rating. The classification breaks down further into three-star, four-star, and five-star ratings, with the most sustainable steel (five-star) requiring emissions of less than 1.6 tCO_2/tfs. Steel exceeding the 2.2 tCO_2/tfs threshold will not qualify for green certification, impacting its marketability and future procurement opportunities.

This mandatory framework aims to reduce the industry's average emission intensity to 2.2 tCO_2/tfs by 2030. The taxonomy considers Scope 1, Scope 2, and certain Scope 3 emissions, including upstream processes such as agglomeration and coke making, ensuring a comprehensive approach to decarbonization.

Decarbonizing steel production is a complex and capital-intensive process. Long-term strategies like hydrogen-based steelmaking and renewable energy integration require substantial investment and time. In contrast, carbon capture, utilization, and storage (CCUS) offers an immediate, scalable solution. Retrofitting carbon capture systems onto blast furnaces, which are responsible for the majority of emissions, can significantly reduce emissions without disrupting operations or waiting for new technologies to mature.

Blast furnaces, with flue gas CO_2 concentrations of 17-23%, present an ideal opportunity for CCUS integration. Amine-based absorption and chemical solvent processes, already in use globally, can efficiently capture CO_2 from blast furnace gases. Direct Reduced Iron (DRI) units, integral to India's steel production, can also adopt CCUS technologies.

International case studies offer valuable insights for India's decarbonization journey. Sweden's HYBRIT project is pioneering hydrogen-based steel production, while Japan has successfully reduced emissions through energy efficiency and early CCUS adoption. South Korea's steel sector benefits from strong government incentives, and Germany uses shared CCUS infrastructure across steel, cement & chemical industries. Canada's tax incentives have reduced costs and promoted early CCUS adoption.

India's steel sector is already demonstrating leadership in carbon capture. TATA Steel's pilot project at Jamshedpur captures 5 tonnes of CO_2 per day, while Jindal Steel and Power Ltd. operates one of India's largest CCUS facilities, capturing up to 2,000 tonnes per day. JSW Steel's unit captures 100 tonnes of CO_2 per day, showcasing the commercial potential of using captured CO_2 in the beverage industry. These initiatives demonstrate that carbon capture is not only feasible but already being scaled in India.

To accelerate decarbonization, India must prioritize scalable and cost-effective carbon capture solutions. Technologies that can be retrofitted to diverse steel plants are essential for rapid progress. AI-driven process optimization, advanced solvents, and efficient solvent management will lower operational costs and improve efficiency. Domestic innovation and indigenous development of relevant technologies is crucial to reduce reliance on imports and create jobs, strengthening the industrial base.

The Ministry of Steel's collaboration with industry players, think tanks, and academia signals a collective effort to drive innovation and achieve the objectives of the Green Steel Taxonomy.

With CBAM's implementation approaching and India's Green Steel Taxonomy now in place, the need for collaborative action is clear. India's steel sector stands at a critical juncture and carbon capture is a strategic necessity for Indian steelmakers to secure market access, improve brand value, and ensure India's steel industry remains resilient and sustainable.

Addressing Challenges faced by Compressed Biogas (CBG) sector in India

Mr. Jai Kumar Gaurav
Project Manager, Waste Solutions for a Circular Economy in India project, GIZ-India (Article in personal capacity)

The Compressed Biogas (CBG) sector in India is gaining momentum with significant policy support and ambitious goals. This initiative is expected to reduce reliance on fossil fuel imports and help achieve net-zero emissions.

According to IEA, India's natural gas consumption is forecasted to increase by nearly 60% by 2030, driven by robust growth in city gas distribution, industrial demand, and power generation. Since 2000, India's natural gas consumption more than doubled, exceeding 65 bcm/yr by 2023 or approximately 46.8 million metric tonnes. Between 2023 and 2030, gas consumption is projected to grow by nearly 60%, reaching 103 bcm/yr by 2030. The city gas distribution (CGD) sector is expected to lead this growth, supported by the rapid expansion of compressed natural gas (CNG) infrastructure. Heavy industrial and manufacturing sectors, such as iron and steel production, are also driving demand, collectively adding around 15 bcm/yr during this period. Gas use in oil refining is expected to increase by more than 4 bcm/yr as more refineries get connected to the grid. Gas demand in the power generation sector is projected to reach nearly 15 bcm/yr by 2030, driven by a recovery in large gas-fired power plants and the rapid expansion of gas use in captive power plants[1].

Biogas is a mixture of methane (CH_4), carbon-dioxide (CO_2) and small quantities of other gases produced by the anaerobic digestion of organic matter in an oxygen free environment. The methane content of biogas typically ranges from 45% to 75% by volume, with most of the remainder being CO_2. This variation means that the energy content of biogas can vary; the lower heating value (LHV) is

1 Executive summary – India Gas Market Report – Analysis - IEA

between 16 megajoules per cubic metre (MJ/m^3) and 28 MJ/m^3 (1 MJ is equal to 239 Kcal).

Biogas can be used directly to produce electricity and heat, or even as an energy source for cooking. Biomethane (also known as "renewable natural gas") is a near-pure source of methane produced by "upgrading" biogas (a process that removes any CO_2 and other contaminants present in the biogas). Thus, methane-rich biogas is an alternative to CNG and LPG. In India the government has issued directions to treating enriched compressed methane (minimum 90-95% methane) as equivalent to CNG and issued orders for mandatory blending of CBG with CNG[2] .

There are several government policies and programs promoting adoption of CBG in India:

Sustainable Alternative Towards Affordable Transportation (SATAT): The Ministry of Petroleum and Natural Gas (MoPNG) launched SATAT scheme to encourage entrepreneurs to set up CBG plants and supply CBG to Oil and Gas Marketing Companies (OGMCs) for sale as automotive and industrial fuel. Under the scheme the Government of India plans to roll out 5000 CBG plants of 15 MMTPA capacity in India in a phased manner.[3]

Swachh Bharat Mission (SBM) 2.0: It is estimated that INR 2718 crores are allocated for 15100 TPD of biomethanation plant capacities at 18 crores for 100 TPD processing capacity.[4]

Blending mandate: MoPNG announced the CBG Blending Obligation (CBO) with the aim to promote the production and use of CBG in India. The initiative mandates blending CBG into CNG (transport) and PNG (domestic) sectors of the City Grid Distribution (CGD) system. The CBO by itself is expected to encourage investment of Rs. 37,500 crores and the establishment of 750 CBG projects by 2028-29. The blending will be voluntary until FY 2024-25 and mandatory from FY 2025-26, starting with 1% blending in CNG/PNG consumption. The mandate will gradually increase to 5% by 2028-29.

Waste to Energy Programme of Ministry of New and Renewable Energy (MNRE) for FY 2021-22 to 2025-26: Provides Central Financial Assistance (CFA) of INR 1 Crore per 12000 cum/day generation of biogas or INR 4 Crore for 4800 kg/day generation of CBG.[5]

GOBAR-Dhan Scheme (Galvanizing Organic Bio-Agro Resources Dhan) 2018 – ongoing: A unified registration portal is established under the scheme to allow biogas/CBG plant operators to register and avail of benefits such as market linkages. This is coordinated by the Ministry of Jal Shakti (MoJS).[6]

Priority Sector for lending by the RBI and the Banks: The Reserve Bank of India (RBI) has reviewed and revised the Priority Sector Lending (PSL) guidelines aligning them with national priorities to support environmentally friendly lending practices. Under this revision loans up to ₹30 crore for renewable energy projects like solar power generators, biomass power, and other renewable energy

2_ WCPCD4825678_15052024_1.pdf

3 Sustainable Alternative Towards Affordable Transportation - Ministry of Petroleum And Natural Gas

4 swachh-bharat-2.pdf

5 Waste to Energy Programme | MINISTRY OF NEW AND RENEWABLE ENERGY | India

6 GOBARdhan (Galvanizing Organic Bio-Agro Resources Dhan)| National Portal of India

infrastructure will now qualify for PSL classification. For individual households, loans up to ₹10 lakh for renewable energy purposes are eligible. Loans for bio-fuel production, including bio-fuel extraction units, storage, distribution, and CBG plant setups, are also included[7].

Market Development Assistance (MDA) for Organic Fertilizers for FY 2023-24 to 2025-26: Supports the production and market development of organic fertilizers from biogas slurry by providing financial assistance to fertilizer manufacturers for organic fertilizers at the rate of INR 1500 per tonne. This is coordinated by the Ministry of Chemicals and Fertilizers (MoC&F).[8]

Challenges and Recommendations for Addressing them:

The sector faces the following challenges that can be addressed through the measures mentioned:

1. **Feedstock Availability and Management:** There is a shortage of suitable feedstock like agricultural residue mainly due to limited availability of equipment for collection and transport along with few incentives for farmers to collect and transport the residue. This is particularly the case for rice straw in northern states of India so government should continue to provide more incentives for collecting and transporting the agricultural residues.

   In case of wet fraction of Municipal Solid Waste (MSW) availability is a challenge due to limited source segregation of waste by citizens. Focused awareness programs and penalties can nudge the citizens to segregate the MSW. Dedicated vehicles and financing for collection and transport of segregated wet waste is also necessary and should be the focus of relevant government agencies.

2. **Limited CBG Distribution Infrastructure:** A lack of necessary infrastructure to transport and distribute CBG to end-users makes it difficult to expand its use as a fuel. While policies and incentives are in place to set up retail units and linking with natural gas pipelines the implementation of such measures is delayed and there is a need for closer monitoring and further incentivization of supporting CBG distribution infrastructure.

3. **Financing Issues:** Due to the significant cost of building and operating biogas plants and limited number of successful plants, financial institutions consider such projects as risky. Therefore, most small and medium sized businesses along with new entrepreneurs find it challenging to mobilize debt financing to implement CBG projects. Debt guarantee facilities and capacity building of professionals on CBG project financing can help resolve these challenges.

4. **Challenges in Fertiliser Control Order (FCO) standard compliance and access to Market Development Assistance (MDA):** As feedstock for CBG projects have multiple variations it leads to variations in characteristics of Liquid Fermented Organic Manure (LFOM) and Fermented Organic Manure (FOM). Maximum 70% moisture requirement and need for the product to pass through a 4 mm sieve are difficult parameters. A reasonable range for key parameters rather than exact values in FCO standard will be helpful in achieving compliance and accessing MDA. Removing current FCO retail licensing requirements for branded organic fertilsers will help sales of LFOM and FOM via any store.

5. **Shortage of Skilled Personnel:** A shortage of skilled technical personnel further hampers the sector. Therefore, there is a need to implement national level skills training through colleges and universities.

Strategic planning and collaboration among stakeholders are required to overcome these challenges and unlock the full potential of CBG in India. Addressing these issues through policy modifications, involving farmers as shareholders, and ensuring active participation can help realize the potential of the CBG sector.

7 https://satat.co.in/satat/assets/download/Annexure%20I%20-%20Inclusion%20of%20CBG%20under%20PSL.PDF

8 https://www.fert.nic.in/sites/default/files/2020-082023-09/Market%20Development%20Assistance%20policy%20to%20promote%20Organic%20Fertilizer.pdf

Bangur Energy: A Journey Toward Sustainable Energy and Innovation

Madhvi Bangur
CEO
Bangur Energy

In 2021, I founded Bangur Energy with a clear vision: to replace coal with renewable energy derived from India's vast agricultural surplus. As the founder and CEO, our goal has been to reduce dependence on coal while contributing to environmental conservation and energy security. Initially operating as part of Bangur Shree, a company focused on ash-based waste management, we soon realized the immense potential of biomass. This led to the formation of Bangur Energy as a standalone company, working with over 65 types of agro-waste to supply biomass for more than 35 types of industrial boilers.

The renewable energy sector in India has seen rapid growth, supported by policies like the National Bioenergy Policy and the National Action Plan on Climate Change (NAPCC), which have paved the way for financial incentives and greater awareness of biomass as a viable alternative to coal. Mentorship networks and industry associations also played a key role in helping us fine-tune our business model, expand our team, and chart out a path towards national growth.

However, the journey hasn't been without its hurdles. One major challenge was overcoming

scepticism about biomass energy's efficiency and cost-effectiveness. Through awareness campaigns and collaboration with industries, we demonstrated that biomass could significantly reduce carbon emissions while being a cost-effective fuel source. Another operational challenge was managing the logistics of sourcing and distributing biomass, which is often bulky and hard to access. To address this, we focused on local sourcing, thus reducing logistics costs and and making our supply chain more sustainable and reliable.

With our innovative biomass heat and steam generation systems we could retrofit existing coal-fired furnaces thereby allowing industries to transition to renewable energy without expensive new infrastructure. Our R&D efforts have also focused on improving biomass processing, and today we work with over 65 types of agro-waste, including rice husks and paddy straw, serving industries from textiles to food processing.

At Bangur Energy, we are focused on sustainability, innovation, and collaboration, creating value for our stakeholders—from farmers to industries. As we grow, our mission is to contribute to a cleaner, greener future for India and the world.

For aspiring entrepreneurs I would like to say that, the renewable energy sector offers vast opportunities, but it requires persistence and dedication. Bangur Energy's journey proves that renewable energy, driven by innovation and collaboration, is the future, and together, we can power industries while preserving our planet.

India's Emerging Biofuel Policy Ecosystem – Ethanol & CBG segments

Y B Ramakrishna
Sr. Vice president, IFGE,
Chairperson, IFGE: CBGPF &
Former Chairman- Working
Group on Biofuel MoPNG

Historical Background: For the time immemorial India has been a great advocate of Bioenergy for meeting its energy needs for cooking and heating. Even today biomass derived energy is a significant contributor to the India's energy basket. India has been a pioneer in harnessing the biomass potential for biofuels. India established its very first Biogas plant from Cow dung in Matunga, Mumbai in 1893. In modern times India established more than 4.5 million small and medium sized biogas units for meeting domestic cooking needs as well as domestic and industrial heating applications. India blended up to 20% Etahnol in Gasoline (called Power Petrol) in the city of Mumbai during 2nd world war to run all the BEST buses.

Drivers for Biofuels: India is a very large importer of energy. Almost 45% of its total energy consumed is imported. When it comes to petroleum crude the import is in the region of over 87% and ever increasing as our limited domestic reserves are fast depleting. Achieving energy self sufficiency and energy security is the prime driver. The other important driver is the climate change challenges being faced by the humanity. India is committed to reducing its carbon emissions and has a target to achieve NET ZERO emissions by 2070. Biofuels can significantly contribute towards our NET ZERO journey. The other driver unique to India is its commitment to agrarian society. India generates humongous volumes of agricultural residues and other wasted resources such as municipal solid and liquid wastes, organic industrial wastes, animal dung etc. These wasted resources can be harnessed to meet our energy needs while mitigating the environment challenges it poses with current methods of disposal.

Indian Initiatives in this millennia: Bangalore based voluntary organisation "Samagra Vikas" and "Indian Institute of Science, Bangalore" came together and created a document in 2002 which became the guiding document for the then Planning commission of India to announce "National Bio Diesel Mission" in 2002. A significant decision was made in early 2003 during the National workshop that was organised by Samagra Vikas & IISc jointly in March 2003, by the

hon. minister for Petroleum & Natural Gas Shri. Ram Naik under the able leadership of Hon. Prime Minister Shri Atal Bihari Vajpayee. The ethanol blending program was started in June 2003. Karnataka state 0came up with the Country's first biofuel policy in Mar 2009 and the UPA government at the centre came up with a National Biofuel policy in Dec 2009. The targets were set to achieve 20% ethanol blending in Petrol & 20% bio-Diesel in Petroleum diesel by 2017. While the policy itself was well drafted and ambitious targets were set the implementation lacked direction and commitment.

The Big Push: It was in 2014 when the NDA government was formed at the centre under the leadership of Hon. Prime Minister Shri. Narendra Modi a real big push was given for the Biofuel program in India. Ministry of Petroleum & Natural Gas under the leadership of Shri. Dharmendra Pradhan created a Biofuel Cell and also requested me to be his advisor on Biofuels. A national working group on Biofuels was constituted in June 2005 under my Chairmanship with members from OMCs, Research Institutions, Industry associations and representatives from various other ministries. A new national Biofuel policy-2018 was announced with a revised target to achieve 10% Ethanol blending in Petrol by Oct 2022 and 20% by Oct 2030. Similarly, the 5% blending target was set for Bio-diesel by 2030

Augmenting Ethanol supplies: It is to be noted that the Ethanol blending in 2014 was at 1.4% on Pan India basis and several steps were initiated such as a) Ethanol tax rationalisation and removal of interstate movement restrictions b) Introduction of administered Pricing and feed stock based

differential pricing policy c) Interest subvention schemes d) Introduction of Off take guarantees e) Creation of storage & blending infrastructure by OMCs. These policy enablers significantly helped improve the Ethanol supplies and the percentage blending started increasing. The 2018 policy was the game changer. The industry started expanding the capacities in addition to setting up 500+ new distilleries. Broad basing the feedstock by including B Molasses, sugar Syrup & Juice and damaged & surplus rice, and allowing corn/maize for Ethanol production saw a phenomenal raise in ethanol arrivals. India achieved the 10% blending target 5 months ahead of the set time line in May 2022. This gave the confidence to government to advance the 20% blending target to be revised to 2025 instead of 2030. It is heartening to note that over 18% blending was reported in Dec 2024 and well on target to achieve 20% in 2025-26 sugar year.

Looking beyond 1st Generation ethanol: Considering the humongous volumes of agricultural residues generated in India, the Ministry of Petroleum & Natural gas directed OMCs to set up 14 ligno cellulosic ethanol plants in India with both home-grown and imported technologies. These plants will make use of the agricultural residues to produce Ethanol and lignin as a coproduct. India has also taken the initiative to capture the tail end gases from petroleum refineries and subject it to gas fermentation to get Ethanol. While the Industry is addressing the challenges of scaling the technology and achieving commercial viability the policy enablers are yet to evolve for main streaming these technologies. Government has done quite well by offering capital subsidy/viability gap funding through PM JIVAN yojana, a mandate for use of 2nd/3rd generation ethanol as well as a pricing policy is overdue.

Ethanol Use beyond E20: All these initiatives has helped set up capacities to produce 16 billion liters of 1st generation ethanol a year. For E20 the requirement of ethanol will be about 10-11billion litres. Even after accounting another 3 billion litres for industrial application there will be more ethanol produced. Considering the complete ecosystem evolving on 2nd generation ethanol, very soon India will have surplus ethanol. Indian government has already started E100 sales from over 500 retail outlets and this will go up. The vehicle manufacturers have already announced ethanol

driven two/three wheelers and flexi engine cars. This will create very large market for E100 sales in India.

Ethanol to SAF: In our efforts to decarbonise the aviation segment, India has already announced blending obligation in ATF. SAF or sustainable aviation fuel which can be produced from Ethanol will significantly reduce the carbon emissions when blended with ATF. India has announced blending mandates for international flights to start with and will cover domestic flights and increase blending obligations significantly once we sign the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) agreement. However, a SAF policy is still in the offing. Various policy enablers for this market segment to come into existence are yet to be announced by the government.

Compressed Biogas (CBG) or Bio Methane: There exists several Biogas programs driven by MNRE and GOBAR-Dhan from Department of Water & Sanitation and a portal also has been developed. Under the SATAT (Sustainable alternative to affordable transportation) program initiated by MoP&NG the biogas will be upgraded to biomethane comparable to natural gas for transport application. SATAT is the most ambitious program at the global level and India is looking at setting up 5000 commercial plants to produce 15MMT of CBG/Biomethane from resources such as animal dung, agricultural residues, Industrial organic wastes, organic component of MSW and sewage.

The program itself was announced in Oct 2018. The progress was limited due to Pandemic and then for lack of policy enablers. SATAT was launched with 100% offtake guarantees and at a price which was considered favourable to industry with a floor price. Supply of CBG by cascades to retail outlet, gas pipeline injection and even direct marketing by CBG producers were allowed. Even creation of market for the Fermented Organic Manure (FOM) and CO2 were discussed. However, it took a while before some of the policy enablers were put in place. While some of the policies are facing challenges of effective implementation, many more are still work in progress. Some of the policy enablers empowering the sector are captured below.

- Government of India has announced the National Policy on Bio-Fuels 2018 vide gazette notification no.33004/99 dated 8.6.2018. The policy emphasizes on promotion of advanced Bio-fuels including CBG.
- The Galvanizing Organic Bio-Agro Resources Dhan (GOBAR-Dhan) scheme was launched by Government of India to convert cattle dung and solid waste in farms to Bio-CNG (CBG) and compost. GOBAR-Dhan scheme proposed to cover 700 projects across the country in 2018-19.
- Ministry of New and Renewable Energy (MNRE) has notified Central Financial Assistance (CFA) for Bio CNG.
- Vide Gazette Notification no. 395 dated 16th June 2015, Ministry of Road Transport and Highways, Government of India had permitted usage of bio-compressed natural gas (bio-CNG) for motor vehicles as an alternate composition of the compressed natural gas (CNG)

- Compressed Bio Gas (CBG) to be supplied shall meet IS 16087:2016 specifications of BIS
- Reserve Bank of India has notified inclusion of CBG projects under Priority Sector Lending vide directives to Banks dated 4.9.2020.
- Central Financial Assistance from Ministry of New & Renewable Energy. MNRE has created a portal - https://biourja.mnre.gov.in/ vide which application can be made to obtain Central Financial Assistance for CBG Plants. For plants under Bio CNG generation CFA of Rs 4.0 crore per 4800kg/day (1MW equivalent) can be availed. However Maximum CFA shall be Rs.10 Crore/project.
- State Bank of India has launched a financial product on financing of CBG Plants under SATAT scheme. The LOI holders from OMC's for setting up a CBG plant have to execute an agreement with OMC's which will be a valid and eligible document for applying for financing with SBI. Similar schemes are now announced by Punjab National bank also.
- As an enabling mechanism, inclusion of Bio-manure produced from CBG Plants under Fertilizer Control Order 1985 has been approved and notified vide Gazette Notification dated 14.7.2020 by Ministry of Chemicals & Fertiliser.
- Ministry of Chemicals & fertilisers announced its policy on Promotion of organic fertilisers in July 2023 including market development assistance of Rs.1500 per tonnes of FOM from CBG plants conforming to standards as per FPO order
- IOCL through a circular dated 20th May 2022 decided that the CBG prices were indexed to the prevalent retail selling price of CNG in the market (or CBG RSP for markets where CNG is not available) and the CBG procurement price was fixed with and without GST which approximately worked out to 80% of the RSP.
- MoP&NG approves financial assistance to CBG producers to buy biomass machinery, aiding biomass collection. The scheme allocates Rs.564.75 crore from FY 2023-24 to FY 2026-27
- Crop residues management guidelines (2023-24) issued by Ministry of agriculture and farmer welfare (MOA&FW) providing financial assistance to farmers for procurement of crop residue management machines on individual basis, establishment of custom hiring centres and establishment of crop residue/paddy straw supply chain
- MoA&FW announces in Oct 2022 convergence of agriculture infrastructure fund with GOBAR-Dhan under SBM (Gramin) including CBG plants establishment by eligible beneficiaries of AIF like PACS, Marketing Co-op Societies, FPOs, SHGs etc
- Mandatory blending of CBG in CNG, PNG of CGD network announced in Feb 2024 by MoP&NG – CBG Blending obligation (CBO) with 1%, 3%, 4% in FY 2025-26, 2026-27, 2027-28 and 5% 2028-29 onwards announced for CGD companies
- A scheme for injecting CBG in CGD network announced by MoP&NG in Mar 2024 with a total financial outlay of Rs. 994.50 crores during the FY 2024-25 to FY 2025-26

While these enablers have really helped the industry towards financial closures there are many issues still need clarification or intervention from the government. Some of these open issues still under consideration by the government are

- A revised CBG pricing which would attract big investment into the sector
- A clear guideline and creating the ecosystem for FOM offtake through mandating fertiliser companies to market FOM.
- A revision of market development assistance considering the real expenses involved in managing the FOM
- A clear guideline on gas injection into the pipeline and introduction of open access facility
- Guidelines on Issuance of stand-alone renewable gas certificates (RGC) and market mechanism
- Finalisation of carbon credit scheme under compliance market

Some of these enablers will help achieve the 5000 commercial plants target sooner and contribute towards our Net Zero journey. The government commitment is unprecedented and the industry is hopeful that all its legitimate expectations are fulfilled soon.

EverEnviro's Compressed Bio Gas (CBG) Plant in Indore Sets Global Benchmark in Sustainable Innovation

Mr. K A Chowdary
Chief Projects and Operations Officer- EverEnviro Resource Management Pvt Ltd

EverEnviro's Indore-based Compressed Bio Gas (CBG) plant sets a global benchmark in sustainability. Indore, a populous but beautiful city is recognized as India's cleanest Urban Local Body (ULB), boasting over 95% waste segregation. Once a landfill with 2 Lacs MT of waste, the facility now processes 550 MT of organic waste daily, producing 17 tons of BioCNG and 40 MT of organic fertilizer. Over 20 years, it aims to prevent 4 million tons of waste accumulation.

Operated by Indore Clean Energy Pvt Ltd under EverEnviro, it is India's largest MSW-based CBG facility. The plant has attracted national and international delegates, including British High Commissioner Alex Ellis and Nepal's Mayor Chiri Babu Maharjan. This initiative significantly contributes to Indore's cleanliness efforts and aligns with India's Swachh Bharat Mission for 'Garbage Free Cities.' It exemplifies the transformative potential of CBG technology in sustainable waste management and environmental conservation.

The Indore Plant - A Beacon of Hope for Environment Sustainability

Cleanliness Drive: EverEnviro leads Indore's largest cleanliness initiative, training municipal workers in proper waste segregation.

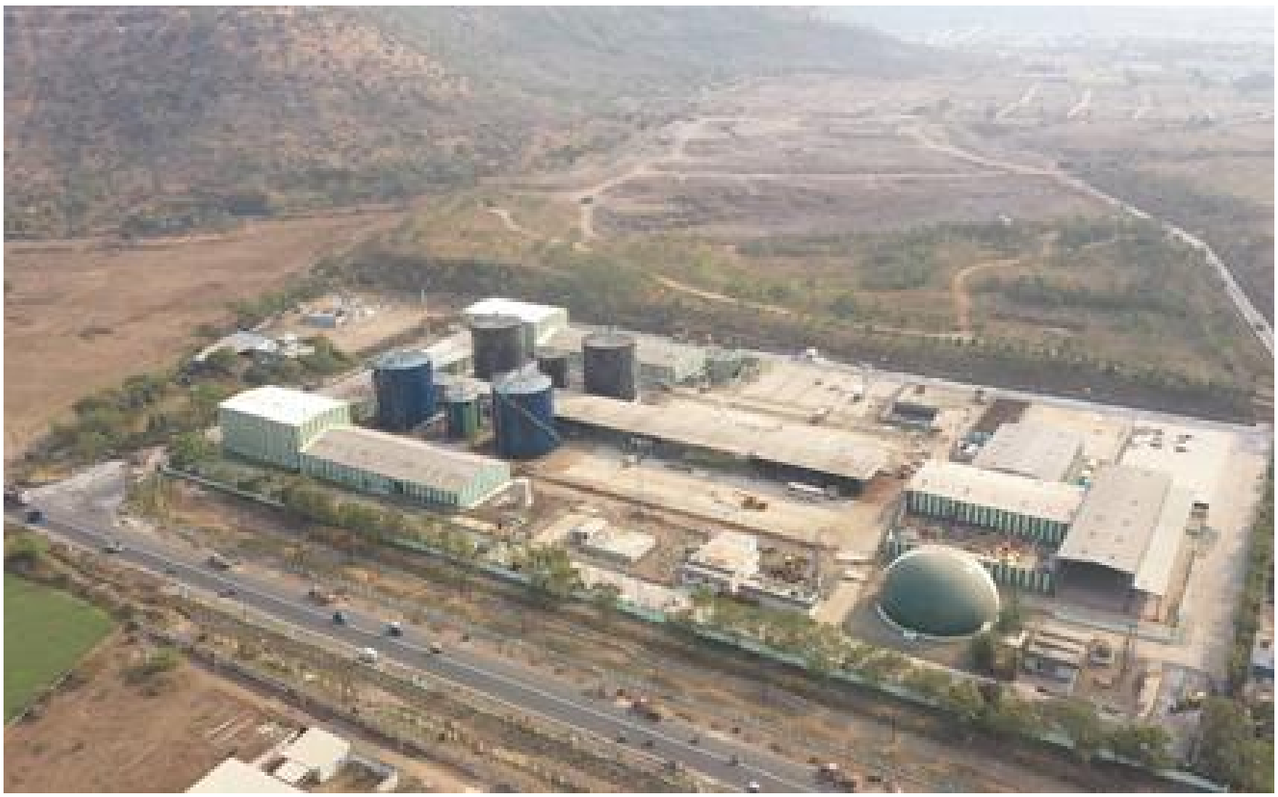
Waste Collection and Processing: The process starts with collecting wet and dry waste, where plastics and metals are removed to ensure only green waste reaches processing.

Processing and Digestion: Daily, 45-55 trucks transport waste through a bunker, hammer mill, and digester for anaerobic digestion.

Biogas Production: Over 30-40 days, microbes break down the waste, producing biogas with 96% methane content. This high-quality biogas is then compressed to 250 bars, highlighting the plant's success in sustainable waste management.

Success Amid Challenges

India's first large-scale compressed



biogas (CBG) facility faced early operational challenges, causing fluctuating production levels. Overcoming these hurdles required strategic planning and substantial investment in advanced global technology, machinery, and skilled manpower to efficiently process source-segregated organic waste.

Now, the facility is India's first CBG project to reach full operational capacity. In collaboration with the Indore Municipal Corporation, it consistently produces nearly 15 tonnes per day (TPD) of CBG, hitting a record 18 TPD in March 2024. The site, once burdened with 200,000 metric tonnes (MT) of waste, now processes 550 MT of organic waste daily.

This initiative has significantly reduced greenhouse gas emissions, preventing 1,77,305 tonnes of CO_2 annually, improving environmental quality for 4.3 million residents. Integrated into Avantika Gas Limited's (AGL) network, the plant supports eco-friendly fuel adoption for 15,000 households. Additionally, it produces 17 tonnes of biofuel and 40 MT of organic fertilizer daily, reinforcing its role

in sustainable waste management.

Mr. KA Chowdary, Chief Project and Operations Head at EverEnviro Resource Management Pvt Ltd, *"Stabilizing this pioneer facility in India was initially challenging for our team. During the initial testing phase, significant investments were made in technologies and machinery to effectively manage source-segregated waste, the most suitable input for the plant. We are proud to announce that, through continuous learning and effort, we have successfully reached nearly 100% operational capacity."*

Testimonials:

H D Wire was utilizing natural gas at its manufacturing facility for heating needs. However, after thorough discussions and addressing all concerns, we have successfully implemented CBG as our primary heating fuel for our processes. We have noticed no difference in calorific value compared to natural gas, and the supply has been consistently prompt from EverEnviro's CBG

plant. We are delighted to contribute to reducing pollution in Indore, known as the cleanest city in India, **says officials from HD Wire**

We intend to source CBG from Indore Clean Energy to mitigate the carbon footprint at the Tata International facility in Indore. EverEnviro has provided us full support, offering a PRS station and three vehicles dedicated to transporting CBG exclusively for Tata International's Dewas operations, ensuring uninterrupted Bio-CBG supply. This initiative has enabled us to cease the use of coal within our premises, **says Sanjay Kapoor, Tata International**

L&T's TLT Pithampur factory uses CBG as process fuel for heating. The machinery/equipment was installed and maintained by EverEnviro's Indore Clean Energy Pvt Ltd. This is considered cleaner and greener than earlier fuel since CBG is being processed and produced from waste and follows the principle of Reduce, Recycle, Reuse. CBG supplied has good calorific value. It is continuous and economical compared to the fuel used earlier. We are happy to use absolute green molecules generated from waste", ***says an official from L&T.***

Expansion of CBG Facilities: EverEnviro is developing 20 CBG projects in MP, UP, Delhi, and Punjab, investing ₹2000 Cr to produce 320 TPD of CBG.

Fermented Organic Manure Production: The CBG plant produces Fermented Organic Manure (FOM), an eco-friendly fertilizer vital for soil health and regenerative agriculture, launching in the mainstream market by FY '24

Testimonial: *"The organic manure, Kissan Amrit, produced at EverEnviro's Compressed Biogas plant, has helped improve the physicochemical properties of the soil on our farmland, preserving soil quality and enhancing crop productivity. As a result, the yield has increased, and we are receiving maximum benefits from the production. Moreover, we have seen improvement in the carbon content within the soil," says* **Piyush Tiwari from village Tajpura, District Khargone , MP**

The Way Forward

EverEnviro's Indore Clean Energy Pvt Ltd plant is making a significant environmental impact by preventing over 1 lakh MT of carbon emissions and replacing 20,000 litres of fossil fuel daily, reducing GHG emissions. Over the next 20 years, it aims to divert over 4 million tonnes of waste.

The plant also supports cleaner transportation, with the Indore Municipal Corporation using 50% of its CBG output, reducing diesel dependency in buses and lowering CO2 emissions. Beyond waste management, its success extends to sustainable agriculture and future initiatives like compost production.

Established by EverEnviro Resource Management Pvt Ltd, the plant showcases how private entities can drive environmental responsibility. Challenges have provided learning opportunities, reinforcing its role in sustainability. With ongoing plans, the Indore facility stands as a model for cleaner energy and waste management solutions.

SAMARTH Mission: An Initiative by Ministry of Power

Satish Upadhyay
Mission Director- SAMARTH, National Mission on Biomass, Ministry of Power, Government of India and ED (Fuel Management), NTPC Limited

Perspective on Indian Solid Biofuel Sector

India is focussing on decarbonisation and sustainability, with initiatives like the National Mission on the Use of Biomass in Thermal Power Plants, also known as SAMARTH Mission (Sustainable Agrarian Mission on the Use of Agro-Residue in Thermal Power Plants) under the Ministry of Power, which taps India's agricultural residue. India being an agrarian state, produces around 755 million tonnes of agricultural residues annually, where 228 million tonnes of biomass is a surplus, which translating to an energy potential of 28,445 MWe.

The SAMARTH Mission was launched by the Ministry of Power on 12.07.2021, to address environmental challenges, with the goal of reducing air pollution caused by stubble burning, especially in Northern India, and cutting carbon emissions through biomass co-firing in coal-based thermal power plants. It also aims to replace part of the fossil fuel usage with renewable biomass sources. Additionally, the mission supports the economic empowerment of farmers by creating a structured market for agricultural residues, providing an alternative income stream. Ultimately, it facilitates India's transition from coal dependency to renewable energy sources, aligning with the country's climate goals under the Paris Agreement.

Mission was constituted by forging eight organizations like Central Electricity Authority (CEA), National Thermal Power Corporation's (NTPC), Bureau of Energy Efficiency (BEE), Ministry of New & Renewable Energy (MNRE), Damodar Valley Corporation (DVC), Central Power Research Institute (CPRI), Bharat Heavy Electricals Ltd. (BHEL) and National Power Training Institute (NPTI).

SAMARTH Mission formulated enabling policies to provide necessary boost to solid biofuel (i.e. pellets) sector. The revised Biomass Co-Firing Policy, modified vide OM dated 3rd May and 16th June 2023, mandates all TPPs to co-fire 5-7% biomass pellets with coal. As of FY 2024-25, thermal power plants are required to co-fire with 5% biomass, and this is expected to increase to 7% by FY 2025-26. Given that India's thermal power plants currently use approximately 700 million tonnes of coal per year, achieving this mandate would make India the single largest producer and user of biomass pellets for power generation worldwide.

Government policies and initiatives are driving biomass pellet co-firing in thermal power plants. The enactment of the Electricity Act 2003 marked a paradigm shift within the power sector with an emphasis on renewable power including bioenergy. The Central Electricity Regulatory Commission (CERC) has issued provisions for the pass-through of landed cost in Energy Charge Rate (ECR) & Capital cost related to biomass co-firing in its Tariff Regulations 2019. In 2019, the Ministry of New and Renewable Energy (MNRE) recognized biomass co-fired power in Thermal Power Plants, as renewable energy & thus eligible for Renewable Purchase Obligations (RPO). The Commission on Air Quality Management (CAQM) mandated up to 5-10% biomass co-firing for TPPs identified within 300 kms of Delhi, with the Supreme Court directing compliance of the minimum threshold. The Ministry of Environment (MoEF&CC) introduced Environment (Utilisation of Crop residue by Thermal Power Plants) Rules in 2023 for mandatory usage of minimum 5% blend of pellets or briquettes made of crop residue

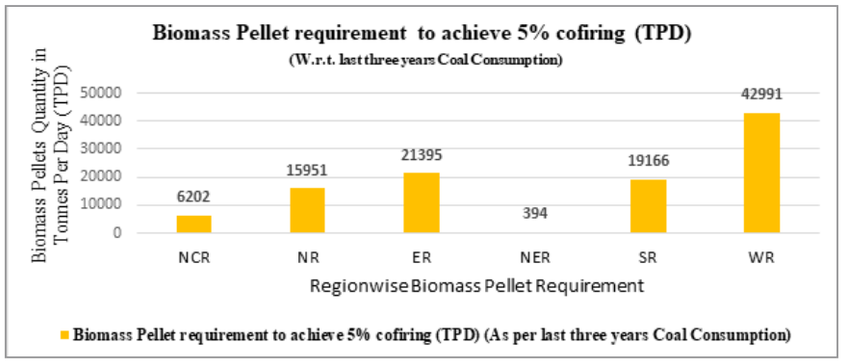
along with coal in TPPs. In which, non-compliance of the rule shall attract Environmental compensation from the thermal power plants on annual basis at the specified rates from 2024-25 onwards.

The National Mission on the use of Biomass in Thermal Power Plants has introduced several executive directives to support the solid biofuel sector, specifically for utilisation of agro-residue based pellets in thermal power plants. Key enabling guidelines include the issuance of a Model SOP for biomass co-firing in PF & FBC boilers, a Standard Bidding Document for biomass procurement, and benchmark price for torrefied pellets in NCR and non-torrefied biomass pellets for coal-based TPPs in NCR, NR & WR. To ease business processes, the government has facilitated administrative approvals for biomass pellet plant installation through the National Single Window System and identified 'biomass pellet manufacturing' under Priority Sector Lending by the RBI. Additionally, agro-residue trading is enabled through the e-Nam portal, and a GeM portal for biomass pellet procurement has been established.

Government of India through MNRE, is providing 'Central Financial Assistance' under 'Biomass Programme' to promote pellet/briquette manufacturing pan India. Whereas, the CPCB grant scheme is dedicated to pellet manufacturers of the NCR region. With all these legislative, executive, and financial measures government of India is building a conducive environment to promote biomass pellet market.

Biomass-Pellet Demand & Market Scenario

The demand for biomass pellets, based on the 5% biomass co-firing mandate for thermal power plants, is as follows: Western Region (WR) accounts for 41%, Eastern Region (ER) for 20%, Southern Region (SR) for 18%, and Northern Region (NR) for 15%. However, the actual co-firing levels in these regions are still in the early stages.

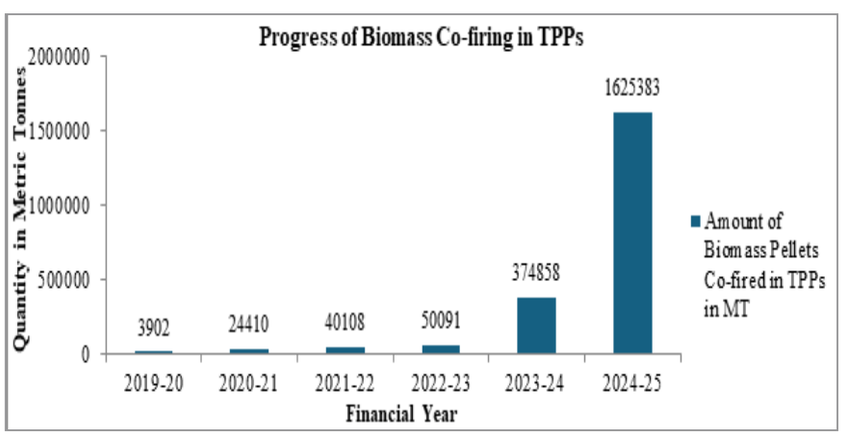


Thermal Power Plants (TPPs) in the NCR region have marked substantial progress in biomass co-firing, driven by consistent interventions from the Ministry of Power, SAMARTH Mission, Central Electricity Authority (CEA), and the Commission on Air Quality Management (CAQM), along with the imposition of Environmental Compensation (EC) by the Ministry of Environment, Forest, and Climate Change (MoEF&CC). Provision like Environmental Compensation (EC) by MoEF&CC, for non-complying TPPs may be expanded to other regions also.

For fiscal year 24-25, biomass consumption from April 1st to March 31st stands at 16,25,383 Metric Tonnes (MT), marking a remarkable increase of

Did You Know?

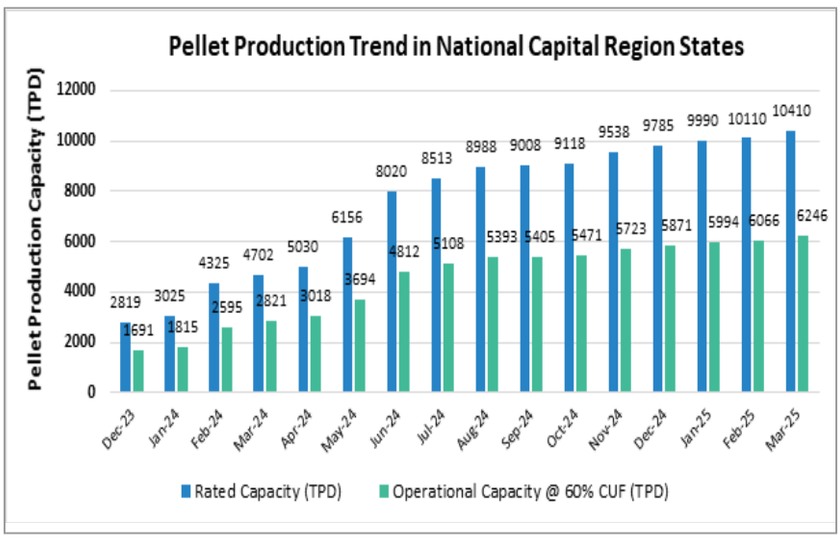
In India, NTPC Dadri project was the first coal-based PF boiler thermal power plant which has started biomass pellets co-firing since Nov' 2019.



approximately 4.4 times compared to thein the previous fiscal year, which was recorded 3,07,750 MT. The adoption of biomass pellets in thermal power plants has witnessed a significant surge in the country, with usage increasing approximately 40 times in FY 2024-25 compared to FY 2021-22. This remarkable growth highlights the success of efforts to integrate biomass co-firing as a sustainable energy solution.

On the supply side, India has a robust infrastructure for biomass pellet production, comprising approximately 680 manufacturing plants capable of producing briquette as well as pellet based on demand. Among these, over 300 plants specialize in pellet manufacturing, as per data available with the SAMARTH Mission. These facilities are strategically distributed across various states to cater to the needs of power plants and other allied industries (such as steel, cement, aluminum, brick kilns etc.).

Currently, India's biomass pellet manufacturing capacity stands at 11.56 million tonnes per annum. However, briquettes dominate the market due to their widespread use as a heat source in industries such as manufacturing, cement, and food processing. This highlights the dual significance of biomass fuels, not only in energy generation but also as a critical resource for industrial heating applications. We have registered strong growth in the pellet manufacturing capacity in National Capital Region (NCR) States.



Since its launch in July 2021, the SAMARTH Mission has achieved several key milestones. By March 2025, 68 thermal power plants in India have adopted biomass co-firing, utilizing 21.18 Lakh MT of biomass and reducing ~ 25 Lakh MT of CO2 emissions, with plants in the NCR achieving notable success. The mission has also created significant economic impact, offering farmers an additional revenue stream. A market worth ₹15,000-20,000 crore is being developed for farmers, while the pellet manufacturing industry could generate a turnover of ₹28,000-35,000 crore annually. Capacity-building efforts have reached over 10,000 stakeholders through 78 programs across 18 states. Additionally, 18 BIS standards for solid Biofuels, grants from MNRE and CPCB have been issued enabling pellet manufacturing sector. The SAMARTH portal enhances logistical integration, connecting stakeholders and providing real-time updates.

To further increase the usage of biomass a comprehensive approach is needed from focusing on supply chain development to create stable demand. Key strategies include enrolling biomass aggregators, providing necessary equipment and working capital, ensuring storage space, enabling time-bound offtake of quality pellets, and implementing regulatory measures. The inefficiency and information asymmetry can be mitigated by leveraging digital platforms for broader accessibility. Additionally, improving raw material aggregation and building storage infrastructure are crucial for supply chain reliability. A stable demand from end users is critical & it requires coordinated efforts from state and central ministries, including Agriculture, Environment, Power, and Renewable Energy. Policies that incentivize thermal power plants to co-fire biomass pellets can further drive this sector growth.

The solid biomass industry, particularly biomass pellets, holds significant potential to drive the bioenergy sector, boosting the rural economy, raising farmers' incomes, and supporting the MSME sector, which is vital for a developing nation. With further strategic actions like focused stakeholder engagement, infrastructure development, and policy coherence, India can be a global leader in biomass utilization. SAMARTH's holistic vision aligns with India's climate commitments and ushers in a new era of renewable energy solutions, marking a milestone in the journey toward a cleaner & greener future.

Uttar Pradesh: Leading the Charge in Bio-Energy Innovation and Sustainability

Narendra Bhooshan, IAS
Additional Chief Secretary,
Energy and Additional Energy
Department, Uttar Pradesh

At COP26, Prime Minister Narendra Modi introduced the "Panchamrita" principle, reaffirming India's commitment to global sustainability. While many developed nations have hesitated to act, India is stepping forward, with Uttar Pradesh (UP), the nation's most populous state, playing a crucial role in realizing this vision. Under Chief Minister Yogi Adityanath's leadership, UP has launched forward-thinking policies such as the Solar Energy Policy 2022, Bio-Energy Policy 2022, and the Green Hydrogen Policy 2024. Among these, UP's bio-energy initiatives are especially noteworthy for their environmental and rural empowerment focus.

Uttar Pradesh's Bio-Energy Policy 2022: A Green Revolution

The Uttar Pradesh Bio-Energy Policy 2022 addresses significant challenges like agricultural residue management and clean energy generation. It aims to reduce environmental harm, enhance farmers' incomes, and create rural employment opportunities. One of the policy's key goals is to establish at least one bio-energy project in each administrative block (tehsil), fostering community empowerment and aligning local efforts with national energy targets.

The policy outlines ambitious targets, including development of:

- 1,000 TPD (tons per day) of Compressed Biogas (CBG) projects
- 2,000 KLPD (kilolitres per day) of Bio-Diesel projects
- 4,000 TPD of Bio-Coal projects

The Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA) is overseeing the execution of these plans.

Incentives and Subsidies: Fueling Bio-Energy Development

To encourage investments, the state has introduced attractive incentives for bio-energy projects like ₹75 lakh per ton for CBG, ₹75,000 per ton for Bio-Coal and ₹3 lakh per kilolitre for Bio-Diesel

In addition, projects can receive subsidies up to ₹20 crore, alongside central government incentives. Bio-manure, a by-product of CBG plants, has been recognized as "Fermented Organic Manure" under the Fertilizer Control Order, increasing its market value.

Agricultural Mechanization Scheme offers further financial assistance, including 30% subsidies (up to ₹20 lakh), for procurement of agricultural equipment like balers and rakers.

Infrastructure and Land Support: Easing Project Development

The state provides vital infrastructural and land support:

- 100% exemption from electricity duty for up to 10 years
- Subsidies for access road construction (up to 5 km) with a maximum investment of ₹50 crore
- Exemption from stamp duty for land acquisition
- Simplified land-use permissions

Government land is available at minimal lease rates:

- ₹1 per acre annually for government entities
- ₹15,000 per acre annually for private entities, with leases extending up to 30 years

Progress and Achievements: Setting a National Benchmark

UP's proactive approach is yielding impressive results. The state leads India in CBG production, with 24 plants operational and a combined capacity of 210 TPD. A total investment of of ₹2,676 crore has been made so far in various initiatives. Approval of 62 projects, including 47 CBG plants (518 TPD), 6 Bio-Coal plants (252.60 TPD), and 9 Bio-Diesel plants (438 KLPD) is in place alongside In-principle approval for 135 more projects, attracting ₹7,128 crore in investments.

With the success of CBG plants, UP aims to double the capacity, reaching 2,000 TPD of CBG, significantly reducing fossil fuel imports, and saving valuable foreign exchange.

Strategic Collaborations for Technical Excellence

To ensure the technical success of bio-energy projects, Uttar Pradesh has partnered with esteemed institutions like IIT Delhi and IIT Kanpur. These collaborations provide critical technical expertise, ensuring that the projects meet global sustainability standards.

Synergy Between GoI and GoUP

The Government of India (GoI) has been promoting bio-energy through policies like the National Biofuels Policy, which focuses on producing biofuels from non-food feedstocks. The Bio-Energy Policy 2022 of Government of Uttar Pradesh (GoUP) aligns with these national efforts by promoting clean energy and agricultural residue management. The collaboration between GoI and the state ensures effective policy implementation, sharing of resources, and financial incentives, thereby significantly advancing bio-energy adoption in Uttar Pradesh.

A Vision for Rural Empowerment and Sustainability

Uttar Pradesh's bio-energy initiative is not just about environmental sustainability; it's also a blueprint for rural empowerment. By addressing waste management and fostering clean energy, the state reduces its carbon footprint while improving rural livelihoods.

With a strong policy framework, attractive incentives, and strategic partnerships, Uttar Pradesh is setting the stage for a greener, more prosperous future. As the world confronts climate change, the state's bio-energy revolution demonstrates how innovation and investment can drive global sustainability.

Celtic Renewables: Leading the Green Chemical Revolution

Mark Simmers
CEO, Celtic Renewables

As the world transitions to a low-carbon future, waste biomass is emerging as a key resource for sustainable innovation. With increasing regulatory pressure, corporate net-zero commitments, and consumer demand for eco-friendly products, companies like Celtic Renewables are pioneering bio-based solutions that drive a circular economy.

A Circular Approach to Green Chemicals

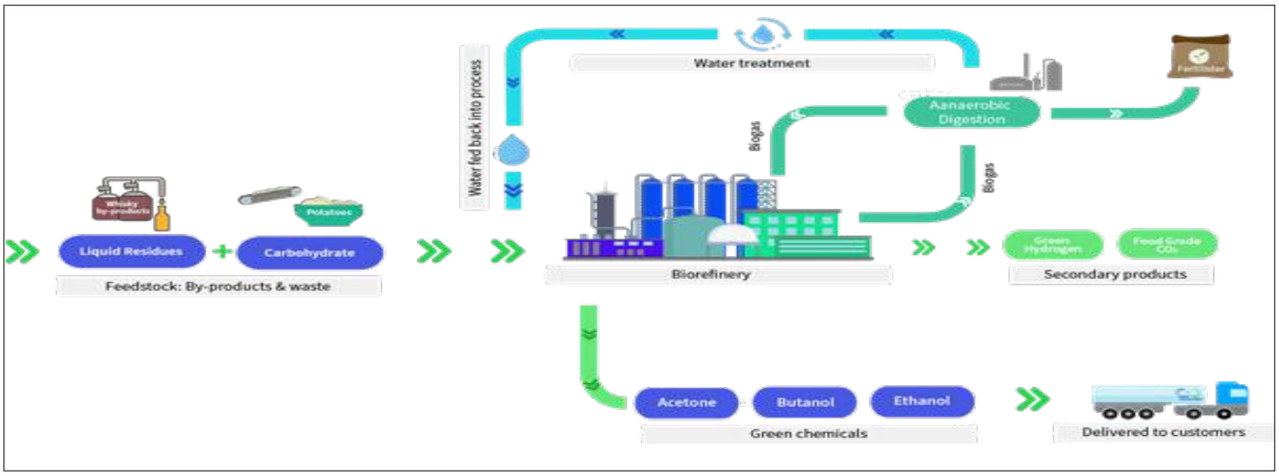
Celtic Renewables, a Scotland-based biotechnology company, is transforming the chemical industry using ABE (Acetone-Butanol-Ethanol) fermentation. Their process converts 100% bio-based feedstocks into green chemicals, replacing fossil-based alternatives in everyday products like medicines, cosmetics, paints, and cleaning supplies.

With the chemical industry consuming 10% of global fossil fuels, sustainable alternatives are more urgent than ever. Celtic Renewables envisions a world where repurposed biomass, rather than fossil fuels, serves as the foundation for chemical production.

The process: Transforming By-products & Waste into High-Value Green Chemicals

By utilizing by-products and waste from various industries such as whisky production residues, reject potatoes, and molasses, Celtic Renewables produces bio acetone, bio butanol, and bio ethanol. These sustainable chemicals help industries like pharmaceuticals and personal care. It also enables specialty chemicals to reduce their carbon footprint while adding value to waste streams

Its patented process offers up to 65% fewer carbon emissions than fossil-based counterparts while producing chemically equivalent, biodegradable alternatives:



- Bio Acetone: Used in printing inks, cosmetics, and pharmaceuticals.
- Bio Butanol: Found in adhesives, paints, cosmetics, biofuels, and food ingredients.
- Bio Ethanol: Used in surface cleaners, perfumes, and detergents.

From Linear to Circular: A Sustainable Model

Traditional economies follow a linear approach; extract, produce, consume, discard. Celtic Renewables is pioneering a circular model, where 100% bio-based inputs create high-value chemicals without waste. This approach enables industries like pharmaceuticals and personal care to meet net-zero goals, cut fossil fuel reliance, and reduce carbon emissions, benefiting businesses, consumers, and the environment alike.

Celtic Renewables is setting a new standard in the chemical industry, proving that sustainability and innovation can go hand in hand.

A fully circular solution: Bioenergy

From feedstock to end-product, Celtic Renewables delivers a fully circular solution. A process that uses above-the-ground carbon from by-products and waste to produce green chemicals, with further complementary processing to also produce hydrogen, food-grade CO2, biogas and clean water, which can be reintegrated back into the Celtic Renewables' process or sold to end users.

A Future Powered by Green Chemicals

Celtic Renewables exemplifies true circularity, proving its positive impact on the planet. The UK's Innovation Strategy (2021) highlighted biotechnology's role in transitioning to a bio-based economy, predicting waste-derived alternatives could replace 80% of fossil-derived products by 2035.

Their innovative efforts support this shift, showcasing how alternative technologies and feedstocks drive the chemical sector's net-zero strategy. Scotland's Deputy First Minister, Kate Forbes, recognized Celtic Renewables' flagship biorefinery in Grangemouth as a key player in Scotland and the UK's bioeconomy, affirming its role in net-zero progress and economic growth.

Market Growth and Global Expansion

With a US$2 billion immediate market opportunity and global demand exceeding US$110 billion, Celtic Renewables is scaling operations. Their first commercial plant in Scotland is exporting green chemicals worldwide, with larger-scale projects in development. Expansion plans include a build-own-operate model in the UK and Ireland, alongside joint ventures and technology licensing for global deployment.

International Opportunities: India

Celtic Renewables is exploring projects in India, Southeast Asia, the Caribbean, and North America. As an industrial member of the Clean Ganges Programme since 2018, they see significant potential in India's drinks industry and agricultural by-products.

Mark Simmers, CEO of Celtic Renewables stated: "Celtic Renewables is very excited about the opportunity to bring our process technology to India and to help drive the transition to Net Zero there. We are very interested in developing partnerships to develop biorefineries across India and enable the production of green chemicals from abundant biomass available there."

Bioenergy in India: A Budgetary Boost for a Sustainable Future

Vaibhav Dange
Founder Director, IFGE

The Union Budget for 2025-26, presented by Hon'ble Finance Minister Nirmala Sitharaman, has brought cheer to the renewable energy sector, particularly bioenergy. The budget has allocated significant funds to promote bioenergy, recognizing its potential to reduce India's dependence on fossil fuels, mitigate climate change, and create employment opportunities.

Bioenergy: A Growing Sector in India

India's bioenergy sector has reached a significant milestone as of January 31, 2025, with a total installed capacity of 11,406.57 MW across various segments. The sector's backbone lies in biomass-based cogeneration, where bagasse-based plants lead with an impressive 9,821.32 MW capacity, while non-bagasse cogeneration facilities contribute 921.79 MW. The waste-to-energy initiatives have also gained traction, with waste-to-power plants generating 279.54 MW and off-grid waste-to-energy projects adding another 383.92 MW to the mix. This strong infrastructure forms a vital component of India's renewable energy landscape, which now stands at 213.70 GW.

The bioenergy sector's growth trajectory remains strong, evidenced by a 4.6% increase from the previous year's 10.84 GW to the current 11.34 GW, highlighting the sector's expanding role in India's sustainable energy future. This steady progress underscores the country's commitment to diversifying its energy sources while tackling agricultural waste management and rural energy needs.

Budgetary Provisions for Bioenergy

The 2025-26 budget has made several provisions to promote bioenergy in India. Some of the key announcements include:

- Increased Allocation for Bioenergy: The budget has allocated ₹1,500 crores for the development of bioenergy, a significant increase from the previous year's allocation.
- Viability Gap Funding: The government has announced viability gap funding for bioenergy projects, which will help bridge the gap between the cost of production and the market price of bioenergy.
- Tax Incentives: The budget has proposed tax incentives for bioenergy producers, including a 10-year tax holiday for new bioenergy projects.
- Research and Development: The government has allocated funds for research and development in bioenergy, focusing on improving efficiency, reducing costs, and developing new technologies.

Impact on the Bioenergy Sector

The budgetary provisions for bioenergy are expected to have a positive impact on the sector, driving growth, innovation, and employment. Some of the key benefits include:

- Increased Investment: The allocation of ₹1,500 crores and viability gap funding are expected to attract increased investment in the bioenergy sector.
- Job Creation: The growth of the bioenergy sector is expected to create employment opportunities in rural areas, contributing to the government's goal of doubling farmers' incomes.
- Reduced Dependence on Fossil Fuels: The promotion of bioenergy will help reduce India's dependence on fossil fuels, mitigating climate change and improving energy security.
- Improved Air Quality: The use of bioenergy will help reduce air pollution, improving the quality of life in urban and rural areas.

Now it is the time to drive India's bioenergy growth, and stakeholders need to adopt strategic actions. Bioenergy producers should align projects with the National Bio Energy Mission, invest in R&D for second-generation biofuels, and collaborate with agricultural cooperatives to cut feedstock costs. Investors should prioritize viability gap funding-eligible projects, diversify into biogas and advanced biofuels, and leverage tax incentives. Policy makers must streamline approvals, ensure transparent access to Rs 500 crore biofuel funds, and establish public-private R&D partnerships. Equipment manufacturers should develop Battery Energy Storage System for grid stability, produce cost-effective local components, and advance bioenergy technologies. These efforts will enhance sustainability, innovation, and energy security.

Way Forward

The 2025-26 budget has provided a significant boost to the biofuels sector in India. To achieve the government's targets, it is essential to:

- Increase Awareness: Create awareness among farmers, entrepreneurs, and consumers about the benefits of biofuels.
- Develop Infrastructure: Develop infrastructure for the production, storage, and distribution of biofuels.
- Encourage Research and Development: Encourage research and development in biofuels to improve efficiency, reduce costs, and develop new technologies.
- Provide Incentives: Provide incentives to entrepreneurs and farmers to invest in the biofuels sector.

In the end overall, the 2025-26 budget has provided a significant boost to the bioenergy sector in India. The allocation of funds, viability gap funding, tax incentives, and research and development initiatives will drive growth, innovation, and employment in the sector. As India continues to transition towards a low-carbon economy, the promotion of bioenergy will play a vital role in achieving the country's sustainable development goals.

Beyond Words

Harvir Singh
Editor-in-Chief
Rural Voice and Rural World

Stubble Burning Continues as Farmers Struggle with Costs and Alternatives; Untapped Bioenergy Potential Highlights Policy Gaps

Despite widespread awareness of the environmental and health hazards of stubble burning, Indian farmers continue to rely on this age-old practice due to financial and logistical barriers. A recent survey conducted by the Indian Federation of Green Energy (IFGE) underscores the persistent challenges that make sustainable alternatives unviable. Small landholdings, expensive machinery, and an unorganized biomass procurement system remain major obstacles, preventing large-scale adoption of eco-friendly solutions.

Why Farmers Still Burn Stubble

While farmers recognize the dangers of stubble burning—including air pollution, soil degradation, and respiratory illnesses—they cite economic and practical constraints as key factors. The narrow window between harvest and the next sowing season forces them to clear fields quickly, leaving few viable options apart from burning.

Manual removal and alternative disposal methods, such as mulching or composting, are often too expensive or logistically challenging. Additionally, biomass collection and storage require significant investment, with only a handful of buyers—primarily brick kilns—offering unpredictable rates.

Bioenergy: A Missed Economic Opportunity

The IFGE survey highlights a mixed response towards bioenergy solutions. Many farmers acknowledge the potential for selling crop residues for biomass-based energy production but stress that procurement is unorganized, labor-intensive, and financially unviable.

While some farmers expressed interest in adopting biogas plants or biomass gasifiers, they cited high setup costs, lack of technical support, and an absence of government-backed price guarantees as deterrents. A significant number of respondents also admitted to being unaware of existing bioenergy initiatives, pointing to a critical need for awareness campaigns and farmer outreach programs.

Government Schemes & Policy Gaps

Several government initiatives, including SATAT (Sustainable Alternative Towards Affordable Transportation), GOBARDHAN (Galvanizing Organic Bio-Agro Resources Dhan), and PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan), have been introduced to promote bioenergy and sustainable agriculture. However, the survey reveals key shortcomings:

1. Lack of Awareness & Accessibility: Many farmers are unaware of government schemes, subsidy structures, and financial support mechanisms.
2. High Initial Investment: Setting up biogas plants, biomass pellet units, or crop residue-based power plants requires capital investment beyond the reach of small and marginal farmers.
3. Procurement & Market Instability: The absence of long-term price agreements and an organized procurement system makes biomass-based income unreliable.
4. Limited Infrastructure & Machinery Support: Subsidized Happy

Seeders, Super Straw Management Systems, and baling machines remain out of reach for many due to limited distribution and high operational costs.

The Way Forward: Strengthening Policy for Scalable Solutions

To effectively combat stubble burning and unlock India's bioenergy potential, the following reforms are essential:

- Guaranteed Price for Biomass: Government-backed, long-term price agreements for biomass procurement can ensure a stable market for farmers.
- Incentives for Crop Residue Management: Direct per-acre incentives for adopting sustainable practices, similar to Minimum Support Prices (MSP), can encourage large-scale participation.
- Decentralized Bioenergy Centers: Establishing village-level bioenergy hubs with government support can reduce logistical barriers and boost participation.
- Affordable Machinery Access: Expanding subsidies and rental services for straw management machines can make alternatives more accessible.
- Farmer Training & Awareness Campaigns: Proactive outreach programs must bridge the knowledge gap on bioenergy benefits and available government support.

Conclusion: Time for Bold Policy Interventions

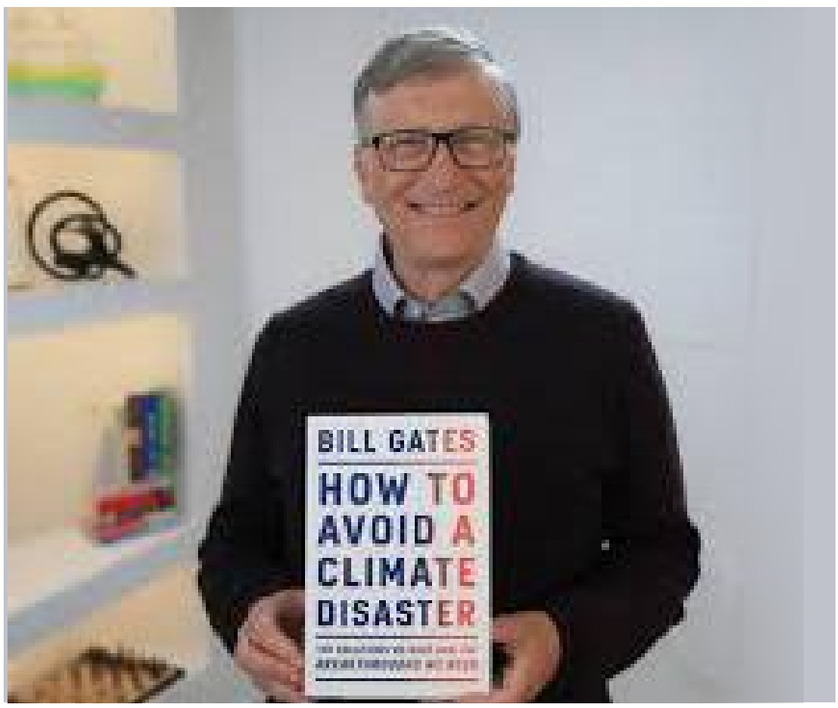
The IFGE survey underscores that farmers are willing to embrace non-burning alternatives, provided there is assured profitability, better infrastructure, and strong policy backing. While bioenergy presents a tremendous opportunity for both rural economies and environmental sustainability, its potential remains largely untapped due to policy gaps and inadequate support systems.

The Indian government must act decisively to restructure subsidies, streamline biomass procurement, and expand awareness programs. Without bold interventions and farmer-centric reforms, the cycle of stubble burning—and its devastating consequences—will persist for years to come.

Book Review: "How to Avoid a Climate Disaster" by Bill Gates

Dilip Patil,
Co- Chairperson, IFGE: SBF &
Managing Director, Karmayogi
Ankushrao Tope Samarth SSK Ltd

Bill Gates' book, How to Avoid a Climate Disaster, is an insightful exploration of climate change, backed by well-researched data and solid facts. In his book, Gates delves deep into the specifics, presenting exact figures on how our planet is warming. Even if you're not well-versed in science, his explanations are clear and accessible.



One of the book's strongest points is Gates' focus on technological solutions. As a tech expert, he provides detailed discussions on innovations like green hydrogen, nuclear power, and carbon capture. These technologies offer hope that we can combat climate change if we invest in them. The language Gates uses is simple and conversational, making complex topics easy to understand. He also uses real-world examples that make the book even more relatable.

However, it would have been great, if Gates had spent less time on discussing large-scale technological solutions and government policies, but would have given more attention to what everyday people can do or how poor communities are most affected by climate change. While he extensively covers solutions like nuclear power, he doesn't highlight enough the effectiveness of more established technologies, like solar and wind energy, which are already making a difference.

Another point of concern is the lack of focus on the disproportionate impact of climate change on poorer populations. This issue is particularly relevant for countries like India, where many communities are struggling to cope with climate-related challenges.

In conclusion, Gates' book is a valuable resource for anyone wanting to understand climate change and potential solutions. While it offers great insights, it's important to also explore other perspectives, especially those addressing the unique challenges faced by vulnerable communities. Solving climate change requires the collective effort of everyone, from large corporations to everyday citizens. We need both technological innovations and lifestyle changes that prioritize the well-being of all, not just the wealthy.

Overall, the book serves as a good starting point to grasp the complexities of climate change but should be complemented with broader viewpoints to get the full picture. After all, this is a global problem that affects us all.

GLIMPSES

Of IFGE Flagship Event IBET 2024

IFGE EVENTS

INDIA-NEPAL POWER SUMMIT
DATE : April 3, 2024
VENUE : India Habitat Centre, New Delhi
DIGNITARIES: Sh Srikant Nagulapalli, Addl Secy, Ministry of Power, Govt of India, H E Dr Shankar Prasad Sharma, Ambassador of Nepal in India

CURTAIN RAISER OF INDIA BIOENERGY & TECH EXPO
DATE: June 3, 2024, VENUE: Pune
CHIEF GUEST : Dr Pramod Chaudhari, President IFGE, Chairman & Founder Praj Industries

CURTAIN RAISER OF INDIA BIOENERGY & TECH EXPO
DATE: August 5, 2024
VENUE: Aerospace Auditorium, Department of Aerospace Engineering, Indian Institute of Science, Bengaluru
CHIEF GUEST : Sh Eshwar Kandre, Hon'ble Minister for Environment and Forests, Govt of Karnataka, and Sh S C Surendra, Chairman, Karnataka Bioenergy Development Board for gracing the function

CBG POLICY DEVELOPMENT: ASSESSMENT OF GOVERNMENT POLICIES AND IMPACT ON CBG DEVELOPMENT"
DATE : Friday, January 17, 2025
VENUE : India Habitat Centre, New Delhi

IFGE WEBINAR

IFGE EVENTS

INDIA-NEPAL ENERGY SUMMIT
DATE : March 26, 2025
VENUE : India International Centre, New Delhi
DIGNITARIES: Sh Akash Tirpathi, Addl Secy, Ministry of Power, Govt of India, H E Dr Shankar Prasad Sharma, Ambassador of Nepal in India

IFGE @ OTHER EVENTS

CARBON POLICY DEVELOPMENT 2024
DATE: May 16, 2024
VENUE: Hotel Le Meridian, New Delhi
Sh Sanjay Ganjoo, DG, IFGE, moderated the session on Bioenergy

EUROPEAN BIOMASS CONFERENCE & EXHIBITION (EUBCE 24)
DATE: June 24 -27, 2024
VENUE: Marseille, France
IFGE organised a special session on India EU Cooperation in Bioenergy

INDIA SUGAR & BIOENERGY CONFERENCE
ORGANISED BY ISMA
DATE: September 26 -27, 2024, **VENUE:** J W Marriot, New Delhi
Sh Sanjay Ganjoo, DG, IFGE, moderated the session The Plethora of Business Opportunities

IFGE WEBINAR

IFGE @ OTHER EVENTS

WORLD BIOGAS INDIA CONGRESS

ORGANISED BY : World Biogas Association

DATE: Oct 23-24, 2024

VENUE: Hotel Le Meridian, New Delhi

Sh Sanjay Ganjoo, DG, IFGE spoke about importance of Global Biofuel Alliance for promoting Bio economy in the world.

RD 20 FOR CLEAN ENERGY TECHNOLOGIES CONFERENCE

ORGANIZED BY TERI - The Energy and Resources Institute .

DATE: December 2- 6, 2024, **VENUE:** IHC, New Delhi

Sh Sanjay Ganjoo, DG, IFGE Shared thoughts about importance of Global Biofuel Alliance for promoting Bio economy in the world.

WORLD SUGAR BIOENERGY CONFERENCE

ORGANISED BY TESO INTL

DATE: Dec 20, 2024, **VENUE:** Leela Ambience, Gurrgram

Mr Sanjay Ganjoo, DG, IFGE moderated the session on Sources of Revenue beyond Sugar & Ethanol.

CBG TRAINING PROGRAMME

ORGANISED BY : Centre for Science & Environment

DATE : Jan 22- 24, 2025

VENUE: Agarwal Environment Training Institute, Tijara, Rajasthan

Mr Sanjay Ganjoo, DG, IFGE made a presentation in Overview and current status of CBG in India session.

IFGE WEBINAR

IFGE @ OTHER EVENTS

SUGAR – ETHANOL & BIOENERGY INDIA CONFERENCE
ORGANISED BY CHINIMANDI
DATE: 30th & 31st Jan, 2025
VENUE: Andaz, Hyatt Hotel, New Delhi
DIGNITARIES : Sh Nitin Gadkari, Hon'ble Minister for Road Transport & Highway, Mr Sanjay Ganjoo, DG, IFGE made a presentation in the CBG session.

INCREASING SHARE OF BIOFUELS IN INDIA'S ENERGY MIX SESSION AT INDIA ENERGY WEEK
ORGANISED BY: FIPI
DATE: Feb 12, 2025, **VENUE:** Yashobhoomi, New Delhi
IFGE organised a special session on "Increasing Share of Biofuels in India's Energy Mix" at India Energy Week. brought together industry leaders and policy enablers to discuss the future of biofuels in India.

SUSTAINABLE FUELS, CHEMICALS AND MATERIALS WORKSHOP ON THE SIDE-LINES OF INDIA ENERGY WEEK
ORGANISED BY : USIBC – Molucule Group
IN PARTNERSHIP WITH : IFGE & IBA
DATE: Feb 13, 2025
VENUE : Hotel Aloft Aerocity, New Delhi

IFGE WEBINAR

MEETINGS WITH POLICY MAKERS

IFGE delegation meeting Dr Devesh Chaturvedi Secretary, Agriculture & Farmer Welfare, Govt of India

IFGE CCUS Forum delegation met Sh Manohar Lal Khattar, Hon'ble Minister of Power and Urban Affairs, Govt of India

IFGE @ OTHER EVENTS

NATIONAL TRAINING PROGRAMME ON BIOGAS PRODUCTION, POWER GENERATION AND COMPRESSED BIOGAS (CBG)

Oranised by : IIT Delhi

Date : March 11, 2025, **Venue** : IIT Delhi

Dignitaries: Sh Shripad Yesso Naik, Hon'ble MoS for New and Renewable Energy

IFGE office bearers participated in the panel discussion on CBG Industry Session.

MEETINGS WITH POLICY MAKERS

IFGE team meeting with H E Sh Shankar Prasad Sharma, Ambassador of Nepal in India and his team.

Meeting of IFGE team with IIT Delhi

Presenting a Pictorial report of IBET Expo to Sh Nitin Gadkari ji Hon'ble Minister for MoRTH and Sh Harsh Malhotra ji Hon'ble MoS MoRTH.

IFGE delegation meeting with Sh Manohar Lal Khattar, Hon'ble Minister of Power and Urban Affairs, Govt of India

MEETINGS WITH POLICY MAKERS

IFGE delegation meeting with Sh Shripad Naik, Hon'ble MoS, MNRE

IFGE delegation meeting with Sh Pralhad Joshi, Hon'ble Minister for Consumer Affairs, Food & Public Distribution of India and MNRE

IFGE delegation meeting with Sh Hardeep Singh Puri, Hon'ble Minister of Petroleum and Natural Gas, Govt of India

IFGE CBGPF delegation meeting with Sh P K Singh, Agriculture Commissioner, Govt of India

IFGE delegation meeting with H E Mr Kenneth Felix Haczynski da Nobrega, Ambassador of Brazil in India

Sh Vaibhav Dange, Founder Director, IFGE meeting Sh N. Chandrababu Naidu, Chief Minister of Andhra Pradesh

An IFGE Publication

BHARAT BIOENERGY HORIZON

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Government of India

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Compressed Biogas | Grain Ethanol | Sugar Ethanol | Biodiesel | Unique/Special/ Innovative Projects

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