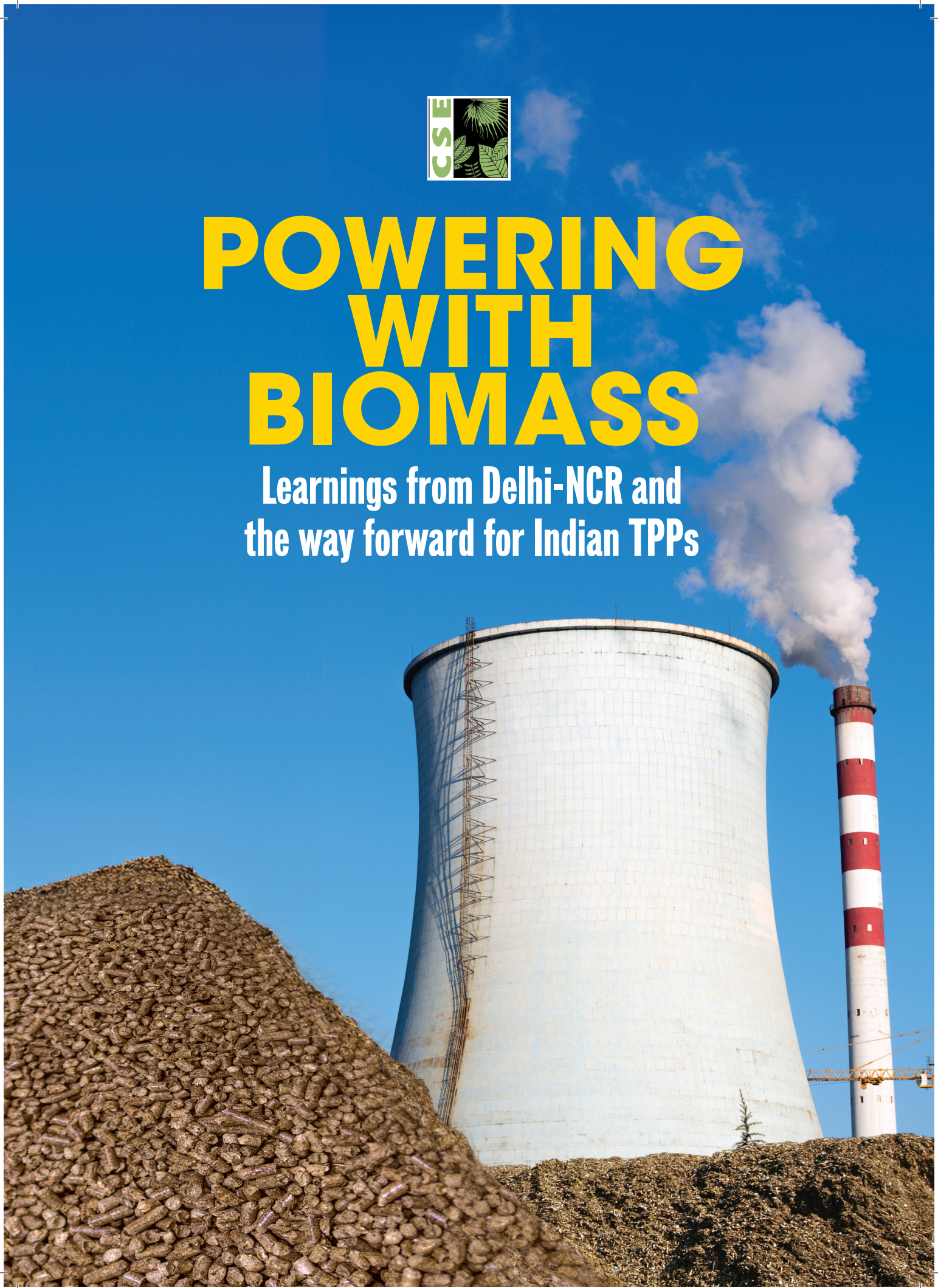
POWERING WITH BIOMASS

Learnings from Delhi-NCR and the way forward for Indian TPPs



POWERING WITH BIOMASS

Learnings from Delhi-NCR and the way forward for Indian TPPs

Research direction: Nivit Kumar Yadav

Author: Shreya Verma

Research support: Sanyam Thakur

Editor: Mohini Chandola

Cover and design: Ajit Bajaj

Production: Rakesh Shrivastava and Gundhar Das

The Centre for Science and Environment is grateful to the Swedish International Development Cooperation Agency (Sida) for their institutional support

Maps in this report are indicative and not to scale.

Citation: Nivit Kumar Yadav and Shreya Verma, 2025, *Powering with biomass: Learnings from Delhi-NCR and the way forward for Indian TPPs*, Centre for Science and Environment, New Delhi

Published by
Centre for Science and Environment
41, Tughlakabad Institutional Area
New Delhi 110 062
Phone: 91-11-40616000
Fax: 91-11-29955879
E-mail: cse@cseindia.org
Website: www.cseindia.org

Contents

1. Introduction

India's strong agricultural foundation leads to the generation of a vast amount of crop residue each year, making the country one of the richest in terms of surplus biomass availability. According to estimates, India produces about 750 million tonnes of biomass annually, out of which about 230 million tonnes is surplus and available for energy generation after meeting fodder and domestic fuel requirements. However, rather than being harnessed productively, a substantial share of this biomass is burned openly in agricultural fields, particularly post-harvest.

Open burning of crop residues, especially paddy straw in the Indo-Gangetic plains during October and November, has become a recurring environmental crisis. Each year, an estimated 30–40 million tonnes of paddy stubble is burned in northwest India.[1] Farmers often resort to this method due to financial pressure, the urgency to prepare for the next crop, and a lack of better ways to manage crop residue. This contributes to severe air pollution episodes, particularly in regions like Delhi-NCR, deteriorating public health and contributing to regional haze and global climate change.

At the same time, India's thermal power sector remains heavily dependent on coal, which accounts for nearly 75 per cent of the country's total electricity generation. As per the Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India's fourth Biennial Update Report (BUR) 2024, India's total electricity consumption reached around 1,440.31 terawatt-hour (TWh) in 2022–23, marking a 9.4 per cent increase over 2021–22.[2] According to data from the Central Electricity Authority (CEA), CO_2 emissions from coal-based thermal power plants reached 1,188 million tonnes (MT) in 2023–24—a figure that already surpasses the sector's projected emissions of 1,100 MT for 2031–32 as outlined in the National Electricity Plan (NEP) 2023.[3] This trend underscores the urgent need for cleaner alternatives and emission reduction strategies within the coal-based power sector.

As per the National Power portal, India has about 191 coal-based thermal power plants with an installed capacity of 213,733 MW (as of February 2025).[4] The power sector consumed around 859.25 million tonnes (MT) of coal in 2023–24 as reported by the India Climate and Energy Dashboard, NITI Aayog.[5] The NEP 2023 estimates domestic coal requirements to rise to 866.4 MT by 2026–27 and

1,025.8 MT by 2031–32. In 2024–25, the domestic coal consumption has already reached 749.1 MT (as per the National Power portal data from April 24–February 25), indicating that demand is on track to outpace projected estimates well before the target years.

Amidst these challenges, biomass co-firing—the partial replacement of coal with biomass in thermal power plants—has emerged as a viable and strategic solution. It offers a dual advantage. It mitigates air pollution caused by open burning of agro-residues and reduces greenhouse gas (GHG) emissions from coal-based power

Table 1: Mapping of surplus biomass in India

All-India mapping	
Total crop area (million hectare)	206.09
Total crop production (MMTPA)	774.38
Total biomass generation (MMTPA)	754.44
Surplus biomass generation (MMTPA)	228.49
Total installed capacity of coal-based TPP (GW)	213
Pellet required @5% co-firing (MMTPA)	38.55
Biomass required @5% co-firing (TPD)	105,610

Source: SAMARTH Mission report 'Biomass co-firing in thermal power plants: A green initiative'

Table 2: States with major surplus biomass

S. No.	State /UT Name	Surplus biomass, MMTPA
1	Punjab	22.25
2	Gujarat	21.74
3	Uttar Pradesh	21.6
4	Maharashtra	21.49
5	Madhya Pradesh	19.93
6	Andhra Pradesh	17.09
7	West Bengal	16.28
8	Karnataka	14.05
9	Telangana	13.76
10	Tamil Nadu	12.22
11	Haryana	10.91
12	Rajasthan	10.21
13	Bihar	7.98
14	Kerala	6.04
15	Chhattisgarh	2.65
16	Assam	2.54
17	Odisha	2.23

Source: SAMARTH Mission data on website

generation. As the combustion of biomass is considered carbon-neutral—since the CO_2 released during burning is roughly equal to the CO_2 absorbed during plant growth—biomass co-firing helps reduce the net emissions from power plants.

The Government of India has recognised this potential and launched several initiatives to promote the use of biomass in thermal power generation. Most notably, the establishment of the National Mission on Use of Biomass in Thermal Power Plants (SAMARTH) in 2021 was aimed to reduce stubble burning, lower the carbon footprint of coal-fired plants and enhance rural incomes.

According to the SAMARTH Mission data, as of April 2025, a total of 68 thermal power plants (TPPs) across India have adopted biomass co-firing and cumulatively utilised 21.14 lakh metric tonnes of biomass. Notably, TPPs in the Delhi-NCR have demonstrated significant progress in this regard. Out of 21.14 lakh metric tonnes of biomass utilised in India till April 2025, Delhi-NCR has utilised about 16 lakh metric tonnes of biomass. This can be attributed to the statutory direction issued by the Commission for Air Quality Management (CAQM)—Direction No. 42 dated 17 September 2021—which mandates co-firing of biomass with coal in the proportion of 5–10 per cent for all TPPs located within 300 km of Delhi.

Building on this progress, the latest data from the SAMARTH Mission (as of 15 May, 2025) indicates that the number of TPPs practicing biomass co-firing across India has increased to 70. The cumulative quantity of biomass co-fired has reached 24.49 lakh metric tonnes, with the Delhi-NCR alone contributing about 75 per cent of the total—which is around 18.28 lakh metric tonnes.

While Delhi-NCR has emerged as a frontrunner in biomass co-firing, the uptake in other regions remains limited. The objective of this study is to identify and understand the challenges faced by thermal power plants outside the Delhi-NCR in implementing biomass co-firing effectively.

2. Policy measures by the government

In response to the surging electricity demand, rising coal consumption in thermal power plants (TPPs), and the recurring issue of stubble burning, the Ministry of Power (MoP) began exploring sustainable alternatives to reduce environmental impacts and enhance energy security.

Early demonstration of biomass co-firing: NTPC Limited, the country's largest power producer, had taken a significant initiative in 2017 by demonstrating the feasibility of biomass co-firing at a commercial scale. At its Dadri thermal power plant in Ghaziabad, Uttar Pradesh, NTPC had successfully co-fired 7 per cent biomass along with coal. This initiative proved that biomass could be used in existing coal-fired boilers without major modifications, offering a practical solution for reducing coal dependency and cutting emissions.

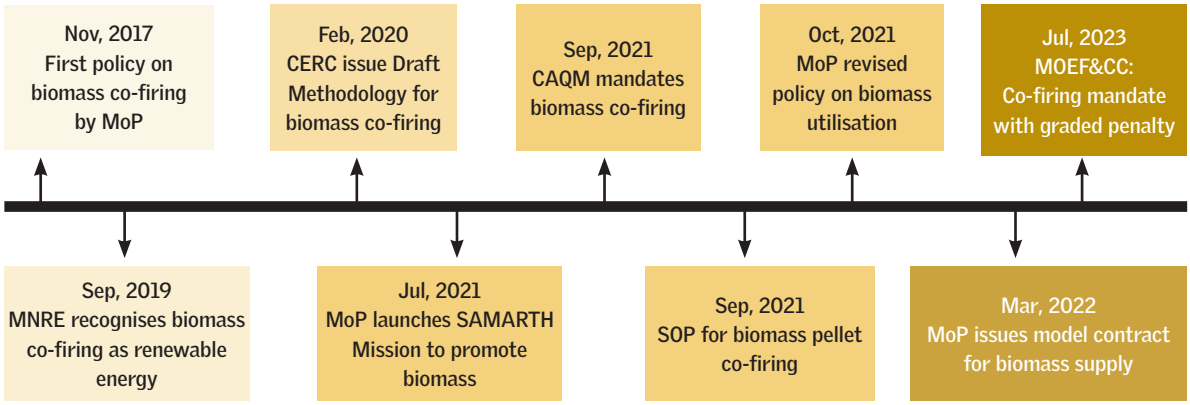
MoP introduces biomass co-firing policy in November 2017: Following NTPC's success, the Union Ministry of Power (MoP), on 17 November 2017, introduced a policy titled *Biomass utilisation for power generation through co-firing in pulverised coal fired boilers*.[6] The objective of this policy was to encourage TPPs across the country to adopt biomass co-firing as a strategy to reduce coal usage, lower carbon emissions, address the issue of crop residue burning, and promote the circular use of agricultural waste.

Coal-based power plants use one of the three types of mills for coal pulverisation—ball mill, ball-and-race mill, and ball-and-tube mill. To address the issue of stubble burning, the MoP, through its letter no. 11/86/2017-Th. II dated 17 November 2017, encouraged all coal-fired TPPs—except those equipped with ball-and-tube mills—to co-fire 5–10 per cent biomass pellets along with coal for power generation.

Timeline of biomass co-firing policy in thermal power plants

To further institutionalise biomass co-firing, key government institutions such as the MoP, Ministry of New and Renewable Energy (MNRE), Central Electricity Regulatory Commission (CERC), and Commission for Air Quality Management (CAQM) introduced several policy measures over the years.

Figure 1: Chronological overview of key policies promoting biomass co-firing in TPPs



Source: CSE compilation, 2025

MNRE recognises biomass co-firing as renewable energy in September 2019: In order to promote co-firing of biomass in TPPs, the Ministry of New and Renewable Energy (MNRE), in a GOI vide order dated 26 September 2019,[7] stated that the power generated from biomass co-firing in TPPs is renewable energy and it is eligible under the non-solar renewable purchase obligation (RPO). MNRE also requested the CERC to formulate and notify a methodology for quantifying the energy generated from biomass co-firing in coal-based TPPs.

CERC issues draft methodology in February 2020: Accordingly, the CERC issued a draft methodology on 29 November, 2019 for quantifying the energy generated from co-firing of biomass in thermal power plants. A public hearing was held in December 2019 to discuss the draft methodology and the final order was released in February 2020.[8]

MOP launches SAMARTH in July 2021: In order to address the issue of air pollution due to farm stubble burning and to reduce carbon footprints of thermal power generation, the MoP launched the National Mission on Use of Biomass in Coal-Based Thermal Power Plants (SAMARTH—Sustainable Agrarian Mission on the Use of Agri-Residue in Thermal Power Plants) on July 2021.

CAQM mandates TPPs in Delhi-NCR to co-fire biomass pellets in September 2021: The Commission for Air Quality Management (CAQM), through Statutory Direction No. 42 dated 17 September 2021, directed 11 identified thermal power plants within 300 km of Delhi to co-fire 5–10 per cent biomass pellets along with coal.[9]

Under Section 14 of the CAQM Act, 2021, non-compliance is punishable with imprisonment up to five years, a fine up to Rs 1 crore, or both. The other direction issued by CAQM on 17 March, 2023, also promoted biomass co-firing in captive thermal power plants and co-generation TPPs in NCR.[10]

SOP for biomass pellet co-firing in Pulverized Fuel (PF) boilers issued in September 2021: The National Mission on Use of Biomass in Thermal Power Plants, under the Ministry of Power (MoP), issued the standard operating procedure (SOP) for biomass pellet co-firing in Pulverized Fuel (PF) boilers on 23 September, 2021.[11] This SOP provides technical and safety guidelines for biomass pellet co-firing in coal-based TPPs, with the goal of reducing greenhouse gas emissions and controlling air pollution caused by stubble burning. Later, SAMARTH Mission introduced SOPs for biomass co-firing in Fluidised Bed Combustion (FBC) boilers.

This guideline highlights key aspects such as the types and properties of biomass pellets, procedures for their handling, storage, and blending, monitoring of chemical parameters, the impact of biomass co-firing on combustion, associated safety considerations, and the infrastructure requirements for effective biomass pellet handling.

As per the SOP, sample collection is done from every truck arriving at the thermal power plant. Sample collection is done from truck-top. The top 25 cm is removed and then random samples are collected from four to five spots. The collected sample is brought immediately to a lab and all portions collected are thoroughly mixed, followed by coning-quartering until the sample quantity reduces to about 3 kg. This 3 kg sample is divided into three equal parts—one part for power plant's owner, one part for the seller, third part for referee purpose.

MoP revises policy on biomass utilisation in October 2021: On 8 October 2021, the Ministry of Power (MoP) issued a revised policy on biomass utilisation (vide letter no. 11/86/2017-Th. II), making it mandatory for all coal-based TPPs in India to co-fire biomass pellets at a minimum of 5 per cent.[12] This mandate is to be implemented within one year from the policy's issue date. The policy will remain in force for 25 years or until the end of the plant's useful life, whichever comes earlier. Power plants seeking exemptions must submit their case to the Central Electricity Authority (CEA) for review.

As per the revised policy, the following points have been mandated:

- All coal-based TPPs of power generation utilities with bowl mills shall mandatorily co-fire biomass pellets—primarily made from agro-residues—at

BIOMASS PELLETS

There are two types of pellets that can be used for co-firing: torrefied and non-torrefied.

Torrefied biomass pellets: Torrefaction is a thermal process to convert biomass into a coal-like material, which has better fuel characteristics than the original biomass. Torrefied biomass is more brittle, making grinding easier and less energy-intensive. Compared to fresh biomass, storage of the torrefied material can be substantially simplified since biological degradation and water uptake are minimised. Torrefaction involves the heating of biomass in the absence of oxygen to a temperature of typically 200°C to 400°C. The structure of the biomass changes in such a way, that the material becomes brittle and more hydrophobic.

Non-torrefied biomass pellets: They are pellets made from agro-based residue without torrefaction. The main disadvantage with these pellets is that they are hygroscopic in nature and absorbs moisture readily.

a minimum blend of 5 per cent with coal on an annual basis, starting one year from the date of issuance of this guideline. This obligation shall increase to 7 per cent with effect from two years after the date of issue of this order and thereafter.

- All coal-based TPPs of power generation utilities with ball-and-race mill, shall mandatorily co-fire biomass pellets (torrefied only)— primarily made from agro-residues—at a minimum blend of 5 per cent with coal on an annual basis, starting one year from the date of issuance of this guideline. This obligation shall increase to 7 per cent with effect from two years after the date of issue of this order and thereafter.

- All coal-based TPPs of power generation utilities with ball-and-tube mills, on an annual basis, shall mandatorily use 5 per cent blend of torrefied biomass pellets with volatile content below 22 per cent, primarily made of agro residue, along with coal. This is to be complied within a year.

Model contract for use of biomass in thermal power plants introduced on 2 March, 2022: The Ministry of Power (MoP) introduced a 'Model Long Term Contract for Biomass Supply' on 2 March, 2022, providing a comprehensive contractual framework for the procurement and delivery of agro residue-based biomass pellets to thermal power plants (TPPs).[13] The purpose of this model contract is to provide a standardised contractual structure for the long-term supply (minimum seven years) of agro residue-based biomass pellets to power plants, ensuring reliable quality, consistent quantity, and sustainable fuel sourcing. In the model contract, the MoP has issued a mandate to all power stations within a radius

of 300 km of NCR to use a minimum of 50 per cent raw material as stubble/straw/crop residue of rice paddy sourced from Punjab, Haryana or NCR for co-firing.

Recognising the evolving biomass pellet supply chain infrastructure and the need for greater market flexibility, the MoP revised the model contract on 6 January, 2023. The updated version includes amendments to certain clauses and incorporates provisions intended to support further development of the biomass market and promote ease of adoption by stakeholders.

Highlights of the model contract

1. Scope of work

- Supply, loading, transport, and deliver agro-residue-based biomass pellets to the power plant.

- Material type: Only agro/crop residues (e.g., paddy, mustard, cotton stalks). Wood-based pellets are not allowed.

- Technical specs:
  a. **GCV (ARB):** 2,800–4,000 kcal/kg (non-torrefied), 3,400–5,000 kcal/kg (torrefied)
  b. **Moisture:** Max 14 per cent
  c. **Diameter:** ≤25 mm; no other dimension >35 mm
  d. **Fines (length <3mm):** ≤5 per cent
  e. **Bulk density:** ≥600 kg/m^3
  f. **Hard Groove Grindability Index (HGI):** ≥50

- Transport mode: Covered waterproof trucks or by rail (with prior consent).

- Before unloading, samples shall be tested for moisture content.

2. Raw material requirements

- Base material: Only agro residue (e.g., paddy straw, husk, stubble).

- Mandatory use of at least 50 per cent paddy straw from Punjab, Haryana, or NCR for plants within 300 km of NCR.

- Wood from tree cutting is not allowed.

- The supplier shall mention the name(s) of agro/crop residue(s) used for manufacturing torrefied/non-torrefied pellets and their approximate proportion in consignment details during the dispatch of material.

- Natural additives (like starch, lignin) permitted and must be declared.

- Power plants reserve the right to exclude any base material/additive/ binder if harmful to boilers.

3. Period of contract

- Minimum seven years of contract period.

- The supplier shall commence delivery of material within 270 days from the issue of purchase order.

- Grace period of three months/year for delays due to valid reasons (up to 21 months).

- Daily and monthly supply quantities specified; variation allowed up to ±15 per cent monthly.

- If the power plant cannot receive the full quantity of biomass pellets as per the contract in a given period (due to technical breakdown, maintenance, grid restrictions, etc.), the situation can be handled in one of three ways—the unused biomass pellets may be stored at the power plant site for future use, the biomass can be diverted to another plant owned by the same organisation or the supply period may be extended at the same plant without applying Liquidated Damages (LD), which means the supplier will not be penalised for the delay in delivery caused by the plant's inability to receive the material.

- In case of diversion, the price of pellet for the diverted plant upon mutual agreement between the destination plant and the supplier. If distance from supplier works to the diverted plant is within ±10 per cent of the distance of destination plant from supplier works, the price will remain the same. However, in case of distance from supplier works to the diverted plant is more than 10 per cent of the distance of destination plant, then the supplier will get proportional compensation for transportation cost assuming 20 per cent of the landed cost of pellet of that consignment at the destination plant as total transportation cost.

4. Pricing and escalation

- Price basis: Free on road/rail at plant site stores.

- Price escalation allowed based on diesel price, electricity and labour cost

5. Security deposit

Rs 5,000 per MTPD per year (e.g., Rs 35 lakh for 100 MTPD over seven years).

6. Liquidated Damages (LD)

- The supplier shall have to commence delivery of material within 270 days from the date of issue of the purchase order. Once delivery starts, they get a 120-day grace period to scale up operations without penalty.

- Liquidated Damage (LD) shall not be applicable for short supply up to 15 per cent in a month against aggregate of daily delivery schedule in that month. However, for monthly short supply beyond 15 per cent, LD shall be recovered from supplier at 5 per cent of price of the biomass pellets for shortfall quantities.

7. Quantity and quality determination

- Weighing of vehicles shall be carried out on weighbridges (for tare weight and gross weight) at the power plant.

- The power plant will carry out sampling and analysis of torrefied/non-torrefied pellets as per the provisions of either Bureau of Indian Standards (BIS) or American Society for Testing and Materials (ASTM), as per the choice of power plant. It will also carry out the sampling and testing process as per the relevant BIS (IS 436 Part-1) standards for vehicle top sampling.

- Before unloading, the power plant tests biomass samples for moisture. If moisture content is within 14 per cent, unloading is allowed; if it exceeds 14 per cent, the consignment is rejected and must be taken back by the supplier at their own cost.

- The final lab sample is split into three parts—Part 1 of the sample is for analysis of Gross Calorific Value (GCV) and other technical parameters by the power plant lab at the site. Part 2 sample is to be handed over to the pellet supplier for its own analysis. Part 3 of the sample, called referee sample, shall be sealed jointly and shall be kept with the power plant under proper lock and key arrangement.

- In case a dispute is raised within the stipulated time period, the reference sample shall be analysed in a NABL-accredited laboratory as notified by the power plant from time to time, for which the expense shall be borne equally by both the power plant and the pellet supplier. The NABL-accredited laboratory report of the referee sample shall be final and binding on both the parties.

8. Price adjustment for quality

In case of torrefied pellets:

- Minimum limit: 3,400 Kcal/kg; maximum limit: 5,000 kcal/kg.

- If the Gross Calorific Value (GCV) of torrefied pellets exceeds the maximum limit, the price adjustment will be capped at the value corresponding to the maximum GCV limit specified.

- For downward variation from the minimum GCV limit, pro-rata price adjustment will apply based on the following:
  - GCV between 3,000 Kcal/kg and 3,400 Kcal/kg: Price = 0.75 × [FOR Price × (Actual GCV / Quoted GCV)]
    *FOR: Free on Road Price
  - GCV between 2,600 Kcal/kg and 3,000 Kcal/kg: Price = 0.5 × [FOR Price × (Actual GCV / Quoted GCV)]
  - GCV below 2,600 Kcal/kg: No payment will be made for material with GCV less than 2,600 Kcal/kg, even if it has already been delivered and consumed.

In case of non-torrefied pellets:

- Minimum limit: 2,800 Kcal/kg; maximum limit: 4,000 kcal/kg.

- Supplier shall supply the agro residue-based non-torrefied biomass pellets of GCV not less than 2,800 kcal/kg. Price shall be adjusted for GCV variation of supplied material as below:
  - If the Gross Calorific Value (GCV) of non-torrefied pellets exceeds the specified maximum limit, the price adjustment shall be capped at the value corresponding to the maximum GCV limit for non-torrefied pellets.
  - GCV between 2,800 and 2400 Kcal/Kg: 75 per cent of the adjusted price will be paid. Price= 0.75× (FOR Price × Actual GCV / Quoted GCV)
  - GCV between 2,400 Kcal/kg and 2,000 Kcal/Kg: 50 per cent of the adjusted price will be paid. Price= 0.5× (FOR Price × Actual GCV / Quoted GCV)
  - GCV below 2,000 Kcal/kg: No payment will be made for material with

GCV less than 2,000 Kcal/kg, even if it has already been delivered and consumed.

9. Recovery on account of excess fines in consignment

The dimensions of agro residue-based pellets must conform to the technical specifications. Any dust or crushed pellets received at the power plant will be considered as fines. If the fines exceed 5 per cent, a deduction shall be applied to the payment for that consignment.

The recovery amount will be calculated using the following formula:
Recovery = Adjusted price of biomass pellets × W × (Fines per cent beyond 5 per cent)

10. Rejection level

The consignment of agro residue-based pellets arrived at the power plant shall initially be tested for moisture. If moisture exceeds 14 per cent, the consignment will be rejected.

Ministry of Power revised policy for biomass utilisation for power generation through co-firing in coal-based TPPs in June 2023:

- All coal-based TPPs of power generation utilities with bowl mills shall, on an annual basis, mandatorily use minimum 5 per cent blend of biomass pellets, primarily of agro-residues along with coal, with effect from FY 2024–25. This obligation shall increase to 7 per cent with effect from FY 2025–26.

- All coal-based TPPs of power generation utilities with ball-and-race mill shall, on an annual basis, mandatorily use 5 per cent blend of biomass pellets (torrefied only), primarily of agro-residue along with coal, with effect from FY 2024–25. This obligation shall increase to 7 per cent with effect from FY 2025–26.

- All coal-based TPPs of power generation utilities with ball-and-tube mills shall, on an annual basis, mandatorily use 5 per cent blend of torrefied biomass pellets with volatile content below 22 per cent, primarily made of agro-residue along with coal, with effect from FY 2024–25.[14]

Provisions related to tariff determination and scheduling under revised biomass policy: The revised policy on biomass co-firing provides greater clarity on tariff determination and scheduling for coal-based thermal power plants (TPPs). For power plants operating under Section 62 of the Electricity Act (where tariffs

are regulated by the appropriate regulatory commission), the additional cost of biomass used for co-firing is allowed as a pass-through in the Energy Charge Rate (ECR). This means that the extra cost incurred due to biomass can be directly added to the variable cost component of the electricity tariff and recovered from consumers.

For power plants operating under Section 63 of the Act (where tariffs are discovered through competitive bidding), the increase in ECR due to biomass co-firing can be claimed under the 'Change in Law' provisions. In such cases, the generator may seek compensation or tariff adjustment, as the co-firing requirement constitutes a new policy directive introduced after the signing of the power purchase agreement.

It is important to note that any increase in ECR due to biomass co-firing will not be considered while determining the Merit Order Dispatch (MOD). This means, TPPs will not be penalised in the dispatch order for having a slightly higher variable cost due to the use of biomass.

For context, electricity tariffs generally consist of two components:

- **Fixed cost**: This covers capital investment and is paid to generators as long as the plant is available to generate electricity, regardless of actual generation.

- **Variable cost**: This includes fuel costs (such as coal or biomass) and is incurred only when electricity is generated. It is paid in proportion to the actual electricity produced.

MOEF&CC issues notification on mandating biomass co-firing in coal-based TPPs, in July 2023: On 11 July, 2023, the Ministry of Environment, Forest and Climate Change (MOEF&CC) issued a notification and mandated all coal-based TPPs of power generation utilities to mandatorily use minimum 5 per cent blend of pellets or briquettes made of crop residue along with coal.[15] These rules are applicable to all coal-based TPPs located within the NCR and adjoining areas, as defined under the Commission for Air Quality Management Act, 2021.

To enforce compliance, the notification introduces an environmental compensation mechanism. From FY 2024–2025, if a power plant uses less than the mandated 5 per cent crop residue, it will be subject to a graded penalty depending on the actual percentage of usage. For instance, using less than or equal to 1 per cent will attract a compensation of Rs 0.03 per unit of electricity generated. The penalty becomes stricter from FY 2025–2026 onwards, with Rs 0.05 per unit levied for using less than 1 per cent crop residue. Additionally, the tariff for electricity generated by

Table 3: Environmental compensation for 2024–2025 and 2025–2026

S. No.	% Crop residue used (annual blend)	Environmental compensation (Rs/ unit electricity generated) 2024–25	Environmental compensation (Rs/ unit electricity generated) 2025–26 onwards
1	> 4% to ≤ 5%	0	0.01
2	> 3% to ≤ 4%	0	0.02
3	> 2% to ≤ 3%	0.01	0.03
4	> 1% to ≤ 2%	0.02	0.04
5	> 0% to ≤ 1%	0.03	0.05

Source: MOEF &CC

these plants will be determined by the central or state Electricity Regulatory Commissions, which must take into account compliance with the crop residue usage mandate.

Biomass price benchmarking for co-firing in thermal power plants:

Price benchmarking of non-torrefied biomass in NCR region (3 October, 2024): On 3 October, 2024, the Ministry of Power addressed the price benchmarking for non-torrefied biomass pellets specifically for NCR. It outlines a decision to maintain the benchmark price at Rs 2.32/1,000 Kcal for a further year (up to 31 August, 2025), excluding GST and transportation costs. The pellet shall have moisture content below 14 per cent, GCV between 2,800 kcal/kg and 3,400 kcal/kg.[16]

Price benchmarking of torrefied biomass in NCR region (18 November, 2024): In line with the MoP's revised biomass policy issued on 16 June, 2023, a committee was formed on 22 June, 2023, to benchmark biomass pellet prices region-wise, enhance pellet manufacturing capacity, and address raw biomass price volatility. The committee focused on torrefied biomass pellets for the NCR region and recommended a benchmark price of Rs 2.58 per 1,000 kcal (excluding GST and transportation cost at the pellet manufacturing plant site), valid for one year. The specified pellet characteristics include moisture content below 14 per cent, GCV between 3,400 kcal/kg and 5,000 kcal/kg, and volatile matter below 22 per cent.[17]

Price benchmarking of biomass pellets in the western region (8 November, 2023): The MoP addresses the price benchmarking of biomass pellets for co-firing in thermal power plants within the western region. Following a previous policy modification and the formation of a committee, a benchmark price of Rs 2.24/1,000

kcal was established for non-torrefied pellets for a one-year period effective 8 November, 2023, which excludes GST and transportation costs. The pellets shall have moisture content below 14 per cent and GCV between 2,800 kcal/kg and4,000 kcal/kg. Thermal power plants are instructed to adhere to this benchmark price as part of efforts to promote sustainable biomass supply chains and facilitate pellet procurement.[18]

Price benchmarking of biomass pellets in the northern region (8 November, 2023): The MoP outlines a new price benchmark for biomass pellets intended for co-firing in TPPs within the northern region of India. Following a previous policy aimed at promoting sustainable biomass supply chains, a committee was established to determine region-specific pricing. Based on the committee's findings, biomass fuel price was set for a year starting 8 November, 2023. The benchmark prices for non-torrefied biomass pellets in the northern region have been derived as Rs 2.27/1,000 kcal, excluding GST and transportation costs at the production site. The pellets shall have moisture content below 14 per cent and GCV between 2,800 kcal/kg and 4,000 kcal/kg.[19]

Table 4: Biomass price benchmarking for co-firing in TPPs

Region	Type of pellet	Benchmark price (Rs/1,000 kcal)	Validity	Moisture content	GCV range (kcal/kg)	Other specifications
NCR	Non-torrefied	Rs 2.32	Up to 31 August, 2025	< 14%	2800–3400	Excl. GST and transportation
NCR	Torrefied	Rs 2.58	1 year (from 18 November, 2024)	< 14%	3400–5000	Volatile matter < 22%
Western Region	Non-torrefied	Rs 2.24	1 year (from 08 November, 2023)	< 14%	2800–4000	Excl. GST and transportation
Northern Region	Non-torrefied	Rs 2.27	1 year (from 08 November, 2023)	< 14%	2800–4000	Excl. GST and transportation

Source: SAMARTH

3. Status of biomass co-firing in India

India is actively pursuing decarbonisation and sustainability in the power sector through targeted initiatives such as the National Mission on the Use of Biomass in Thermal Power Plants, also known as the SAMARTH Mission (Sustainable Agrarian Mission on the Use of Agro-Residue in Thermal Power Plants), launched by the Ministry of Power (MoP). The mission was constituted by forging eight organisations like the Central Electricity Authority (CEA), National Thermal Power Corporation (NTPC), Bureau of Energy Efficiency (BEE), Ministry of New and Renewable Energy (MNRE), Damodar Valley Corporation (DVC), Central Power Research Institute (CPRI), Bharat Heavy Electricals Ltd. (BHEL) and National Power Training Institute (NPTI). This mission aims to leverage India's significant agricultural residue for clean energy generation by promoting biomass co-firing in coal-based thermal power plants (TPPs).

Being a predominantly agrarian economy, India generates about 755 million tonnes of agricultural residues annually. Of this, about 228 million tonnes are estimated to be surplus and available for energy generation—translating to a substantial energy potential of 28,445 megawatts electric (MWe).[20] Harnessing this biomass not only offers a renewable energy alternative but also helps curb stubble burning and reduce air pollution across the country.

To promote ease of doing business in the biomass sector, the government has facilitated administrative approvals for setting up biomass pellet manufacturing plants through the National Single Window System (NSWS). In a significant policy push, the Reserve Bank of India (RBI) has also categorised biomass pellet manufacturing under Priority Sector Lending.

Furthermore, to strengthen the biomass supply chain, agro-residue trading is now facilitated via the National Agriculture Market (e-NAM) portal, while a dedicated Government e-Marketplace (GeM) portal has been established for the transparent and efficient procurement of biomass pellets by power producers and public sector entities.

The Ministry of New and Renewable Energy (MNRE) is supporting the expansion of the biomass sector by providing Central Financial Assistance (CFA) under

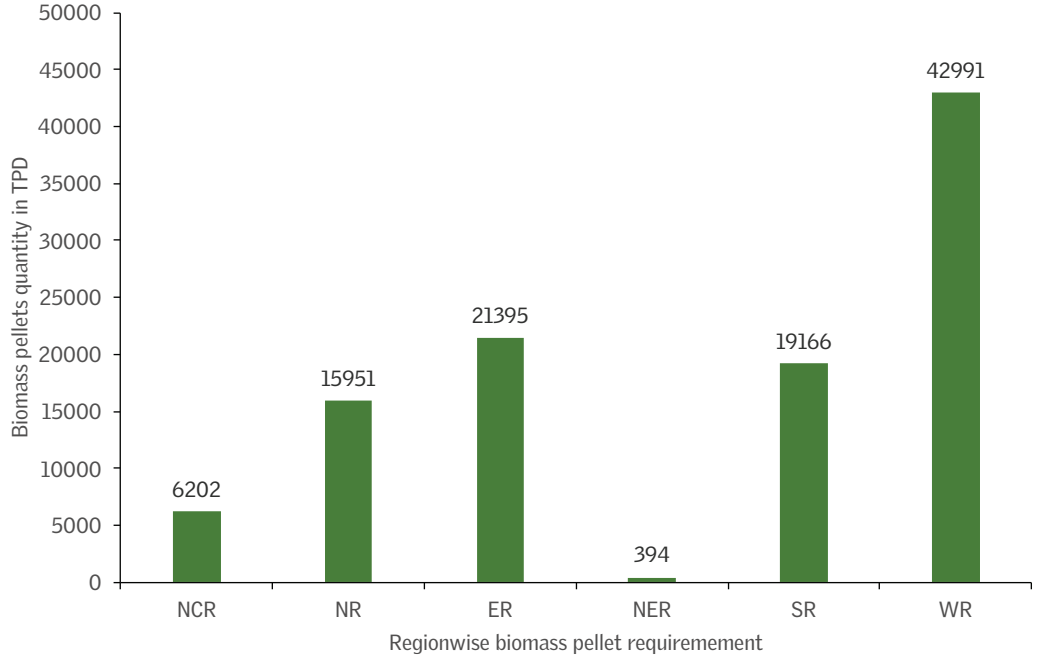
its biomass programme to encourage the establishment of pellet and briquette manufacturing units across the country. Meanwhile, the Central Pollution Control Board (CPCB) is implementing a dedicated grant scheme specifically for biomass pellet manufacturers operating in the NCR, aiming to curb stubble burning and reduce regional air pollution.

Through a combination of legislative, executive, and financial interventions, the Government of India is actively fostering a supportive ecosystem for the growth of the biomass pellet market, driving both environmental sustainability and rural economic development.

Biomass pellets demand and market scenario

As per the SAMARTH Mission article, under the 5 per cent biomass co-firing mandate for thermal power plants, the projected demand for biomass pellets is regionally distributed, with the western region (WR) accounting for 41 per cent, followed by the eastern region (ER) at 20 per cent, the southern region (SR) at 18 per cent, and the northern region (NR) at 15 per cent. However, the actual co-firing levels in these regions are still in the early stages.[21] Notably, the NCR and northeast region (NER) report lower demand due to relatively lower installed coal-based capacity.

Graph 1: Biomass pellet requirement to achieve 5 per cent co-firing (TPD)



Source: SAMARTH

As per the SAMARTH Mission data, for FY 2024–25, biomass consumption from 1 April to 31 March stands at 16,25,383 metric tonnes (MT), marking a remarkable 4.4 times growth compared to the previous fiscal year, which was recorded at 3,07,750 MT. The adoption of biomass pellets in TPPs has witnessed a significant surge in the country, with usage increasing by nearly 40 times in FY 2024–25 compared to FY 2021–22. This remarkable growth highlights the successful efforts to integrate biomass co-firing as a sustainable energy solution. Notably, of the total 16 lakh metric tonnes of biomass consumed during FY 2024–25, about 13 lakh metric tonnes, or nearly 80 per cent, was consumed by TPPs in the Delhi-NCR alone, highlighting the region's leadership in implementing co-firing mandates and pollution mitigation strategies.

Sustained policy and regulatory push from the Ministry of Power, the SAMARTH Mission, the Central Electricity Authority (CEA), and the Commission on Air Quality Management (CAQM), along with the imposition of Environmental Compensation (EC) by the MoEF&CC, have driven higher adoption of biomass co-firing in regional TPPs.

As of March 2025, a total of 68 TPPs across India have adopted biomass co-firing, consumed 21.18 lakh metric tonnes of biomass and reduced about 25 lakh metric tonnes of CO_2 emissions.

Biomass availability and regional disparities

The state-wise biomass co-firing status is detailed in Table 5, which highlights installed TPP capacity, biomass consumption, estimated requirement at 5 per cent co-firing, and surplus biomass availability across states.

It is evident that India has ample surplus biomass (218.13 MT) to meet and even exceed the 5 per cent co-firing requirement, which demands around 43.81 MT annually. For a 10 per cent co-firing scenario, about 87.62 MT would be required.

As per the Ministry of Power's revised policy issued in October 2021, 5 per cent biomass co-firing is mandatory. However, actual implementation remains far below the target—only about 1.6 million tonnes of biomass is currently being co-fired in TPPs across India. This gap underscores the need for improved implementation, supply logistics, and financial incentives.

To bridge supply gaps in biomass-deficit states like Chhattisgarh and Jharkhand, inter-state transportation of biomass from surplus-rich states like Madhya Pradesh,

Table 5: State-wise biomass co-firing status in TPPs and surplus biomass availability

S. No.	State	Installed capacity of TPP (MW)	Total biomass consumption (tonnes) 2024–25	Biomass required quantity @5% co-firing million tonnes	Surplus biomass million tonnes
1	Andhra Pradesh	14,540	NIL	2.819	17.09
2	Assam	750	NIL	0.152	2.54
3	Bihar	9,060	NIL	2.154	7.98
4	Chhattisgarh	23,088	9,914	5.837	2.65
5	Gujarat	14,692	16,499	2.132	21.74
6	Haryana	5,330	625,694	1.056	10.91
7	Jharkhand	7,805	26,029	1.947	1.2
8	Karnataka	9,480	NIL	1.324	14.05
9	Madhya Pradesh	23,800	115,105	4.880	19.93
10	Maharashtra	22,656.01	82,472	4.385	21.49
11	Odisha	10,740	2,973	2.409	2.23
12	Punjab	5,680	358,979	1.046	22.25
13	Rajasthan	9,200	NIL	1.828	10.21
14	Tamil Nadu	10,459	792	2.099	12.22
15	Telangana	9,442.5	NIL	1.948	13.76
16	Uttar Pradesh	26,715	349,835	5.293	21.6
17	West Bengal	11,252	33,057	2.510	16.28
			16,21,349 tonnes 1.6 million tonnes	43.81	218.13

Note: The quantity of biomass required for 5 per cent co-firing has been estimated based on the coal consumption for 2024–25. The annual coal consumption was derived using monthly coal consumption data available on the National Power Portal. However, data for March 2025 is currently unavailable. Therefore, the coal consumption for March has been estimated using the average of the available data from the preceding 11 months.

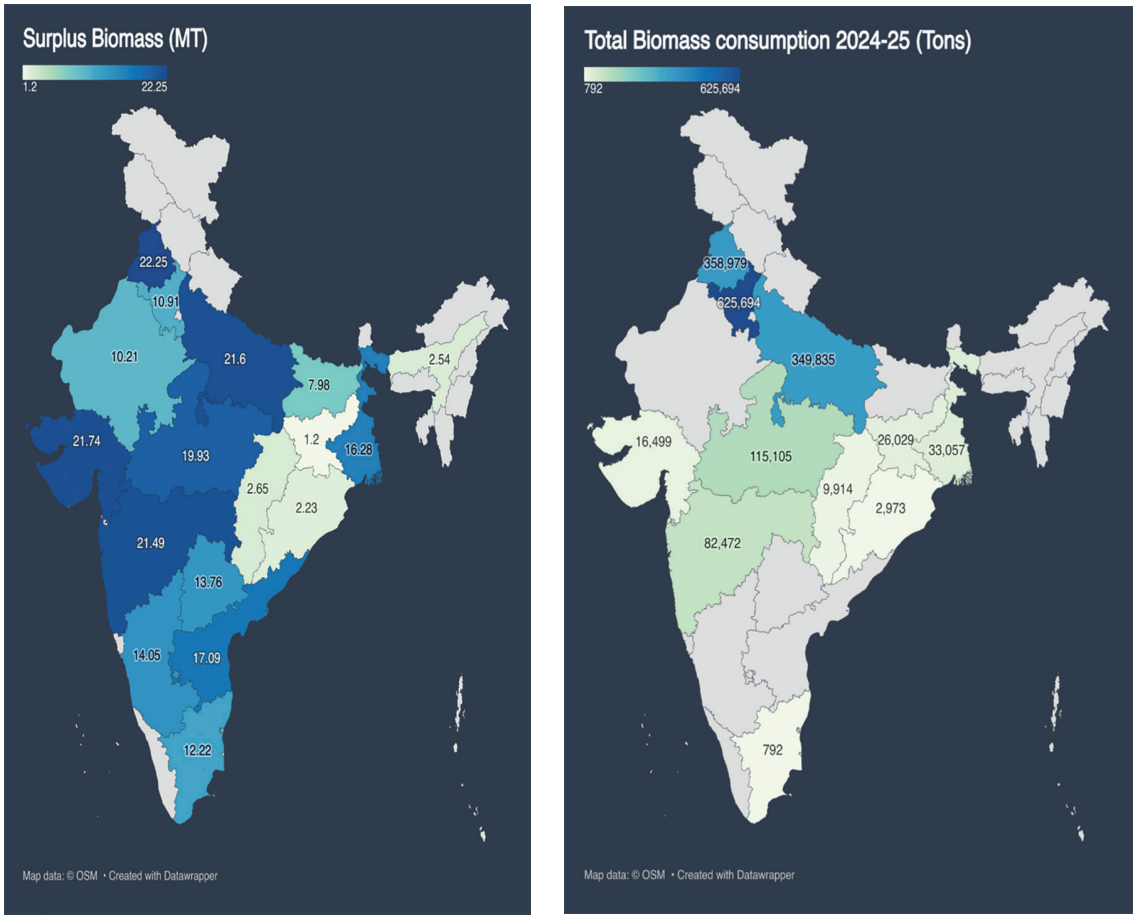
Source: CSE analysis

West Bengal, Uttar Pradesh, and Bihar can be a viable strategy. Building robust supply chain logistics will be crucial for sustaining the co-firing momentum.

The two maps below (see *Map 1: Current biomass co-firing vs surplus biomass availability in India*) present a comparative picture of biomass surplus availability and actual biomass consumption by thermal power plants (TPPs) across India in FY 2024–25. The first map illustrates the state-wise surplus agricultural biomass availability. States like Punjab (22.25 MT), Maharashtra (21.74 MT), Uttar Pradesh (21.6 MT), Madhya Pradesh (19.93 MT), and West Bengal (16.28 MT) exhibit the highest surplus biomass potential.

In contrast, the second map shows the actual biomass consumption by TPPs, indicating how much biomass was utilised for co-firing during 2024–25. The Delhi-

Map 1: Current biomass co-firing vs surplus biomass availability in India



Source: CSE analysis

NCR region, especially Haryana (625,694 tonnes), Punjab (358,979 tonnes), and Uttar Pradesh (349,835 tonnes), show the highest levels of consumption, largely driven by strict environmental regulations and policy interventions. In comparison, most other states outside the NCR have recorded significantly lower levels of biomass usage, despite having considerable surplus availability. This highlights a clear underutilisation of biomass resources in non-NCR regions, pointing to logistical challenges, lack of policy enforcement, and limited infrastructure to support large-scale biomass co-firing.

Biomass pellet manufacturing capacity in India

On the supply side, as per the SAMARTH Mission, India has a robust infrastructure for biomass pellet production, comprising approximately 680 manufacturing plants capable of producing briquette as well as pellets based on demand. Among

these, over 300 plants specialise 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. Currently, India's total biomass pellet manufacturing capacity is estimated at 11.56 million tonnes per annum, translating to about 30,000 tonnes per day.

Beyond energy generation, this growing sector is also delivering significant economic benefits. It provides an alternative revenue stream to farmers by creating a structured market for agricultural residues. A biomass market worth Rs 15,000–20,000 crore is currently taking shape for farmers, while the pellet manufacturing industry itself is projected to generate an annual turnover of Rs 28,000–35,000 crore. This dual advantage of environmental sustainability and rural economic upliftment underscores the sector's strategic importance in India's energy transition.

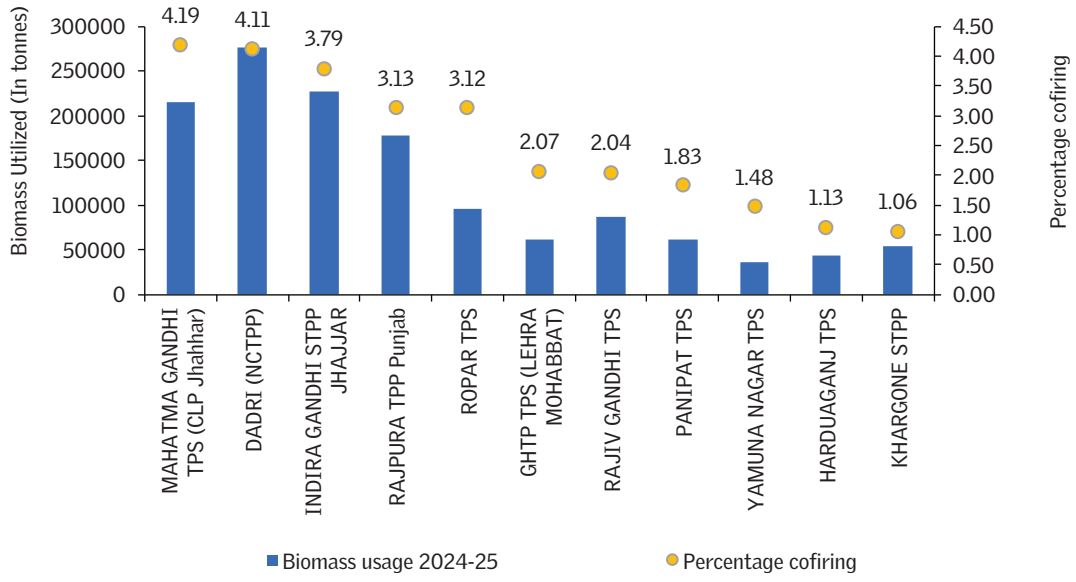
4. Good practices of biomass co-firing in India

The objective of this study is to identify the key operational, logistical, and policy-related enablers that facilitate effective biomass utilisation in thermal power plants (TPPs) across India. While the national push for biomass co-firing has been underway for several years, progress has been uneven, with some plants demonstrating sustained implementation while others continue to lag.

This chapter focuses on those TPPs that have successfully integrated biomass co-firing into their operations. It examines the specific strategies, institutional mechanisms, and ground-level interventions that have enabled consistent biomass use. These best-performing plants not only contribute to reducing stubble burning and air pollution but also help diversify fuel sources—aligning with India's environmental objectives and clean energy transition goals.

A key finding from this study is the significantly better adoption of biomass co-firing practices in Delhi-NCR, compared to the rest of the country. This success can be

Graph 2: India's top 10 biomass co-firing power plants



Source: CSE analysis

Process flow chart from harvesting to co-firing as a fuel

Source: CSE Survey

largely attributed to the proactive regulatory approach of the Commission for Air Quality Management (CAQM). The CAQM's clear mandates, strict timelines, and continuous monitoring have created a strong sense of urgency and accountability among NCR-based power producers. As a result, Delhi-NCR has emerged as a model for biomass co-firing implementation.

Case study 1: Biomass co-firing at NTPC Dadri

The National Capital Power Station (NCPS), also known as NTPC Dadri, is a major coal-based TPP in Vidyut Nagar, District Gautam Budh Nagar, in Uttar Pradesh. With an approved capacity of 1,820 MW, the plant consists of four units of 210 MW each and two units of 490 MW each, commissioned between October 1991 and July 2010. Strategically positioned to serve the energy needs of the NCR, the NTPC Dadri sources its coal from Piparwar Mines in Jharkhand and water from the Upper Ganga Canal (Mat Branch). The plant supplies electricity primarily to Delhi and Uttar Pradesh, Rajasthan, Haryana and Gujarat, playing a pivotal role in the region's power infrastructure.

Biomass co-firing at NTPC Dadri: To reduce coal dependency and lower carbon emissions, NTPC Dadri has implemented biomass co-firing. The initiative was launched as a pilot project in September 2017, reflecting India's broader commitment to clean energy and sustainable development. Following the pilot's success, commercial-scale co-firing commenced on 4 December, 2018, and was subsequently scaled up to a 500-MW unit by 16 January, 2020.

Maximum biomass of 41,130 tonnes was handled in March 2025 with single-day maximum consumption of 1,956 tonnes with 57 trucks on 30 March 2025. On an average, the daily biomass consumption is around 1,000–1,200 tonnes per day.

Phased pilot testing

Phase 1: 5 per cent biomass pellets with 95 per cent coal using one pulverising mill (Unit no. 4)

Phase 2: 10 per cent biomass pellets with 90 per cent coal, one mill

Phase 3: Full load co-firing with 10 per cent biomass pellets and 90 per cent coal across four mills

Non-torrefied biomass pellets

Source: CSE Survey

Best practices implemented at NTPC Dadri

- **Automated unloading and handling system:** NTPC Dadri uses non-torrefied biomass pellets. These biomass pellets are transported in trucks and promptly sampled following SAMARTH Mission protocols. Once the required physical parameters are approved, the biomass pellets are unloaded using a dedicated mechanised system called a 'truck tippler' that minimises manual handling and reduces unloading time. The biomass is transported using bulldozers to a designated storage area and then moved to emergency hoppers as needed. From there, an automated conveyor system carries the biomass to blending points, where it is mixed with coal—usually at a 5 per cent biomass to 95 per cent coal ratio. To prevent fuel degradation, the unloaded biomass is typically consumed the same day.

Biomass sampling at entry point

Truck tippler for biomass unloading

Dozers moving biomass to storage area

Storage area

Biomass heap near hopper area

Hoppers

Dozer feeding biomass into hoppers

Biomass handling at NTPC Dadri

Source: CSE Survey

- **Robust sampling and testing protocols:** Each truck carrying biomass is subjected to a sampling process, where about 30 kg of material is drawn from multiple points within the truckload in accordance with SAMARTH Mission guidelines. The collected sample is immediately sealed in an airtight, tamper-proof bag and labelled with a unique code to prevent any manipulation or identity-based bias during testing. At the sample preparation site, the 30 kg sample is reduced to 3 kg using the coning and quartering method, and the final sample is divided equally into three parts—for the plant, the vendor, and for a referee laboratory. This ensures transparency and allows for third-party verification if needed.

  The plant's in-house laboratory then tests the sample for moisture content, which must be below 14 per cent to be accepted. Once approved, biomass pellets are loaded in the truck and they are allowed for unloading at specified unloading site. Further testing includes determining the Gross Calorific Value, fines and ash content. These tests are completed within three to four days. In case of discrepancies or quality concerns, a fresh sample is taken directly from the unloaded biomass load and re-evaluated to check conformity with the standards.

  NTPC Dadri has awarded biomass supply tender to 176 biomass manufactures to ensure consistent supply throughout the year and comply with MoP's directions to meet 7 per cent co-firing standard by FY 2025–26.

- **System modifications for safe biomass co-firing**: NTPC Dadri has made some modifications. A critical aspect of the modification involves controlling the mill inlet temperature, which is strictly maintained below 180°C to prevent ignition risks. For enhanced thermal control, an additional inlet temperature thermocouple (T/C) has been installed, while the mill outlet temperature is maintained between 60–65°C to ensure stable combustion.

  To support proper air-fuel mixing, the primary air (PA) header pressure has been slightly increased to around 800 millimetres of water column (mmWC). Fire protection measures include automatic hot air gate (HAG) closure if the inlet temperature exceeds 180°C, effectively stopping hot air flow, in case of overheating.

  NTPC Dadri has also introduced a comprehensive mill inerting system, featuring motorised inerting valves in each mill, individual pulverized fuel (PF) pipe temperature sensors, and orifices in mill inerting lines for regulated steam flow. Continuous monitoring is essential, with parameters such as mill inlet

and outlet temperatures, mill current, and differential pressure (DP) under constant surveillance. The mill reject system must be regularly observed for signs of malfunction or blockage. Operators are required to be stationed locally to respond quickly to any fire hazards.

In case of a fire, the protocol mandates an immediate mill trip, followed by steam injection via the motorised inerting valve, while closely watching furnace pressure. Fire tenders may be used, if necessary. Additionally, flue gas (FG) temperatures in the superheater (SH) zone and air preheater (APH) outlet must be continuously monitored. Any signs of clinkering or slagging should be identified, both visually and through abnormal rises in SH zone temperatures, with soot blowing and long retractable soot blowers (LRSB) activated as needed to maintain system cleanliness and performance.

- **Surveillance system for monitoring:** To uphold the transparency and credibility of the sampling and testing process, the entire biomass sampling and preparation area is under CCTV surveillance. Cameras are installed at all critical points—including the truck unloading zone, sampling stations, and laboratory handling areas. The live feed from these cameras is continuously monitored by designated personnel to prevent any unauthorised access, tampering, or procedural lapses.

Challenges faced by NTPC Dadri in biomass co-firing

- **Monsoon storage issues**: During the rainy season, the hygroscopic biomass pellets absorb moisture, degrading quality and reducing combustion efficiency, despite same-day consumption practices.

- **Dust generation**: Unloading and loading biomass into hoppers generates dust, posing air quality concerns, especially with a daily usage of 1,000–1,200 metric tonnes per day (MTPD).

- **Lack of standardised testing:** No standard procedure exists for testing biomass composition (e.g., sulphur, chlorine, volatile matter), causing discrepancies and challenges in ensuring boiler compatibility.

Case study 2: Biomass co-firing at Nabha Power Limited (NPL), Rajpura

The Nabha Power Limited (NPL) is located in Rajpura, Punjab. NPL is owned and operated by Larsen & Toubro. The plant comprises two supercritical units of 700 MW each, with the entire 1,400 MW output contracted to Punjab State Power

Corporation Limited (PSPCL) through a 25-year Power Purchase Agreement (PPA). NPL is the first power plant in India to achieve commercial operations using an indigenously-manufactured supercritical boiler-turbine-generator, built with advanced technology from Mitsubishi Heavy Industries (now MHPS) in Japan, and fabricated through the L&T-MHPS joint venture at Hazira in Gujarat.

The unit 1 and unit 2 in NPL was commissioned in record time—48 months and 54 months, respectively. The plant began commercial operations in 2014. It secures its coal supply through a 20-year Fuel Supply Agreement (FSA) with Southeastern Coalfields Limited, while water needs are met via the Bhakra-Nangal distributary, as allocated by the state irrigation department.

Biomass co-firing at NPL: The Nabha Power Limited (NPL) effectively began biomass co-firing in FY 2024–25, marking a major stride toward cleaner power generation. The plant-initiated co-firing with a 3 per cent blend of non-torrefied biomass pellets with coal (2024–25) and increased the ratio to about 4.8 per cent in 2025–26. On average, the plant consumes around 16,000 tonnes per day (TPD) of coal, alongside 600–700 TPD of biomass pellets.

Storage yard at NPL, Rajpura

Source: CSE Survey

Nabha Power Limited (NPL) utilises a Mitsubishi Hitachi Power Systems (MHPS) unit, a technology that has demonstrated high potential for biomass co-firing. While NPL currently operates at a co-firing ratio of about 4.8 per cent by weight, the MHPS units have previously achieved biomass co-firing ratios of up to 34 per cent by heat value at rated load, and up to 50 per cent at partial load, as demonstrated at the 112-MW Soma Energy Park plant in Japan. This performance was achieved using wood pellet fuel without significant equipment modifications, underscoring the latent capability of the MHPS boiler design.

Best practices implemented at NPL

- **Automated handling and quality control systems:** Upon arrival, biomass-laden trucks are first sampled using elevated platforms that allow deep and accurate extraction of material for testing. Moisture content is immediately checked, and only consignments with moisture levels below 14 per cent are accepted. To streamline logistics, dedicated weighbridges have been installed, reducing truck turnaround time and improving entry efficiency. Once accepted, the biomass is moved to the storage yard and consumed within the same day to prevent quality degradation due to moisture absorption. Currently, NPL lacks a dedicated mechanism to blend biomass with coal during the feeding process. As an interim arrangement, the biomass is manually mixed with coal in the storage yard, and the combined fuel is then collected by the reclaimer. The reclaimer transports the blended material to the mills, enabling continuous and controlled co-firing within the combustion system. Currently, NPL is working on installing a dedicated biomass-coal mixing mechanism.

- **Sampling and testing protocols:** NPL employs a two-stage sampling and testing process to ensure biomass quality. Initial sampling is done at the plant gate, where incoming truckloads are tested for moisture content. The process takes 20 minutes to 1.5 hours, with an average decision time of 45 minutes. Loads with moisture below 14 per cent are accepted and moved to the storage yard.

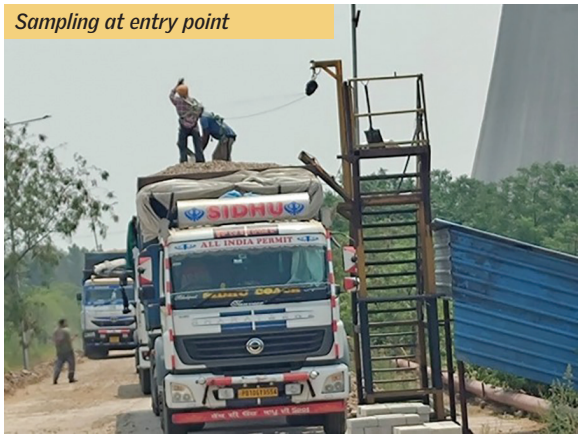
  A second sampling is conducted post unloading to counteract intentional material stratification, where vendors may place better-quality pellets on top to pass surface-level checks. This stage evaluates Gross Calorific Value (GCV), fines, and ash content. Testing is done in NPL's in-house lab. With biomass sourced from 16 vendors, the average GCV recorded is around 3,200 kcal/kg. This protocol ensures only high-quality biomass is used, supporting efficient and reliable co-firing.

  Additionally, NPL is working on developing an automated, faster sampling method aimed at reducing both the turnaround time and manpower requirements. It is also testing a mechanical auger system for deep sampling. However, operational trials revealed that the auger tends to break biomass pellets, resulting in a higher proportion of fines in the sample, which can lead to disputes between NPL and vendors over representativeness. In light of these challenges, NPL is still evaluating alternative automated sampling solution.

- **Surveillance system for monitoring:** To ensure transparency and reliability in the sampling and testing process, CCTV cameras have been installed throughout the biomass sampling and preparation areas. These cameras cover all key locations, such as the truck unloading zone, sampling points, and laboratory handling sections.

- **Operational controls for safe biomass co-firing:** NPL enforces strict control of boiler inlet temperatures to prevent thermal instability. Additionally, continuous monitoring and risk mitigation protocols are in place to manage fire hazards inherent in biomass storage and handling, ensuring safe and reliable plant operations.

Sampling at entry point



Sampling after unloading

Sampling using auger machine

Reclaimer used to collect coal and biomass

Biomass handling at NPL, Rajpur

Source: CSE Survey

- **Vendor development and inclusive procurement for biomass co-firing** NPL has relaxed the Bid Guarantee (BG), Earnest Money Deposit (EMD), and technical/financial qualification norms in order to expand its biomass supplier base from five to 16 within a year. This enabled a rapid logistics scale-up from 10 to 1,224 trucks (April–December 2024), overcoming seasonal disruptions. NPL also ensured timely payments and advocated for district-level paddy certification and supporting its co-firing target.

Challenges faced by NPL in biomass co-firing

- **Fuel quality issues:** In the initial phase of biomass co-firing, there were significant issues with fuel quality. Some vendors delivered biomass contaminated with non-agricultural residues, including materials like litters and press mud, which negatively affected combustion quality and increased the risk of operational disruptions and emissions.

- **Supply chain disruptions:** The plant initially faced challenges in securing a consistent and timely supply of biomass. Disruptions in the supply chain hindered daily co-firing operations. However, through improved coordination and stronger vendor management, significant improvement in supply consistency has been recorded over time.

- **Securing energy charge pass-through for biomass costs:** NPL faced regulatory hurdles in securing biomass cost pass-through under the 'Change in Law' clause. Punjab State Power Corporation Limited's (PSPCL) resistance and an adverse state regulator order had stalled cost recovery. NPL's sustained engagement with MoP and CEA led to a clarification on 14 May 2024, affirming biomass fuel cost as pass-through in Energy Charge Rate for Section 63 projects.

- **Seasonal variability in biomass quality:** During monsoon season, the moisture content in biomass significantly increases, leading to a substantial drop in its Gross Calorific Value (GCV). This seasonal variability poses a challenge in maintaining combustion efficiency and consistent boiler performance.

5. Challenges in biomass co-firing in TPPs

Biomass co-firing has emerged as a key strategy to reduce carbon emissions, enhance energy security, and manage agricultural waste. However, despite the potential, biomass co-firing in coal-fired thermal power plants (TPPs) faces numerous challenges that hinder its large-scale and sustained implementation. These challenges span across technical, economic, policy, logistical, and environmental domains.

1. Regulatory and policy challenges

Regulatory challenges

Unclear mandates and enforcement: While the Ministry of Power (MoP) and the Ministry of Environment, Forest and Climate Change (MoEFCC) have issued guidelines on biomass co-firing, these are often perceived as advisory rather than mandatory. Without strict enforcement and accountability mechanisms, many TPPs do not prioritise implementation of these guidelines. In contrast, Delhi-NCR has achieved the highest levels of biomass co-firing, largely due to the presence of a clear mandate backed by penalty provisions for non-compliance.

Lack of pressure from state governments: State government-owned TPPs have shown lower levels of compliance with biomass co-firing guidelines. This is primarily due to the absence of adequate pressure or directive from state governments to ensure adherence to the prescribed targets.

Policy challenges

Unfair sample collection technique for biomass: According to the SAMARTH Mission's SOP for biomass co-firing in PF boilers and FBC boilers, sampling for key parameters such as moisture, ash content, and Gross Calorific Value (GCV)—is carried out using the sample collected from the top layer of biomass loaded truck. The top 25 cm is removed and then random samples are collected from four to five spots to be used for analysis of parameters such as moisture, ash content, and GCV.

However, a survey conducted by CSE revealed that many thermal power plants like Harduaganj thermal power plant in Aligarh and Panipat thermal power plant have raised concerns about this method. The representatives from TPPs highlighted that biomass suppliers often load higher-quality biomass at the top of the truck and lower-quality material underneath. As a result, the samples taken from the top do not accurately represent the overall quality of the biomass being supplied, leading to discrepancies during actual use.

During CSE's survey, Harduaganj TPP reported that it had been facing this issue for a long time. To address it, the plant modified the biomass sampling method in its latest tender, moving away from the approach prescribed in the SAMARTH Mission's SOP. The plant has now introduced a new condition requiring biomass sampling to be carried out after unloading the material from the truck, ensuring a more representative and accurate assessment of fuel quality.

2. Biomass supply chain and market challenges

Mismatch between biomass pellet demand and production: As per the MoP's policy on biomass utilisation, about 0.25–0.3 million tonnes (MT) of biomass pellets are required annually for every gigawatt (GW) of thermal power capacity operating at 7 per cent co-firing.

However, there is a significant mismatch between demand and supply due to the limited number of pellet manufacturers in the country. Currently, India's total pellet manufacturing capacity stands at about 30,000 tonnes per day, while the estimated daily requirement is around 105,610 tonnes (at 5 per cent), according to data from the National Mission on Use of Biomass in Coal-Based Thermal Power Plants.

Diversion to lucrative markets: Biomass is not used only by TPPs—there is a growing demand from other industries such as cement, paper, packaging, and other energy-intensive sectors. These industries often offer better prices and more flexible contracts than power utilities. Consequently, many biomass vendors find it more profitable to divert their supply to these higher-paying clients, even if it means breaching existing contracts with power plants and paying associated penalties.

3. Biomass quality

Supply of poor quality of biomass to thermal power plants

Thermal power plants (TPPs) are often supplied with biomass of inadequate quality, which hampers efficient combustion and system reliability. In several cases, the Gross Calorific Value (GCV) of biomass pellets supplied is lower than what is claimed by manufacturers, leading to performance issues and reduced co-firing efficiency.

Lack of mechanism or testing facility to verify biomass pellet composition

Currently, there is no established mechanism or testing facility to verify the composition of biomass supplied to thermal power plants. Although the government mandates the use of paddy stubble for pellet manufacturing—especially for supply to power plants in Delhi-NCR—there is no way to independently verify compliance. Coal-based TPPs are required to ensure that at least 50 per cent of the biomass used in pellets comes from paddy stubble. However, during a recent survey conducted by CSE, officials at Harduaganj TPP reported concerns about the poor quality of biomass being supplied by manufacturers. While suppliers claim that the biomass contains the mandated 50 per cent paddy content, these claims cannot be verified without a dedicated testing facility.

4. Termination of defect liability period for boilers in TPPs

Boiler manufacturing companies, as per their standard policy, inform thermal power plants that the boilers are designed specifically for coal-based operations. The use of any alternative fuel—such as biomass pellets—renders the defect liability period (DLP) null and void. The DLP, typically valid for five years, is contingent upon the exclusive use of coal as the fuel.

Consequently, manufacturers explicitly instruct TPPs not to use biomass or any other non-coal fuels in the boilers to avoid forfeiting the warranty and associated liabilities. For example, at the Harduaganj TPP, the supercritical unit (660 MW) is equipped with a boiler manufactured by Doosan. The manufacturer has explicitly instructed the plant not to use biomass, stating that any such use would nullify the boiler's defect liability period.

5. Challenges faced by biomass manufacturers

Non-remunerative pricing

Mr. Harmik from Taranjot Energy Solutions Pvt Ltd, Sirsa, Haryana and Mr. Thannasiappan from Waste Resource Management in Punjab, highlighted concerns regarding the reverse bidding process in biomass procurement. They reported that this mechanism frequently drives tender prices below the government-notified benchmark of Rs 2.3 per 1,000 kcal—with some bids falling as low as Rs 1.8 per 1,000 kcal. Such pricing is economically unviable, especially considering the energy content and high input costs associated with biomass fuel production.

High storage and land costs

Biomass manufacturers typically lease agricultural land to store large quantities of biomass, especially during peak harvest seasons. However, this land leasing comes with high financial costs and is often unreliable. Therefore, landowners may ask manufacturers to vacate the land at short notice, disrupting storage plans and operations.

Additionally, monsoon rains pose a serious risk. If biomass is not stored properly, moisture seepage can degrade its quality, particularly its calorific value (energy content) by as much as 15–20 per cent. This results in revenue losses, increased costs for drying, and in some cases, even total material loss. For vendors who store fuel for several months at a time, these risks could make long-term storage logistically complex and economically burdensome.

Manipulation of biomass mix

Some biomass vendors manipulate the composition of their fuel mix by adding low-cost materials, such as press mud—a by-product of sugar mills—to increase the overall weight and reduce machinery wear during processing. While this practice is cost-effective for the vendor, it compromises the quality of the biomass fuel. Press mud typically has a lower calorific value than agricultural residues like paddy straw or mustard husk, which reduces the energy output of the final product.

Additionally, it may negatively impact combustion efficiency and lead to a higher ash content in thermal power plants. This not only affects the operational performance of TPPs but also creates an unfair market environment, where vendors supplying genuine, high-quality biomass are unable to compete with those using such additives. As a result, the integrity of the biomass fuel market is undermined, highlighting the need for strict quality monitoring and enforcement.

Degradation during storage

Biomass fuel, such as paddy straw or mustard husk, is highly susceptible to moisture absorption when stored over long periods—especially during the monsoon season or in open storage conditions without adequate protection. When exposed to moisture, the calorific value (energy content) of the biomass can drop by 15–20 per cent, which means that it generates significantly less energy when burned.

This not only reduces the efficiency of power generation at TPPs but also leads to higher fuel consumption to meet the same energy demand. Additionally, degraded biomass may become partially unusable, resulting in increased waste and financial loss for vendors. For suppliers who store fuel for several months at a time, moisture-related degradation becomes a major operational and economic challenge, highlighting the need for improved storage infrastructure and weather protection measures.

Operational and technical constraint

High machinery wear: Processing paddy straw, which constitutes a major share of the biomass mix, is particularly taxing due to its high silica content and tough texture. It causes frequent equipment breakdowns and is about 30 per cent costlier to process than mustard residue.

6. Recommendations

To ensure sustained and effective implementation of biomass co-firing in thermal power plants (TPPs) across India, we suggest the following recommendations. These are based on an assessment of successful case studies (especially in Delhi-NCR), current policy frameworks, and key operational challenges faced by thermal power plants located in states other than the Delhi-NCR:

1. Strengthen regulatory framework and enforce mandates

- **Pan India enforcement:** Extend the strict compliance framework of Delhi-NCR—including penalties and monitoring—to all regions in India. This will ensure uniform compliance across all regions and encourage TPPs across India to adopt biomass co-firing more proactively.

- **Strengthening state-level enforcement of biomass co-firing mandates:** State governments should be directed to make biomass co-firing mandatory in their TPPs and actively monitor its implementation. Including biomass co-firing in state-level energy and environmental targets will help ensure accountability and faster adoption by state-owned utilities.

- **Strengthen environmental compensation framework:** Replicate the environmental compensation framework from the MoEF&CC notification across all states and regions. Ensure that penalty slabs are periodically revised to reflect current environmental and economic conditions. This will promote consistent enforcement, enhance accountability, and strengthen deterrence against violations.

2. Revise biomass sampling and testing protocols:

- **Improve sampling practices:** According to the current SOP under the SAMARTH Mission, biomass samples are collected from the top of the truck after removing the top 25 cm, with samples taken from four to five random spots. However, this method has been flagged as inadequate by several thermal power plants, including Panipat Thermal Power Station, NTPC Dadri, and Harduaganj TPP, as it does not reflect the true quality of the entire consignment. To address this, the SOP should be updated to mandate post-

unloading sampling, as already implemented by Harduaganj TPP and NTPC Dadri. This will ensure a more accurate and fair assessment of biomass quality.

- **Develop mechanism to verify biomass pellet composition:** Almost all thermal power plants have raised concerns about the lack of a standard mechanism to verify the composition of biomass pellets—especially the proportion of paddy straw. A reliable system for testing the composition of biomass is urgently required to ensure compliance with regulatory requirements and maintain fuel quality standards.

3. Expand and support biomass supply chain infrastructure

- **Boost pellet manufacturing capacity**: To bridge the significant gap between the demand and supply of biomass pellets for co-firing in TPPs, there is an urgent need to expand and decentralise pellet manufacturing capacity across India.

- **Facilitate inter-state biomass movement:** Establish a regulatory framework to facilitate the inter-state movement of biomass, enabling surplus biomass-rich states to supply deficit states efficiently. This framework should be supported by transport incentives to reduce logistical costs. Such measures will promote optimal utilisation of biomass resources, reduce regional shortages, and enhance sustainable biomass-based energy deployment across states.

4. Address boiler manufacturer constraints

- **Harmonise technical standards:** Some boiler manufacturers warn thermal power plants (TPPs) that biomass co-firing may terminate the defect liability period (DLP) or void the boiler warranty. To address this concern, national guidelines should be developed in consultation with original equipment manufacturers (OEMs) to certify biomass-compatible boiler operations. These guidelines should ensure that co-firing practices do not void warranties, thereby providing clarity and confidence to plant operators while promoting wider adoption of biomass co-firing.

- **Update boiler contracts:** Update boiler purchase and maintenance contracts to explicitly allow flexibility for biomass co-firing. This will help eliminate warranty-related barriers and ensure that the use of biomass does not conflict with the terms of the contract, thereby encouraging its adoption in TPPs.

5. Standardisation of pelletisation machines

- To address the issues caused by lack of standardisation in machinery, it is recommended to establish and adopt uniform technical standards for all equipment used in the pellet production process. This includes selecting machines that meet specific quality and performance criteria to ensure compatibility and efficiency. Implementing standardised machines will help reduce dust generation, optimise electricity consumption, minimise breakdowns, and lower wear and tear. Additionally, it will improve material utilisation by reducing waste and ensure consistent pellet output, thereby enhancing overall operational efficiency and product quality.

6. Promote capacity building and awareness

- **Training for TPP personnel**: Conduct national-level training on biomass storage, handling, combustion optimisation, and emissions control.

- **Stakeholder engagement:** Conduct awareness campaigns targeting farmers and pellet manufacturers on biomass economics, policy incentives, and market opportunities.

References

1. Central Electricity Authority, 2020. *Policy on Biomass Utilisation for Power Generation through Co-firing in Coal-Based Power Plants*. Ministry of Power, Government of India, https://cea.nic.in/wp-content/uploads/2020/04/policy_biomass_utilization.pdf, last accessed on 4 June, 2025

2. Anon 2024. *Expansion of thermal power capacity. Press Information Bureau*, Ministry of Power, Government of India. www.pib.gov.in/PressReleasePage.aspx?PRID=2041641, last accessed on 4 June, 2025

3. Central Electricity Authority. 2023. National Electricity Plan – Volume I (Generation), May 2023, Ministry of Power, Government of India.202309011256071349.pdf, last accessed on 5 June, 2025

4. Central Electricity Authority. 2025. *Monthly Executive Summary on Coal for February 2025*. Ministry of Power, Government of India. https://npp.gov.in/public-reports/cea/monthly/fuel/2025/FEB/monthCoal1-2025-Feb.pdf, last accessed on 4 June, 2025

5. Niti Aayog, India Climate and Energy Dashboard Coal Consumption in India

6. Anon 2017. *Policy for Biomass Utilization for Power Generation through Co-firing in Coal Based Power Plants.* Central Electricity Authority, Ministry of Power, Government of India. https://cea.nic.in/wp-content/uploads/2020/04/policy_biomass_utilization.pdf , last accessed on 20 June, 2025

7. As per clarification provided by Ministry of New and Renewable Energy vide reference dated 26.9.2019 stating that the power generated from co-firing of biomass in coal based thermal power plants is renewable energy and is eligible for meeting non-solar Renewable Purchase Obligation (RPO) as viewed from Central Electricity Regulatory Commission 'Methodology for Estimation of Electricity Generated from Biomass in Biomass Co-fired Thermal Power Plants" 2020 , available at https://samarth.powermin.gov.in/content/policies/2eaf69ff-83b1-4a9f-a4b2-2faea7ebcdf0.pdf , as accessed on 20 June, 2025

8. Anon 2020. *CERC Order No. SO12-SM-18-02-20 dated 18 February 2020. Central Electricity Regulatory Commission*.https://cercind.gov.in/2020/orders/SO12-SM-18-02-20.pdf, last accessed on 20 June, 2025

9. Anon 2021. Statutory Direction No. 42 dated 17 September 2021, Commission for Air Quality Management in National Capital Region and Adjoining Areas, mandating 11 identified thermal power plants within 300 km of Delhi to co-fire 5–10% biomass pellets along with coal. https://caqm.nic.in/WriteReadData/LINKS/42-04d2335d-1a71-4ccf-9762-dfaaa6eecf4e.pdf, last accessed on 20 June, 2025.

10. Anon 2023. Statutory Direction No. 72 dated 17 March 2023, Commission for Air Quality Management in National Capital Region and Adjoining Areas, promoting biomass co-firing in captive thermal power plants and co-generation TPPs in NCR.https://caqm.nic.in/WriteReadData/LINKS/Direction%2072056e2ebe-5a7b-4173-867d-2fe600fe83cc.pdf, last accessed on 20 June, 2025

11. Anon 2021. Standard Operating Procedure dated 23 September 2021 for biomass pellet cofiring in Pulverized Fuel (PF) boilers, issued by the National Mission on Use of Biomass in Thermal Power Plants under the Ministry of Power, Government of India. https://samarth.powermin.gov.in/content/policies/f71b956e-3f01-4c04-b567-754a55cb3027.pdf, last accessed on 20 June, 2025

12. Ministry of Power. 2021. Revised Policy for Biomass Utilisation for Power Generation through Co-firing in Coal Based Power Plants, dated 8 October 2021. Government of India. https://samarth.powermin.gov.in/content/policies/56bc49bd-9a7b-4aab-81ef-c5fc44272cdc.pdf, last accessed on 20 June, 2025

13. Ministry of Power. 2022. *Revised Model LongTerm Contract for Biomass Supply,* introduced on 2 March 2022 by the National Mission on Use of Biomass in Thermal Power Plants under the Ministry of Power, Government of India. https://samarth.powermin.gov.in/content/policies/ecef0cd8-2d9c-4082-912d-89e1a48ed492.pdf, last accessed on 20 June, 2025

14. Ministry of Power. 2023. *Modification of Revised Policy for Biomass Utilisation for Power Generation through Cofiring in Coal Based Power Plants.* 16 June 2023. Government of India. https://samarth.powermin.gov.in/

content/policies/9e10785f-fd9f-412e-a561-4ee18633a63b.pdf, last accessed on 20 June, 2025

15. Ministry of Environment, Forest & Climate Change. 2025. Extraordinary Gazette notification dated 26 March 2025, under Section 6 of the Environment (Protection) Act 1986. https://egazette.gov.in/(S(d0lwxchf3d45kaugunqqjrqo))/ViewPDF.aspx, last accessed on 20 June, 2025

16. Ministry of Power. 2024. *Price Benchmarking of NonTorrefied Biomass Pellets for the National Capital Region (NCR)*, dated 23 August 2023, containing recommended benchmark tariff as ₹2.32 per 1,000 kcal, effective from 1 September 2023 for a one-year period.https://samarth.powermin.gov.in/content/policies/17237111-35ec-49dc-975c-4de96dc89017.pdf, last accessed on 20 June, 2025

17. Ministry of Power. 2024. *Price Benchmarking of Torrefied Biomass Pellets for the National Capital Region (NCR)* dated 18 November 2024. Government of India. https://samarth.powermin.gov.in/content/policies/20eb5262-b8a9-45a6-b19a-4dc1214a08d6.pdf, last accessed on 20 June, 2025

18. Ministry of Power. 2023. *Price Benchmarking of Biomass Pellets for Cofiring in Thermal Power Plants in the Western Region,* dated 8 November 2023. Government of India. https://samarth.powermin.gov.in/content/policies/7ee99f13-8262-4b40-be7a-ea320f8d4fb4.pdf, last accessed on 20 June, 2025

19. Ministry of Power. 2023. *Price Benchmarking of Biomass Pellets for Cofiring in Thermal Power Plants – Northern Region (excluding NCR)*, dated 8 November 2023. Government of India. https://powermin.gov.in/sites/default/files/Price_Benchmarking_of_Biomass_Pellets_for_co_firing_in_Thermal_Power_Plants_for_Northern_Region_excluding_NCR_0.pdf, last accessed on 20 June, 2025

20. Indian Federation of Green Energy, Publication-Volume-1 (January to March 2025) https://ifge.org.in/publication/

21. Ibid.

India's abundant agricultural biomass is frequently burned openly, contributing significantly to air pollution and climate change. Regions like Delhi-NCR exemplify the severity of this issue, experiencing some of the worst air quality impacts from stubble burning. Concurrently, coal-based thermal power plants remain a major source of greenhouse gas emissions.

Biomass co-firing—blending agro-residues with coal—offers a dual solution: curbing stubble burning nationwide and reducing carbon emissions while supporting rural economies.

The Centre for Science and Environment (CSE) reveals that Delhi-NCR has emerged as a leader in biomass co-firing, driven by stringent mandates and innovative practices. However, adoption in other regions remains limited due to logistical, technical, and policy constraints.

This report distils key learnings from Delhi-NCR's success, spotlighting best practices from the likes of NTPC Dadri and Nabha Power Limited. It confronts the challenges—supply chain gaps, quality control issues, and policy delays—and provides actionable recommendations for scaling up co-firing nationwide.

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Phone: 91-11-40616000 Fax: 91-11-29955879
E-mail: cse@cseindia.org Website: www.cseindia.org