WORLD BIOENERGY ASSOCIATION

May 2024


# INDIA: THE NEXT BIG BIOENERGY REVOLUTION

## WBA White Paper

**Authors:**
Alejandra Leon Lavandera,
Bharadwaj Kummamuru

*Design by Lízia Branco*

## WBA White Paper

The report is developed by World Bioenergy Association to showcase the bioenergy developments with updates in technologies, policies, finance, supply chains and markets.

## About Us

Founded in 2008 in Stockholm, Sweden, the World Bioenergy Association (WBA) is a leading international NGO and non-profit association committed to advancing sustainable bioenergy development worldwide.

Through the publication of insightful reports and the organization of and support to impactful events, WBA shares insights on the latest bioenergy developments, encompassing markets, policies, technologies, and finance. It also offers a vibrant platform for stakeholders in the bioenergy sector to showcase their offerings, encompassing a diverse membership including national and regional associations, equipment manufacturers, fuel producers, traders, CHP facilities, utilities, and more from over 40 countries.

Additionally, WBA actively engages in strategic partnerships and international collaborations, such as the REN Alliance, the Global Bioenergy Partnership, and the IRENA Coalition for Action. For more information about the World Bioenergy Association, visit www.worldbioenergy.org.

## Our Members

**>> Join the leading global bioenergy community: link**

# Table of Contents



## Disclaimer

This document is published by the World Bioenergy Association (WBA) as a part of its annual publications. The findings, interpretations and conclusions expressed herein are a result of a collaborative process facilitated and endorsed by the WBA but whose results do not necessarily represent the views of the WBA, nor the entirety of its Members, Partners or other stakeholders. The previous version of the report published on May 31st 2024 had wrongly depicted the Indian map due to a software issue. This has been rectified in this version.

# 1. Executive Summary

India stands as a pivotal player in the global energy landscape, grappling with surging demand amidst pressing climate challenges. As the world's most populous nation and third-largest energy consumer, India's dynamic economy needs a balanced approach to energy security and environmental sustainability.

India's energy narrative unfolds against a backdrop of rapid urbanization and industrialization, fueled primarily by coal, oil, and gas. Despite this reliance on conventional fuels, India has committed to ambitious climate and energy targets, including deriving 50% of its energy from renewables by 2030 and achieving net zero emissions by 2070.

Amidst the diversification of its energy mix, bioenergy emerges as a cornerstone in India's renewable energy portfolio. Leveraging its agricultural abundance, India boasts vast biomass resources, with crop residues and agricultural waste serving as key feedstocks. Government initiatives such as the National Bioenergy Programme, the National Biofuels Policy, and the SATAT scheme, among others, exemplify India's commitment to promoting modern bioenergy solutions. Policy and regulatory frameworks play a pivotal role in facilitating bioenergy deployment. From financial incentives to awareness programs, the Indian government has instituted a set of comprehensive strategies to incentivize bioenergy projects and foster a conducive ecosystem for their development.

Presenting current status and projections, this white paper underscores the untapped potential of bioenergy in India. With a projected agro biomass power potential exceeding 35 GW by 2030, bioenergy stands poised to significantly augment India's energy landscape. However, realizing these potential needs concerted efforts in policy implementation, technological innovation, and market interventions.

This paper also incorporates insights from roundtable discussions held in Goa and Delhi, organized by the World Bioenergy Association in February 2024. These discussions highlighted the shifting perception regarding the utilization of agricultural residues and identified challenges in incentivizing biomass pellet co-firing in thermal power plants. Despite hurdles such as demand-supply gaps, logistical constraints, and price sensitivity, there is optimism within the sector. Innovations in digital supply chains and technology, along with exploration of new markets, offer promising solutions. From pellet co-firing to BioCNG production and novel applications like methanol production, the bioenergy sector in India is poised for transformative growth, driven by innovation and sustainability goals.

By navigating the opportunities and challenges outlined in this document, India can chart a course towards a greener, more sustainable energy future, resonating across the global energy landscape.


Figure 1. WBA at MNRE, New Delhi (left), Discussions with Praj, Pune (top-right), WBA at India Energy Week 2024 (bottom-right).

Source: Canva

## 2. Introduction

India has emerged as a significant player in the global scenario amidst the world's geopolitical challenges. Last year, India became the world's most populous country and is now the world's third-largest energy-consuming country. Moreover, India has the potential to become the world's third-largest economy within five years and a developed nation by 2047[1]. As an already dynamic and rapidly advancing economic powerhouse, India faces the challenge of meeting the surging energy demand while also keeping up with climate action.

In this context, India is in the spotlight under the global energy dialogue. With its thriving economy and expanding population, the country is projected to witness the largest increase in energy demand, making it a significant contributor to global energy demand growth.

In the last two decades, the ongoing urbanization and industrialization processes have led to a substantial increase in India's energy demands. Since 2000, India's energy use has doubled with over 80% of its energy demand being met by coal, oil, and gas. Coal remains the largest single fuel in the energy mix and has underpinned the expansion of electricity generation and industrial development. In 2023, India was the world's second-biggest thermal coal importer (172 million tons)[2]. The country is the third-largest global emitter of $CO_2$, despite low per capita $CO_2$ emissions (~2 ton $CO_2$)[3]. In comparison, the per capita emissions of the EU and the USA are 6.2 and 14.9 tons of $CO_2$ respectively[4]. This reliance not only exacerbates environmental concerns but also poses significant social and health challenges, as evidenced by the alarming rates of air pollution and associated health impacts[5].

In response to these challenges, India has embarked on an ambitious transition journey with climate and energy pledges that promise to shape the future of the up-to-be most crucial energy market.

**Policy Annoucements**

India submitted its first National Determined Contributions (NDCs) in 2015 following the Paris Agreement. Among the eight objectives outlined in the 2015 NDC, three are particularly noteworthy for their quantifiable targets extending to 2030. These targets include[6]: achieving a cumulative installed capacity of non-fossil fuel sources to constitute 40% of the electric power capacity, reducing the emissions intensity of GDP by 33 to 35% compared to 2005 levels, and fostering the creation of an additional carbon sink of 2.5 to 3 billion tonnes of $CO_2$ equivalent through the expansion of forest and tree cover.

In 2022, an updated version was submitted – which was presented at COP26. At the conference, Indian Prime Minister Shi Narendra Modi presented its "Pachamrit Strategy" with five points pledge to combat climate change[7]. The strategy includes that by 2030, India has to meet 50% of its energy requirements from renewable energy, take its non-fossil energy capacity to 500GW, reduce the total projected carbon emission by 1 bn tons, and reduce the carbon intensity of its economy by less than 45%. In addition to that, India is planning on achieving net zero by 2070. With this plan, India can set an example within the renewable energy sector. For this to be achieved, domestically available renewable energy sources must be optimally utilized.

In this white paper, we delve into the multifaceted role of bioenergy in India's energy transition. We examine the country's bioenergy resources, policy landscape, and industry perspectives, shedding light on the opportunities and challenges that lie ahead. By synthesizing insights from industry stakeholders, policymakers, and researchers, we aim to provide a comprehensive understanding of India's bioenergy panorama and chart a path that might not only shape India's trajectory but also reverberate across the global energy landscape.

## 3. RE Status

In 2022, India's total energy demand was approximately 10,000 TWh, with a per capita usage of about 7,000 KWh[8]. The primary sources of energy to meet this demand were coal (55.13%), oil (27.58%), gas (5.75%), hydro (4.50%), solar (2.45%), wind (1.80%), biofuels (0.36%), and other sources (1.69%)[9].

To fulfill its energy needs and achieve its climate goals, India must integrate renewable energy sources into its energy mix. The latest Energy Statistics in India highlights the high potential for generating renewable energy from various sources such as wind, solar, biomass, small hydro, and cogeneration bagasse in India. As of the end of March 2023, the estimated potential for renewable power generation in the country was 2,110 GW, including solar power potential of 749 GW (36%), wind power potential of 1164 GW (55%), small and large-hydro power potential of 154 GW (7%), biomass power of 28 GW (1%), and 14 GW from bagasse-based cogeneration in sugar mills[10].

In 2023, India ranked fourth globally in renewable energy capacity and in wind, hydrobiopower and biopower[11]. n numbers, a total of 168 GW RE capacity has been installed in 2022. Solar power dominated India's renewable energy landscape, constituting approximately 37.7 % of the total installed capacity, followed by wind power (~25%), and bioenergy (6.4 %)[12]. Notably, solar power capacity exhibited robust growth, with a staggering 30.95% increase from 2021 to 2022[13]. According to the IEA, India is expected to add 205GW over 2023-2028, doubling 2022's capacity, making it the world's third-largest market for renewables[14].

Within the bioenergy field, as of March 2023, the cumulative installed capacity of biomass power and cogeneration projects reached about 10.2 GW, with Maharashtra and Uttar Pradesh accounting for over 45% of the installed capacity[15]. Additionally, waste-to-energy projects contributed 0.55 GW to India's renewable energy portfolio[16]. Table 1 shows the total installed capacity of Biomass Power, Bagasse Cogeneration, and Non-bagasse Cogeneration Plants per state as of the end of March 2023[17].

To meet the target of 50% RE for its energy requirements, India is witnessing notable progress in its RE landscape, with solar and wind power dominating the discourse. However, amidst these developments, as the country

Table 1. Total installed Capacity of Biomass power, and Waste-to-Energy[18]

| State | Installed Capacity (MW) | |
|---|---|---|
| | Biomass | Waste-to-energy |
| Andhra Pradesh | 483,67 | 82,36 |
| Arunachal Pradesh | - | - |
| Assam | 2,00 | - |
| Bihar | 124,70 | 1,32 |
| Chhattisgarh | 274,59 | 0,41 |
| Delhi | - | 84,00 |
| Goa | - | 0,34 |
| Gujarat | 77,30 | 33,43 |
| Haryana | 240,66 | 18,77 |
| Himachal Pradesh | 9,20 | 1,00 |
| Jammu & Kashmir | - | - |
| Jharkhand | 4,30 | - |
| Karnataka | 1 887,30 | 14,85 |
| Kerala | 2,27 | 0,23 |
| Madhya Pradesh | 107,35 | 27,59 |
| Maharashtra | 2 584,40 | 56,29 |
| Manipur | - | - |
| Meghalaya | 13,80 | - |
| Mizoram | - | - |
| Nagaland | - | - |
| Odisha | 59,22 | - |
| Punjab | 496,15 | 26,12 |
| Rajasthan | 121,25 | 3,83 |
| Sikkim | - | - |
| Tamilnadu | 1 012,65 | 31,05 |
| Telangana | 160,10 | 60,27 |
| Tripura | - | - |
| Uttar Pradesh | 2 118,26 | 98,47 |
| Uttarakhand | 130,22 | 9,22 |
| West Bengal | 338,62 | 4,48 |
| **Total** | 10 248 | 554 |

To meet the target of 50% RE for its energy requirements, India is witnessing notable progress in its RE landscape, with solar and wind power dominating the discourse.

Source: Canva

endeavours to diversify its energy mix, bioenergy still plays a key role as a versatile and reliable solution with significant untapped potential.

## 4. Bioenergy Resources

**Importance**

In light of India's predominantly agricultural nature, with around 60% of its land devoted to it, the agricultural sector holds substantial importance in the nation's development[19]. It contributes more than 15% to its GDP and supports over half of its population's livelihoods. The vast agricultural expanse results in an abundant supply of biomass, primarily in the form of crop residues and agricultural waste, generated throughout the production cycle. While these residues find use in animal feed, composting, thatching, domestic fuel, and industry; a significant portion, approximately one-third, remains unutilized for economic gain[20]- presenting a significant opportunity for bioenergy development.

Biomass has traditionally served as a vital energy source in India, especially in rural areas where it [traditional biomass] remains the primary energy source for most rural and peri-urban households, as well as some rural enterprises[21]. Currently, more than 30% of the total primary energy used in the country is still derived from biomass, and more than 70% of the country's population depends upon it for its energy needs[22]. Recognizing this, the Indian government has been actively advocating for the use of biomass for energy generation – with ambitious climate and energy goals, there's a growing emphasis on modern bioenergy[i]. The government has rolled out various initiatives to support the production of pellets, briquettes, and bio-CNG, along with promoting biomass-based power generation, and biogas plants, among others.

**Potential**

It was estimated that- annually- India has more than 750 million metric tonnes of available biomass from crops, with around 2/3 of the total biomass produced being used for domestic purposes and other purposes like cattle feeding, compost fertilizer, etc[23]. The remaining portion, about 230 million tonnes has resulted as surplus biomass, equal to a potential of about 28GW (ibid.). Additionally, it is projected that around 14 GW of extra power could be generated through bagasse-based cogeneration from over 550 sugar mills[24]. With further technological progress in new and existing projects, the total estimated potential for biomass power is about 42 GW[25].

The greatest contributors to India's biomass power potential are Punjab (10.6%), Uttar Pradesh (9.8%), followed by Gujarat (9.3%), Maharashtra (9.2%), Madhya Pradesh (8.8%) and Andhra Pradesh (7%) states majorly[26]. Graphic 1 shows the distribution of the total agro biomass, the biomass surplus, as well as the bioenergy potential from each state.

This shows that the available biomass in India is a significant resource for energy production, with the potential to contribute to the country's energy needs and reduce its reliance on fossil fuels. The current bioenergy scenario of India is still progressive but not equivalent to its potential. The potential represents almost four times what it is currently installed. Thus, the continued development of biomass power has the prospective to play a substantial role in India's energy landscape, aligning with the country's efforts to increase the share of renewable energy in its overall energy mix.

i Such as liquid biofuels, pellets, bio-CNG, and biogas.

The projected agro biomass power potential at all India levels based on the time series analysis (trend component) is expected to increase to 33 GWe by 2025, and 36 GWe by 2030[27]. The increase in biomass power potential may be contributed by increased area and production under different crops, by a change in cropping pattern, or by utilization of the residual biomass at the farm level[28].

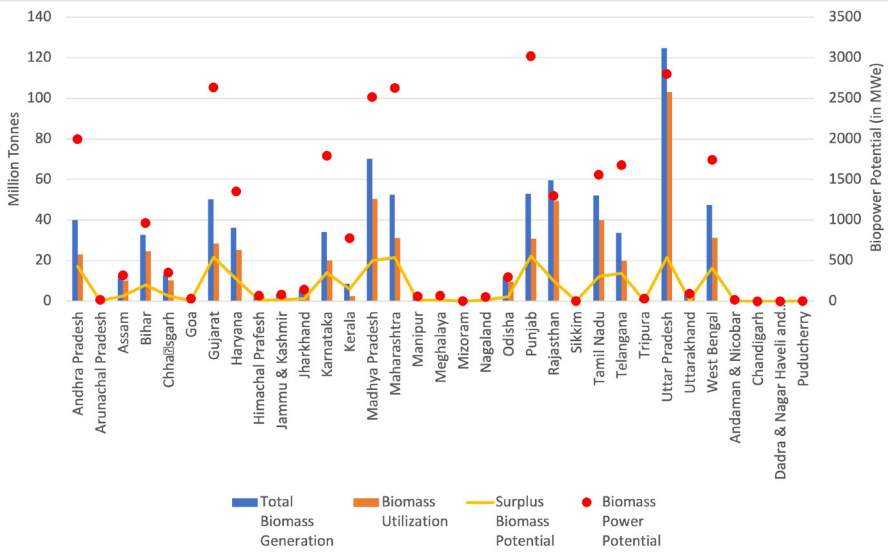


Figure 2. Total biomass generation, utilization and power potential by region in India. Data from "CES and ASCI, 2021"

Table 2. Major Crops contributing to the total biomass Power Potential at all India Level[31].

| Major Crop | Surplus Biomass (Mt) | Biomass Power Pot. (Mwe) |
|---|---|---|
| Rice | 41.7 | 5682,5 |
| Cotton | 46.2 | 5590,1 |
| Wheat | 33.4 | 4505,3 |
| Maize | 15.2 | 1776,4 |
| Potato | 17.4 | 1617,1 |
| Sugarcane | 6.4 | 867,9 |
| Pulses | 11.2 | 1308 |
| Oilseed | 17.8 | 2013,4 |
| Others | 39.2 | 5084,8 |

Source: CES and ASCI, 'Final Report on Evaluation Study for Assessment of Biomass Power and Bagasse Co-Generation Potential in the Country', 2021.

Table 1 delineates the primary crops contributing to the overall biomass potential at a national level. The highest potentials are attributed to rice (20%), cotton (19.7%), and wheat (16%)[29]. Specifically, regarding rice, a study conducted by the Indian government estimates that, on average, the surplus factor for rice crops is approximately 0.21, signifying that 21% of the total biomass production is surplus[30]. The states with the most significant concentrations of this potential are Punjab, Tamil Nadu, and Haryana. Similarly, for cotton, Maharashtra, Gujarat, and Telangana emerge as the top three states. As for wheat, Uttar Pradesh, Madhya Pradesh, and Rajasthan exhibit the highest potential.

## 5. Policy and Regulatory Framework

India has embarked on a well-planned trajectory to harness its bioenergy potential, with a focus on biogas, biomass power, and co-generation as the main contributors[32]. Various programs and initiatives have been implemented to promote the development and deployment of bioenergy technologies across the country[33].

Table 2 displays an overview of the most important bioenergy-related policies established so far. In most of them, the Ministry of New and Renewable Energy (MNRE) has been at the forefront of those efforts, initiating -for instance- the National Bioenergy Programme to capitalize on the surplus biomass, cattle dung, industrial, and urban biowaste available in the country[34]. Under the National Bioenergy Programme, the MNRE has provided significant support, including Central Financial Assistance (CFA), to incentivize the setting up of bioenergy projects such as Biogas, BioCNG, and power generation from urban, industrial, and agricultural waste/residues. These financial incentives aim to reduce the capital costs and interest on loans, thereby enhancing the viability of bioenergy projects[35].

Within the biogas field, the government has implemented various programs aimed at tackling local and national needs. For example, the Gobardhan scheme will provide financial assistance of up to Rs. 50.00 lakh per district for setting up model community biogas plants[36]. Along the same line, the Ministry of Petroleum and Gas has launched the "Sustainable Alternative Towards Affordable Transportation (SATAT)" initiative intending to establish an ecosystem for the production of Compressed Bio Gas (CBG) from various waste/biomass sources and for promoting its use along with Natural Gas (ibid.).

Additionally, the Ministry of Power has implemented the SAMARTH Mission (National Mission on Use of Biomass in Thermal Power Plants) to promote the blending of biomass in the existing coal-powered thermal power plants (ibid). Within the liquid biofuel sphere, India promotes it through different pathways for its development and deployment at a national level. These policy efforts include mandates or targets for blending, subsidy schemes, tax exemptions, credits, R&D funding, lower import charges, and other initiatives to promote local biofuel production and use[37].

A major milestone for the boost of biofuels in India was the formation of the Global Biofuels Alliance in the last G20 Summit held in 2023 in Delhi. The initiative aims to position biofu-

Source: Canva

Table 3. Bioenergy-related policies in India

| Policy | Year | Aim | Financing Implications |
|---|---|---|---|
| National Bioenergy Programme (NBP) | 2021 | To promote the utilization of surplus biomass, cattle dung, industrial and urban biowaste available in the country for recovery of energy. The program has the following sub-schemes: Waste to Energy Programme, Biomass Programme, and Biogas Programme. | The programme provides Central Financial Assistance (CFA) to project developers. The budget outlay is Rs. 1715 Crore for the whole programs. Total budget for phase 1 is Rs. 858 crore. |
| Biomass Programme (part of NBP) | 2021 | To support setting up of Biomass Briquette/Pellet manufacturing plants and to support Biomass (non-bagasse) based cogeneration projects in Industries in the country. | The Biomass Programme has a budget outlay of Rs 158 crore for the period FY 2021-22 to FY 2025-26. |
| Biogas Programme (part of NBP) | 2021 | Setting up of biogas plants for clean cooking fuel, lighting, meeting thermal and small power needs of users. | The Biogas Programme has a budget outlay of Rs 100 crore for the period FY 2021-22 to FY 2025-26. |
| Waste To Energy Programme (Wte) (part of NBP) | 2021 | Setting up of plants for generation of Biogas/ BioCNG/Power from urban, industrial and agricultural waste by providing CFA | The WTE Programme has a budget outlay of Rs 600 crore for the period FY 2021-22 to FY 2025-26. |
| SAMARTH (Sustainable Agrarian Mission On Use Of Agro Residue In Thermal Power Plants) | 2021 | Promoting the use of biomass in thermal power plants. The current biomass policy mandates 5% biomass co-firing in Thermal Power Plants (TPPs) from FY 2024-25, to increase to 7% from FY 2025-26. Also, to create an ecosystem for biomass supply chain management, which includes biomass collection, transportation, storage, and processing. The goal is to have a larger share of carbon-neutral power generation from the thermal power plants. | |
| Sustainable Alternative Towards Affordable Transportation (SATAT) | 2018 | Establishing an ecosystem for production of Compressed Bio Gas (CBG) from various waste / biomass sources and for promoting its use along with Natural Gas. | |
| Galvanizing Organic Bio-Agro Resources Dhan (Gobar-Dhan) | 2018 | To facilitate the conversion of organic waste such as cattle dung and agricultural residues into biogas, CBG, and Bio-CNG. It includes schemes and programs from various ministries and departments | The operational guidelines of Phase-II of SBM(G) provide for financial assistance up to Rs.50.00 lakh per district for the period of 2020-21 to 2024-25 for setting up of cluster/community level biogas plants. |
| National Biofuels Policy (NBP) | 2018 | The policy's objective is to reduce the import of petroleum products by fostering domestic biofuel production. Indicative target of 5% blending of biodiesel in diesel /direct sale of biodiesel has been proposed by 2030. | India regularly updates fixed ethanol pricing based on feedstock type, ensuring sales and reducing the Goods & Service Tax from 18% to 5%. India also provides an interest subvention scheme for new or modified facilities. |

| | | | |
|---|---|---|---|
| Ethanol Blended Petrol Programme (EBP) | 2003 | Target of 20% ethanol blending in Petrol by 2025/2026 (4 years before than the initial target of 2030) | The government is providing interest subvention at a rate of 6% per annum or 50% of the interest charged by financial institutions, whichever is lower, for five years, including a one-year moratorium. This initiative has led to investment opportunities exceeding Rs 40,000 crore, benefitting both urban and rural areas. |
| CBG Blending Obligation (CBO) | 2023 | Stimulate demand for CBG in transport and domestic sectors, import substitution for LNG, promote circular economy. The CBO will be voluntary until FY 2024-2025, becoming mandatory from FY 2025-2026 onwards, starting at 1% and gradually increasing to 5% by FY 2028-2029. | Stimulate demand for CBG in transport and domestic sectors, import substitution for LNG, promote circular economy. The CBO will be voluntary until FY 2024-2025, becoming mandatory from FY 2025-2026 onwards, starting at 1% and gradually increasing to 5% by FY 2028-2029. The investment would be around Rs. 37500 crores and facilitate establishment of 750 CBG projects by 2028-29. |
| SUSTAINABLE AVIATION FUEL (SAF/BIO- ATF) Initiative | 2023 | Initial indicative blending % targets were set by the committee. Which are (i) 1% SAF indicative blending target in 2027 (Initially for International flights) (ii) 2% SAF blending target in 2028 (Initially for International flights ) | |

els as a key to energy transition. It intends to expedite the global uptake of biofuels by facilitating capacity-building, providing technical support for national programs, sharing best practices, and promoting technology advancements[38]. The Alliance brings together 22 countries and 12 international organizations, among the major players in the sector including the US and Brazil which holds the potential to increase the demand and supply and ensure to expand sustainable biofuels market infiltration[39]. Overall, this Alliance is expected to provide additional opportunities to Indian industries in the form of exporting technology and equipment, generating employment and skill development[40].

## 5.1. Progress Made

During 2023, 105 MWeq capacity of Bioenergy Projects among biomass and waste-to-energy projects were installed during the year[41]. The achievement was possible due to a variety of program implementations and financial assistance from the government.

Figure 3. WBA Meeting with MNRE.

**Solid Biomass**

Under the Biomass Program, the provision of Central Financial Assistance (CFA) for setting up Biomass Briquette/Pellet manufacturing plants and Biomass (non-bagasse) based cogeneration projects in the country has been secured. By the end of 2022, more than 800 cogeneration-based power plants have been installed. This added a capacity of 10209 MW, distributed among bagasse cogeneration (7562 MW), biomass IPP sector (1871 MW), and the non-bagasse cogeneration sector (776 MW)[42].

Under the Biomass Policy, modified in June 2023, it is mandated to have a rate of 5% of biomass co-firing in Thermal Power Plants from 2024. Until May 2023, approximately 164 976 Metric tonnes of biomass from agricultural residues have been co-fired in 47 coal-based thermal power plants[43]. Pricing schemes have been implemented aiming to promote sustainable supply chains, ensure faster procurement of biomass pellets for

co-firing with coal in thermal power plants, and bring stability to raw biomass prices in the market[44]. Moreover, the Central Pollution Control Board, Ministry of Environment, Forest and Climate Change has notified guidelines to provide financial support for setting up of Biomass Pellet plants in the NCT of Delhi, States of Punjab and Haryana and NCR districts of Rajasthan and Uttar Pradesh. National Biomass Mission, Ministry of Power, has organized 51 awareness programs for various stakeholders including farmers across 18 states in the country to promote Biomass co-firing in thermal power plants[45].

**Biogas**

The government has implemented a range of strategies, including incentives and research and development support, to encourage the production of Compressed Biogas (CBG) from diverse sources such as agricultural and municipal waste, to utilize it in the transportation sector.

One of the strategies is the SATAT (Sustainable Alternative Towards Affordable Transportation) scheme, which aims to derive economic benefits from biomass waste by producing Compressed Biogas (CBG) and biomanure. Municipal solid waste, press mud from the sugar industry, and agricultural residue are all rich sources for the production of these byproducts. Although the aim when launching the scheme in 2018 was to set up 5000 CBG plants for the production of 15 million Metric tons (MMT) per annum of CBG by 2023-24, currently there are only 61 plants commissioned – as shown in the registration portal[46].

Another key initiative in this endeavor is the Galvanising Organic Bio-Resources Dhan (GOBARdhan) program, launched in 2018. It serves as a key element in managing bio-degradable waste to promote cleanliness in rural areas. By converting organic/biodegradable waste, including cattle dung, crop residue, and market waste, into biogas and bio-slurry, GOBARdhan contributes to waste management[47]. The program envisions at least one model community-level biogas plant per district. Presently, 1243 biogas plants and 604 bioCNG plants have been registered on the Unified Registration portal, although only 754 biogas plants and 84 bioCNG plants are operational[48].

In line with the Budget Announcement for 2023-24, the government plans to establish 500 new 'waste to wealth' plants under the GOBARdhan initiative, promoting the circular economy. These will include 200 bioCNG plants, with 75 designated for urban areas, and 300 community or cluster-based plants, requiring a total investment of Rs.10,000 crores[49]. The GOBARdhan initiative will be further supported by the impending introduction of the 5% bioCNG mandate and proposed exemptions to the GST for bioCNG contained in blended natural gas[50].

**Waste to Energy**

At the outset of 2023, the Waste to Energy Programme boasted 90 ongoing projects. Among these were 7 Biogas Generation plants with a combined daily production capacity of about 83,400 cubic meters, 34 BioCNG Generation plants capable of producing approximately 248,000 kilograms per day, and 49 Power generation plants with a cumulative production capacity of about 330 megawatts[51].

**Liquid Biofuels**

Over the past five years, the Government has implemented various measures to encourage the use of biodiesel. This included revising the National Policy on Biofuels-2018 in June 2022, wherein it was proposed to achieve a target of 5% blending of biodiesel in diesel or direct sale of biodiesel by 2030[52]. Furthermore, significant progress has been made in the Ethanol Blended Petrol (EBP) Programme. The Government successfully reached the target of 10% average blending of ethanol in petrol in June 2022, five months ahead of schedule. Subsequently, a new target of 20% blending of ethanol in petrol was set from 2030 to 2025-2026[53].

Building on the amended National Biofuels Policy, the government published a "Roadmap for Ethanol Blending in India 2020-25", which states that the new blending targets would require approximately 1016 crore liters of ethanol to replace the equivalent quantity of petrol. It is estimated that a successful E20 program could save the country about 4 billion US Dollars (USD) annually[54].

In addition to using molasses and damaged food grains, surplus sugar and grains are employed to bolster ethanol production. On the other hand, biodiesel sources are restricted to non-edible oilseeds, recycled cooking oil, animal tallow, and other non-food oils[55].

Additionally, by the end of 2023, the Indian Government has assisted in a total of 1212 projects under the interest subvention scheme to boost ethanol production for EBP. These projects include 590 molasses-based, 474 grain-based, and 148 dual-feed-based initiatives, aimed at enhancing the production capacity of ethanol in the country[56]. As a result, by the end of 2023, the ethanol production capacity in the country was about 1380 crore litres out of which about 875 crore litres were molasses-based and about 505 crore litres is grain-based[57].

## 6. Prices

Fuel pricing plays a pivotal role in shaping the trajectory of bioenergy development in India. Understanding these trends is essential for assessing the economic feasibility, competitiveness, and potential impact of initiatives within India's evolving energy matrix. As the country deals with the dual challenges of energy security and environmental sustainability, the dynamics of fuel pricing have a profound influence on the adoption and viability of bioenergy solutions.

From traditional fossil fuels like petrol, diesel, gas, and coal to renew-

able alternatives such as bioethanol, pellets, briquettes, and emerging solutions like BioCNG, Table 3 presents a snapshot of the current pricing of fuels in India.

Table 4. Fuel prices in India.

| Fuel | Price (Rs. / Unit) |
|---|---|
| Coal | 148.91 Rs/ ton[58,ii] |
| Petrol | 94.72 Rs. /Litre[iii] |
| Diesel | 87.62 Rs. /Litre[iii] |
| Natural Gas | 825 Rs. / MMBTU[iv] |
| Bioethanol | 71.86 Rs. /Litre (maize-based) |
| Pellets | 2.24 – 2.32 Rs. /1000kcal (non-torrefied) |
| BioCNG | 54 Rs. /Kg |

In line with India's strategic objectives to bolster ethanol production for blending with gasoline, state fuel retailers have recently increased the purchase price of maize-based ethanol by 5.79 rupees per litre to 71.86 rupees per litre to promote its production for blending with gasoline. This move is part of India's efforts to promote maize as an alternative to sugar for ethanol production. In addition, the procurement price for ethanol made from C-heavy molasses has also been raised by 8.87 Indian rupees per litre. Although the Indian Sugar Mills Association has projected a decline in sugar production for the 2023/24 marketing year, with estimates falling to 32.5 million metric tons compared to the previous year's 33.7 million tons[59], sugarcane will remain a primary feedstock for ethanol production. As the country gets closer to the 20% target, half of the ethanol will be made from sugarcane, and the other half will be derived from maize and damaged food grains[60].

Moreover, the government also set a procurement price framework for bioCNG under the SATAT scheme, aiming to incentivize the widespread uptake of bioCNG as a viable alternative fuel source. With a minimum procurement price of Rs. 54/kg (exclusive of applicable taxes, until March 31, 2029), the viability and additional provisions for varying retail prices and transportation costs are ensured. In addition to that, it is set that when the retail selling price of bioCNG is up to Rs. 70 per kilogram, the procurement price is set at Rs. 56.70/ kg[61].

In parallel, the establishment of benchmark prices for non-torrefied biomass pellets intends to accelerate the adoption of biomass pellets for co-firing with coal in thermal power plants. The prices- set at Rs 2.32, Rs 2.27, and Rs 2.24 per 1000 kcal for various regions- will try to expedite pellet procurement and stabilize raw biomass prices[62].

## 7. Case Studies

**World's largest vaccine manufacturer switches to biomass**

Serum Institute is the world's largest vaccine manufacturer and produces more than a billion doses of a variety of vaccines every year. It played a critical role in the production and supply of vaccines during the COVID crisis – both domestically and abroad. Considering the critical nature of the work, it was important for a steady supply of steam for the plant. The facility was initially utilizing a Fuel Oil (FO) boiler, but due to cost increase, switched to a briquette biomass boiler. There is a natural gas boiler still located in the premises for contingency operation. The conversion has saved 30% of the fuel costs for the facility.

The biomass boiler uses briquettes delivered by multiple trucks daily. The briquettes are manufactured by nearby vendors and use a mixture of primary fuels (predominantly agro residues) including cotton stalk, sugarcane bagasse, soybean straw etc. The handling of the briquettes is done manually while mechanical equipment is used to transfer the feedstock to the conveyor belts to transport the briquettes to the boilers. The total capacity of the facility is 22 tons per hour of steam or 10 MW.

*Key findings*

- Depending on the season and location, the biomass briquette can vary widely in composition, but the biomass boiler is flexible enough to utilize a wide composition. This ensures a constant supply of biomass to the boilers to run the operation.
- The emission cleaning system is very effective as the plant is located very near to a residential locality and has thereby to adhere to strict emission norms. The ash is treated with water to control the spread of dust in the air and the trucks transporting the ash are also covered.
- A key challenge for the facility is a lack of storage space for biomass briquettes. The current storage can last only a few hours and thereby it is critical for effective supply chains. The feedstock flexibility is key.

**First of its kind demo plant for 2G ethanol production**

Praj is one of the leading ethanol producers in the country and estimates that the technology accounts for 10% of the global ethanol production. It is also a leading technology provider for 2G ethanol production and has significant interest in the biogas field. Recently, the company set up a second-generation ethanol facility nearby Pune that processes mainly bagasse from the nearby sugar mill to produce ethanol. The plant is flexible and can also utilize corn cobs, rice and wheat straw, cotton stalk and empty fruit bunches. The total capacity of the facility is 1 million litres per annum. The facility also has a biogas facility

ii Price for "Indian Coal" as of February 2024.

iii Max. price for gas produced from discoveries in Deepwater, Ultra Deepwater, and High-Pressure High-Temperature areas from April-September 2024.

iv Max. price for gas produced from discoveries in Deepwater, Ultra Deepwater, and High-Pressure High-Temperature areas from April-September 2024. Source: PPAC, 'Gas Price', Petroleum Planning & Analysis Cell, 31 March 2024, https://ppac.gov.in/natural-gas/gas-price.

with provision to produce Bio CNG.

Based on the technology developed in the facility, Praj has recently commissioned – together with IOCL (Indian Oil) the first of its kind 2G ethanol refinery in Haryana with a capacity to process 200 000 tons of rice straw and produce 30 million litres of ethanol. Two more projects – in cooperation with state run refineries of BPCL and HPCL – are in the pipeline.

***Key findings***

It is critical to have demo facilities of such scale to test various feedstock, process parameters and enzymes, for the development of the 2G technology in the country.

One of the significant challenges is the pre-treatment of the cellulosic feedstock. The hydrotreatment of agro biomass to extract sugars (further processed via fermentation to ethanol) is expensive and technologically challenging. Further R&D is required.

The flexibility of the facility in terms of processing capacity of multiple feedstocks as well as multi products is unique.

Figure 4. Policy, industry and Finance roundtable (Delhi. 09 February)

## 8. Lessons Learned

The WBA conducted two roundtable discussions on 07th and 09th February in Goa and Delhi respectively. The roundtables convened key stakeholders in the entire biomass-to-energy value chain. Discussions focussed on the development of the bioenergy sector in India, various public incentives available, challenges, and the opportunities presented due to future collaboration.

There is a widespread belief that there is a significant amount of agricultural residues available in the country. India is predominantly an agrarian society. Millions of tonnes of agricultural commodities such as rice, wheat, maize, etc. are produced annually for domestic consumption as well as exports. The production and processing of these commodities left significant amount of residues such as straw, husk, stalks, shells etc. Previously, these residues were typically used as fodder for farm animals while the remaining residues were either left on the fields to maintain soil quality, landfilled or burned to dispose them.

However, a few recent developments have changed the perception of the current use and disposal. The most significant development was the air pollution issue caused in the national capital and surrounding areas due to stubble burning in North-western states of Punjab and Haryana. Every year, after harvest, the combination of stubble burning and colder climates leads to a dramatic decline in air quality, leading to significant health issues.

Secondly, India signed unto the Paris Agreement of limiting global warming. In their NDC's (Nationally Determined Contributions), India committed to reducing the fossil fuel share in their energy mix. This meant that the country had to look at alternative fuel sources to replace coal in power plants.

Recently, to tackle the issue of air pollution as well as reducing the fossil fuel share in the energy mix, the government of India came up with a slew of policy measures (mentioned in the previous section). A key measure was mandating the co firing of 5 – 7% of densified biomass (torrefied and non-torrefied) in thermal power plants. This measure roughly translates to a national demand of close to 40 million tonnes of pellets. Moreover, to support companies to achieve the targets, the government also announced financial measures to support the setting up of pellet facilities at thermal power plants.

Despite the efforts done to incentivize the co firing of densified biomass, the progress has been very slow. Less than 200 000 tonnes of biomass pellets were co fired (0.5% of the target). During the discussions at the roundtables, the stakeholders highlighted several key challenges:

**High ambition:** The anticipated demand for pellets due to the incentives is roughly 70% of the global production of pellets. It was impractical to set such highly ambitious targets for any sector to achieve and underachievement of the target doesn't reflect well on the overall progress. Moreover, the current global production is based primarily on woody biomass (harvesting and processing residues) as feedstock while the focus in India is on agro biomass residues which have their own challenges.

**Logistics:** Woody biomass predominantly is available as a point source either as harvesting residues in the forest or processing residues such as sawdust in sawmills. The challenge with agro residues is that they are dispersed and the small-scale landholdings. This increases the cost, time, and effort to collect, transport, and store agro residues. Moreover, issues related to the seasonality of the crops and the residues available also raise concerns.


Source: Canva

**Price sensitivity:** Many discussions with power plant operators who are tasked with co firing of biomass have raised concerns about the price sensitivity of the electricity market. Coal – the dominant fuel source for power – is heavily subsidised and it is challenging for high-cost pellets to compete with coal.

**Technical specifications:** The diverse specifications of crop residues available due to varying geographies, climate, farming methods including fertilizer use means that the physical and chemical characteristics of agro residues vary widely which is a significant challenge for combustion.

Although significant challenges persist, there is hope within the sector that bioenergy from agro residues can play a major role in the country's energy mix. To that end, there are lot of innovations within the country to address issues related to supply chains, technologies, markets, etc.

**Supply Chain:** Two key players in the supply chains of agro residues are Biofuel Circle and Biofuel Junction. Biofuel Circle is a cloud-based digital ecosystem for bioenergy supply chain that connects Rural & Industrial economies. It provides a marketplace for trading biomass fuels. On the other hand, Biofuels Junction is a leading player in the solid biomass value chain and is currently producing, aggregating, and promoting sales of 9 000 + tons of biomass fuel per month. Such online marketplaces and companies that act as aggregators can help ease the supply chain constraints currently existing in the bioenergy space in India.

**Technology Innovation:** There are various incentives for the bioenergy sector in India. Apart from pellet co-firing, incentives include Bio CNG production, 2G ethanol, clean cooking fuels, etc. using a variety of feedstock. First-of-its-kind commercial scale facilities are upcoming in a variety of sectors including pellets, 2G ethanol, and BioCNG which are critical for the technological success of the sector.

**New markets:** As per discussions at the roundtables, the co-firing of pellets, as well as Bio CNG, are conventional markets that are receiving a lot of attention. At the same time, companies are exploring novel markets in India including methanol production for marine, SAF (Sustainable Aviation Fuels), Bio propane for cooking, etc. One key emerging market is decarbonizing the industrial process heat and steam demand. There are numerous examples of companies in sectors such as pharma, breweries, dairy, automotive, FMCG, etc. that have projects using biomass that replaced fossil gas. The drivers for such development are mainly net zero commitments from global industry majors. Such commitments along with EU-centric policies such as CBAM (Carbon Border Adjustment Mechanism) which incentivize low-carbon products to be imported to the EU, bioenergy will be an ideal solution.

## 9. Conclusions

India's rich agricultural resources, coupled with its ambitious climate and energy goals, position bioenergy as a key component of the nation's sustainable development agenda. The abundance of agricultural residues, combined with innovative technologies and supportive policies, presents a significant opportunity to harness bioenergy for meeting diverse energy needs, reducing greenhouse gas emissions, and promoting local development.

Key findings from case studies underscore the versatility and effectiveness of bioenergy solutions, ranging from biomass boilers for industrial steam generation to advanced ethanol production facilities. These examples highlight the importance of technological innovation, policy support, and stakeholder collaboration in driving the adoption and scalability of bioenergy projects across various sectors.

However, despite notable progress, challenges persist, including logistical constraints, price sensitivity, and technological barriers. Therefore, drawing from the insights shared

Source: Canva

throughout our discussions, the WBA recommends a holistic approach to foster the continued growth of the Indian bioenergy sector:

**Investment in Research and Development:** Continued investment in R&D is essential to address technological challenges and optimize bioenergy processes, especially for second-generation ethanol production, biomass pelletization, and biogas upgrading technologies.

**Enhanced Policy Support:** Further policy interventions are needed to incentivize bioenergy adoption, including targeted subsidies, tax incentives, and regulatory frameworks that facilitate biomass procurement, storage, and transportation. Additionally, policy coherence and long-term planning are crucial to provide stability and confidence to investors in the bioenergy sector.

**Strengthening Supply Chains:** Developing robust supply chains for biomass feedstocks is critical, requiring collaboration between stakeholders, investment in infrastructure, and leveraging digital platforms for efficient biomass trading and aggregation. Efforts should focus on improving logistics, storage facilities, and market linkages to ensure reliable and sustainable biomass supply.

**Capacity Building and Knowledge Sharing:** Promoting capacity-building initiatives and knowledge-sharing platforms can enhance awareness, skills, and technical capabilities across the bioenergy value chain, fostering innovation and best practices adoption. Public-private partnerships and international collaborations can facilitate technology transfer and skill development to accelerate the growth of the bioenergy sector.

**Market Diversification:** Exploring new markets and applications for bioenergy, such as sustainable aviation fuels, industrial process heat, and clean cooking fuel solutions, can unlock additional growth opportunities and expand the sector's contribution to India's energy mix. Innovative financing mechanisms, market incentives, and public procurement policies can stimulate demand for bioenergy products and create new revenue streams for stakeholders.

It is imperative for stakeholders, including government agencies, industry players, research institutions, and civil society organizations, to collaborate closely and adopt a coordinated approach towards advancing the bioenergy agenda in India. By leveraging India's agricultural abundance, fostering innovation, and creating an enabling policy environment, the bioenergy sector can emerge as a key driver of sustainable development, energy security, and economic growth. Leveraging its expertise, networks, and global perspective, the WBA stands as a steadfast advocate and catalyst for bioenergy development in India. As India charts its course towards a sustainable energy future, the WBA remains committed to supporting the country's bioenergy journey, offering insights, best practices, and strategic guidance to navigate the complexities of the energy transition.

For a complete list of References, click here.

**Conversions:**

1 lakh = 100,000
1 crore = 10,000,000

1 EUR = Rs. 90.58
1 USD = Rs. 83.46
1 GBP = Rs. 105.51

*As of date, from xe.com*

WORLD BIOENERGY ASSOCIATION

**Contact us:**
Kammakargatan 22, SE
111 40 Stockholm, Sweden
Tel. + 46 (0)8 441 70 84
info@worldbioenergy.org

World Bioenergy Association
World Bioenergy Association
@World_Bioenergy
World Bioenergy Association