Unlocking India's Biomass Market Potential

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Abstract*:*

Annually, India produces estimated surplus Agro-residue of around 230 Million MT, which is the excess Raw biomass after all conventional uses. This surplus Agro-residue brings huge potential for an untapped market for Farmers & Entrepreneurs, alongiwth Green Energy generation for Thermal Power Plants. Ministry of Power identifying this potential established a National Mission (a.k.a. SAMARTH) for leading India's path towards the Green Energy Transition through Biomass co-firing. A major demand-supply gap has been identified in the Biomass market leading to lower co-firing ratios. Thus, this paper would cover the present status of Biomass co-firing, the Market Size of Biomass ecosystem, Challenges/issues in present scenario and roadmap/mechanisms for rapid development of Biomass market/supply-chains.

Keywords: Biomass, Market Size, Market Development, Supply-chain, Policy Interventions

1. INTRODUCTION:

India is a nation that is blessed with fertile agricultural lands where a lot of agricultural residues are produced after harvesting. Due to rapid population expansion and changing lifestyles, there is an increase in the amount of energy consumed worldwide. Today, a sizable portion of the world's power is produced from fossil fuels and other traditional energy sources, which poses a serious threat to global warming and climate change. Traditional energy sources like coal, gas, and diesel are used to produce a sizeable portion of the country's electricity. Improving living standard, economic and industrial expansions, population growth has possessed serious challenges on India' s energy sector. Although the country is recognized as one of fastest growing economies of the world. All India installed capacity is likely to be 622,899 MW at the end of year 2026-27 and 865,941 MW at the end of year 2031-32. India currently has an installed renewable capacity of 159.81 GW. With reference to CEA National electricity plan(draft) [3] India needs to add 188 GW of Renewable Capacity in the Next Five Years to Meet Peak Demand.

India is with land area of 31.55 lakh KM^2 in which 206 million hectare of land is annually cultivated where on average 774 million tons of crop produced. Over the past few decades, the amount of agricultural residue in the nation has been rapidly rising. Most Indians live mostly off agriculture because their country is an agrarian one. The by-product of cultivating crops is the agricultural residue. Gross residue potential is the total amount of residue that can be generated. Surplus residue potential, on the other hand, refers to the residue that is left behind after certain applications (such as cow feed, animal bedding, heating, and cooking fuel, and organic fertilizer). The remainder can be utilised to produce bioenergy. [1]. The residue production potential is reflected by the share of cropped area and related productivity. India has surplus Biomass availability of 228 million metric tons per annum which have the energy potential of 28445 MWe.

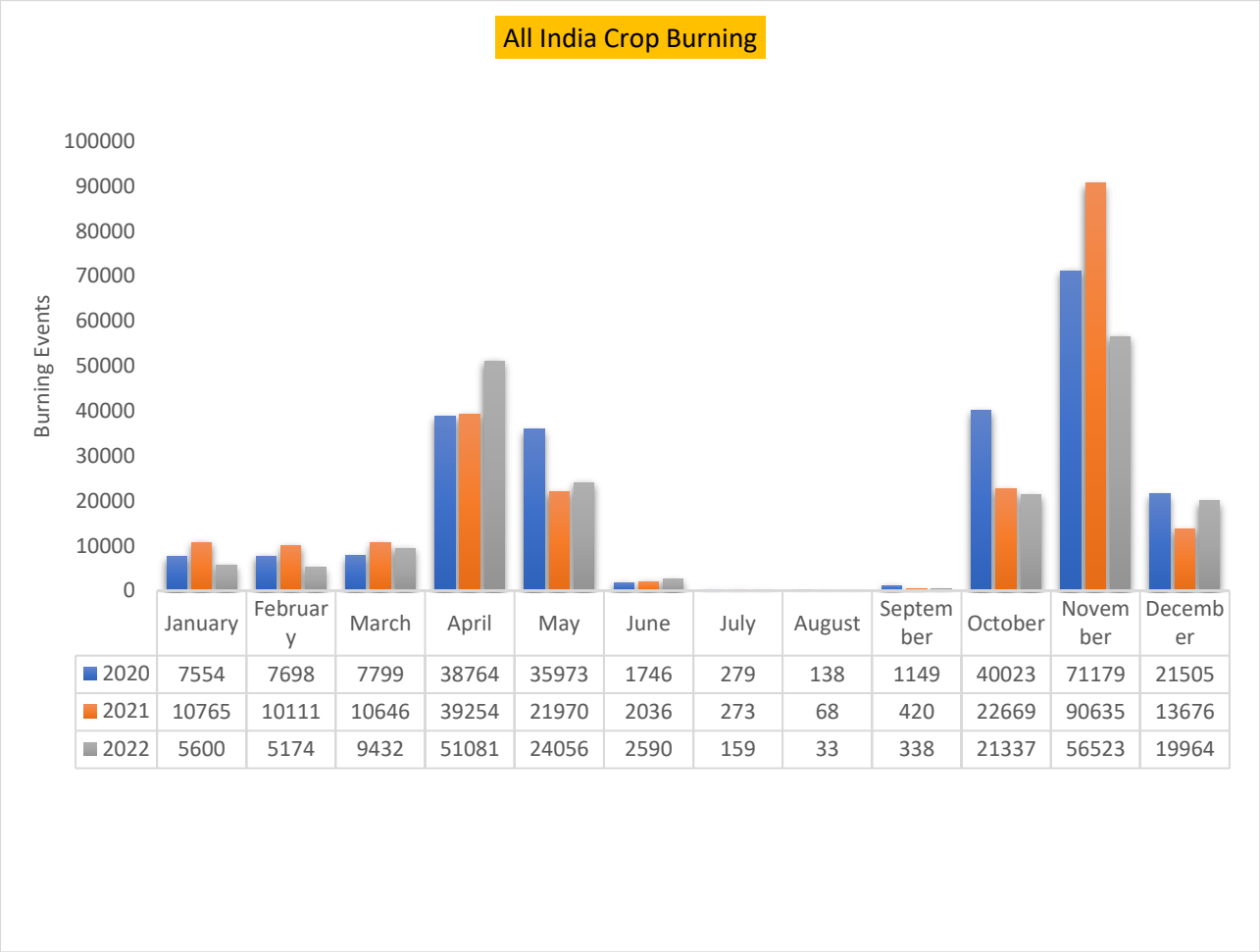
Air pollution becomes a grave threat to human health. Crop intensive states like Uttar Pradesh, Haryana, Punjab, Madhya Pradesh, and Rajasthan burn their stubble immediately after the Harvest to ready for next crop. In Punjab & Haryana most of the farmers practice mechanized farming, and only 7% of wheat and 2% of rice were reported to be harvested manually resulting in the generation of a large quantity of crop stubble where more than 90% of the farmers burn their stubble in the field.

Agro residue burning is one of the major contributors to atmospheric pollution which releasing particulate matter and gaseous pollutants that have severe effects on human health and the environment. It is 3rd significant source of air pollution in the world after industrial and vehicular

emissions.[4] Agro residue burning continuously has been increased over recent years with most of it caused by human activities. It was estimated that about 90% of biomass burning is attributed to human practices with the remaining smaller percentage being linked to natural fires.

Burning crop residue also reduces agricultural lands' biodiversity and degrades soil fertility, in addition to raising PM and smog levels, which pose health risks. Additionally, frequent residue burning causes a catastrophic loss in microbial population and lowers levels of nitrogen and carbon in the topsoil profile, both of which are crucial for the development of crop roots, costing farmers a significant amount of nutrients. In terms of the effects on people's and the soil's health, it represents a significant financial loss. The total national annual emissions of CO2 from crop residue burning are more than 64 times the total annual CO2 emissions in Delhi.

Table 1: All India Crop Burning Incidents

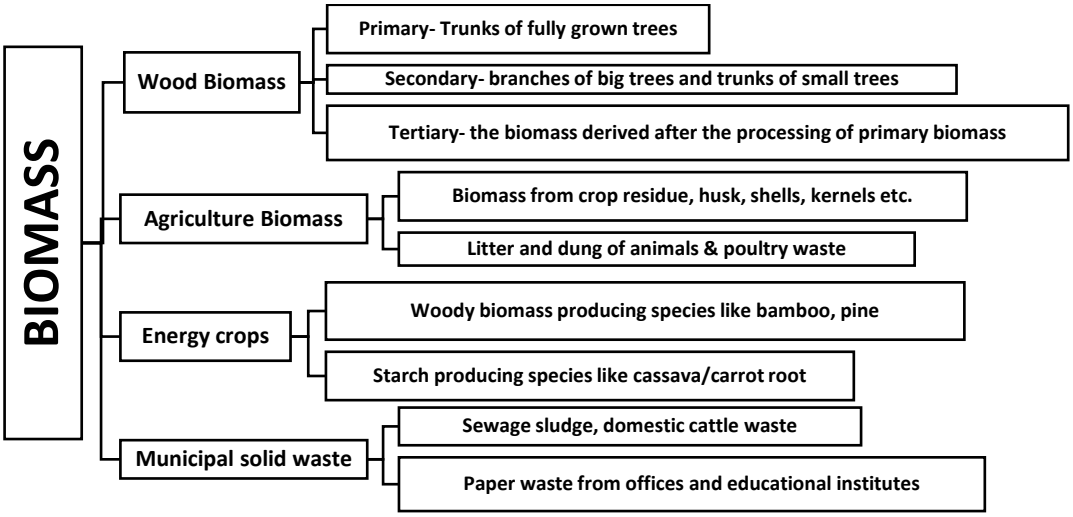


	January	February	March	April	May	June	July	August	September	October	November	December
2020	7554	7698	7799	38764	35973	1746	279	138	1149	40023	71179	21505
2021	10765	10111	10646	39254	21970	2036	273	68	420	22669	90635	13676
2022	5600	5174	9432	51081	24056	2590	159	33	338	21337	56523	19964

2. BIOENERGY

Bioenergy is one of many diverse resources available to help meet our demand for energy. It is a form of renewable energy that is derived from recently living organic materials that stems from plants (including algae, trees, and crops) by converting sunlight into plant material through photosynthesis known as biomass, which can be used to produce Power, transportation fuels, heat, electricity, and products.

- Includes all land and water-based vegetation, as well as all organic wastes.
- Estimated to contribute of the order 10–14% of the world's energy supply.



Waste to wealth suitability of Crop residue for energy sector are

1. The biomass pellets as the fuel of industrial boiler are cheaper the using coal.
2. Very high calorific value (from 3000 Kcal per kilogram to 4200 Kcal of coal)
3. Very less ash content (18% ash over 36% in case of coal)
4. Ash could potentially be used in the cement industry
5. Renewable, Environment friendly and readily available.
6. Can be burned easily in boiler with efficiency of almost 100%
7. Additional income for farmers and for millers as they can directly sell to the power plants.
8. By-product generated from the power industry e.g., brick ash or fire
9. Less capital intensive over the conventional power industry.

Biomass materials available are Paddy straw, sugarcane bagasse, press mud, rice husk, mustard husk, cotton stalk, coconut shells, soya husk, coffee waste, jute wastes, groundnut shells, saw dust etc. Using biomass pellets can significantly reduce the carbon dioxide emission which help protect the environment. Biomass pellets is known as the clean fuel around the world.

- Next Cycle of Plant's generation removes as much CO_2, as is emitted into the atmosphere from its agro-residue(/Biomass) combustion and thus is Carbon Neutral.

- Reduction in Coal Consumption by 5% Biomass co-firing shall result in CO_2 emission reduction of ~38 MMT annually.

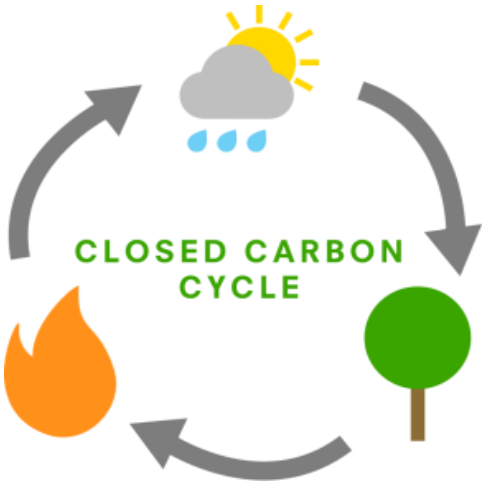


Fig.2. Closed Carbon Cycle representation

3. BIOMASS MARKET SIZE AT 10% CO-FIRING

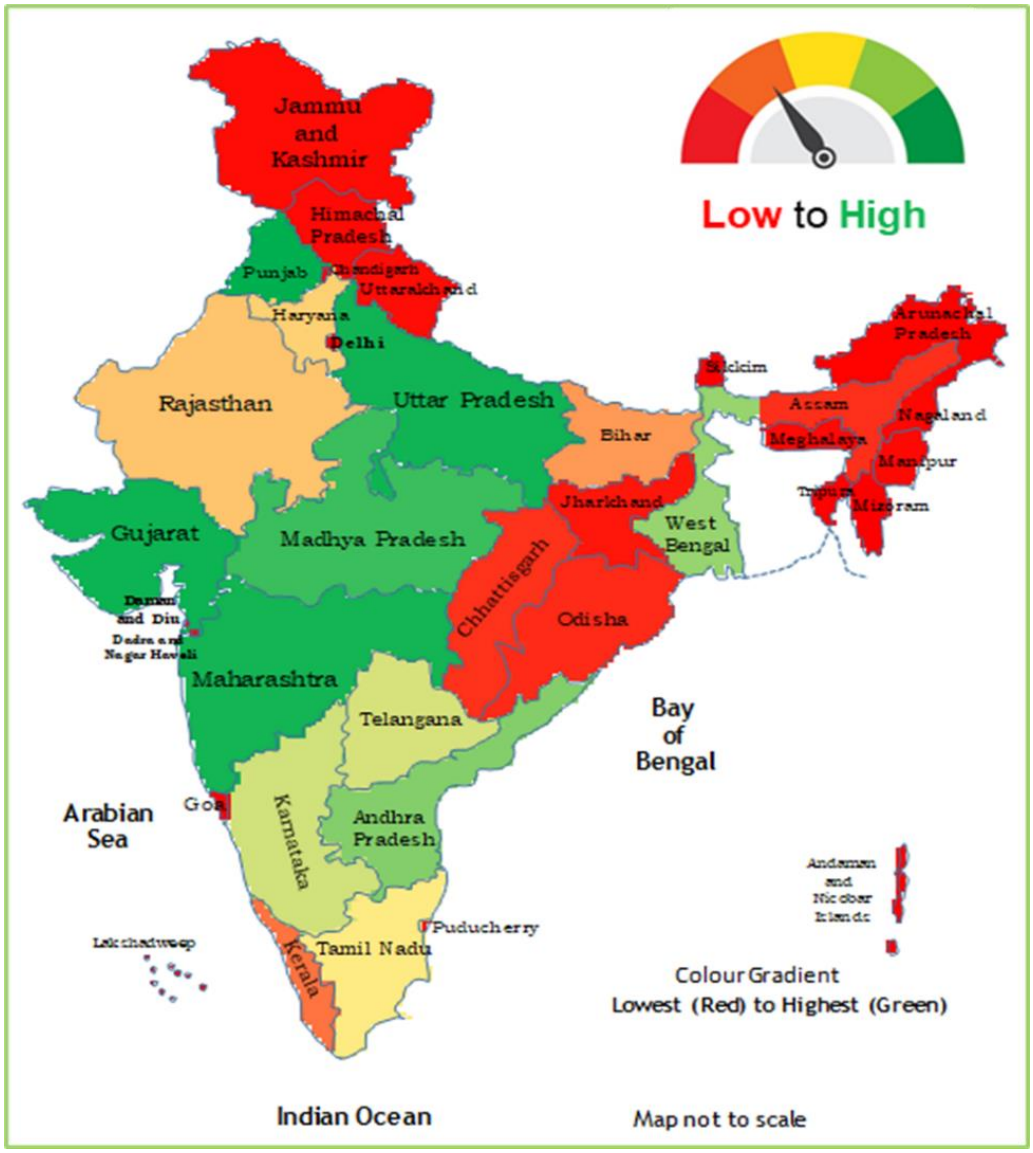


Fig.2. Surplus Biomass Map

The Total Estimated Surplus Biomass is around 230 Million MT, which is the excess Raw biomass after all conventional uses. The requirement of Raw biomass at 10% co-firing is estimated to be around 100 Million MT. This agro-residue will primarily be sourced from the existing farmers/aggregators. The rate of Raw biomass which is presently floating at an average of Rupees 1.5-2 per kg of Raw biomass across several states of India. This translates to a Serviceable Available Market (SAM) for Farmers to be Rupees 15,000 -20,000 Crores.

Similarly, the SAM for Pellet Manufacturers by selling finished Biomass pellets to Thermal Power plants in the range of Rupees 6-7 per kg will be 28,000 to 35,000 Crores. Along with this, the need of Pellet manufacturing Machines has also increased in India. Keeping the future requirement in view, a one-time market of Rupees 5,000-7,000 Crores (NT/T)* is available for OEMs engaged with Pellet Machine manufacturing. The average life of the Pellet manufacturing equipment is estimated to be 10 years. And the market for Operational and Maintenance of these machines' year-on-year basis would be around 750-1050 Crores.

Such huge investments will bring the Financial Institutions into picture for catering the financing needs of Pellet manufacturers for their Cost of project and Working Capital needs. The estimated Finance needed for the Cost of Project would be approximately in the range of Rupees 6500-7000 Crores. And

the average revenue generated for the Financial institutions from the investments at 12% interest rate will be around Rupees 800 crores. Apart from this, the year-on-year working capital investments would require around 3500 crores, and generating a revenue of Rupees 400 crores annually for the banks at 12% assumed interest rate.

So, the Total available market (TAM) from the Biomass co-firing in Thermal power plants (at 60% PLF) would be around Rupees 62,000 Crores. This shows that the market potential of the initiative is enormously large along with Green Energy generation of approximately 100 BU (estimated at 700 grams of Biomass pellet requirement for 1 unit of Power generated).

**(NT/T) refers to Non-Torrefied & Torrefied Pellet Machine manufacturing, the average market price for equipment discovered are Rupees 50 lakhs per TPH & Rupees 60 lakhs per TPH respectively.*

Table: 2 Crop area and Biomass and demand for Cofiring

Sr. No.	Name of State / Union Territory	Total Crop Area (Million Hectare)	Total Crop Production (Million Tonnes)	Total Biomass Generation (MMTPA)	Surplus Biomass Potential (MMTPA)	Coal based TPPs Installed capacity (MW)	Biomass Required for 10% Cofiring (MMTPA)
1	Andaman and Nicobar Islands	0.04	0.08	0.20	0.13	0.00	0.00
2	Andhra Pradesh	7.36	28.62	40.01	17.09	11590.00	4.26
3	Arunachal Pradesh	0.33	0.58	0.75	0.17	0.00	0.00
4	Assam	3.40	8.93	12.57	2.54	750.00	0.28
5	Bihar	7.28	32.50	32.57	7.98	7050.00	2.59
6	Chandigarh	0.00	0.00	0.00	0.00	0.00	0.00
7	Chhattisgarh	5.47	8.71	12.99	2.65	23938.00	8.81
8	Dadra and Nagar Haveli and Daman and Diu	8.00	0.10	0.07	0.02	0.00	0.00
9	Delhi	0.00	0.00	0.00	0.00	0.00	0.00
10	Goa	0.14	0.24	0.45	0.23	0.00	0.00
11	Gujarat	9.67	32.27	50.24	21.74	16092.00	5.92
12	Haryana	6.60	27.17	36.24	10.91	5330.00	1.96
13	Himachal Pradesh	0.77	1.51	2.74	0.57	0.00	0.00
14	Jammu and Kashmir	0.96	1.77	3.24	0.65	0.00	0.00
15	Jharkhand	1.96	3.32	5.31	1.20	4460.00	1.64
16	Karnataka	10.94	51.34	34.09	14.05	9480.00	3.49
17	Kerala	1.30	4.79	8.58	6.04	0.00	0.00
18	Ladakh	0.00	0.00	0.00	0.00	0.00	0.00
19	Lakshadweep	0.00	0.00	0.00	0.00	0.00	0.00
20	Madhya Pradesh	23.70	43.81	70.23	19.93	21950.00	8.08
21	Maharashtra	21.07	86.48	52.54	21.49	24966.00	9.19
22	Manipur	0.34	1.12	1.14	0.48	0.00	0.00

23	Meghalaya	0.25	0.91	1.37	0.56	0.00	0.00
24	Mizoram	0.05	0.13	0.13	0.02	0.00	0.00
25	Nagaland	0.44	1.37	1.37	0.44	0.00	0.00
26	Odisha	4.45	7.88	11.84	2.23	9800.00	3.61
27	Puducherry	0.02	0.27	0.12	0.04	0.00	0.00
28	Punjab	7.17	37.88	53.00	22.25	5680.00	2.09
29	Rajasthan	31.93	32.11	59.50	10.21	9820.00	3.61
30	Sikkim	0.08	0.12	0.23	0.04	0.00	0.00
31	Tamil Nadu	8.96	47.92	52.14	12.22	13160.00	4.84
32	Telangana	9.38	18.57	33.62	13.76	7573.00	2.79
33	Tripura	0.35	0.97	1.41	0.25	0.00	0.00
34	Uttar Pradesh	24.19	246.66	124.69	21.60	23729.00	8.73
35	Uttarakhand	1.00	8.05	3.55	0.72	0.00	0.00
36	West Bengal	8.49	38.20	47.51	16.28	14177.00	5.22
Total	**India**	**206.09**	**774.38**	**754.44**	**228.49**	**209545.00**	**77.10**

4. BIOMASS PELLETIZATION & COFIRING:

a. Pelletization:

The process of Pelletizing is the physical transformation of the loose biomass raw material into a compactly compressed unit. The form change results in a much higher specific density of the material which increases its combustion efficiency as compared to the loose material. Depending upon the type of waste binder may be added.

The biomass process consists of multiple steps including raw material, pre- treatment, palletization, and post-treatment. The first step in the palletization process is the preparation of feedstock which includes selecting a feedstock suitable for this process, its filtration, storage, and protection. Raw materials used are sawdust, wood shavings, wood wastes, agriculture residues like straw, switchgrass etc. The feedstock should be stored in such a manner that it is away from impurities and moisture, in case where there are different types of feedstocks, a blending process is used to achieve consistency. The moisture content in biomass can be considered high and are usually up to 50%-60% which should be reduced to 10 to 15%.

b. Biomass Cofiring:

Co-firing is the process of utilization of a certain portion of biomass with the existing base fuel. It has been demonstrated, tested, and proved in all boiler types commonly used by electric utilities. There is little or no loss in total boiler efficiency after adjusting combustion output for the new fuel mixture.

Benefits of cofiring for GENCOs

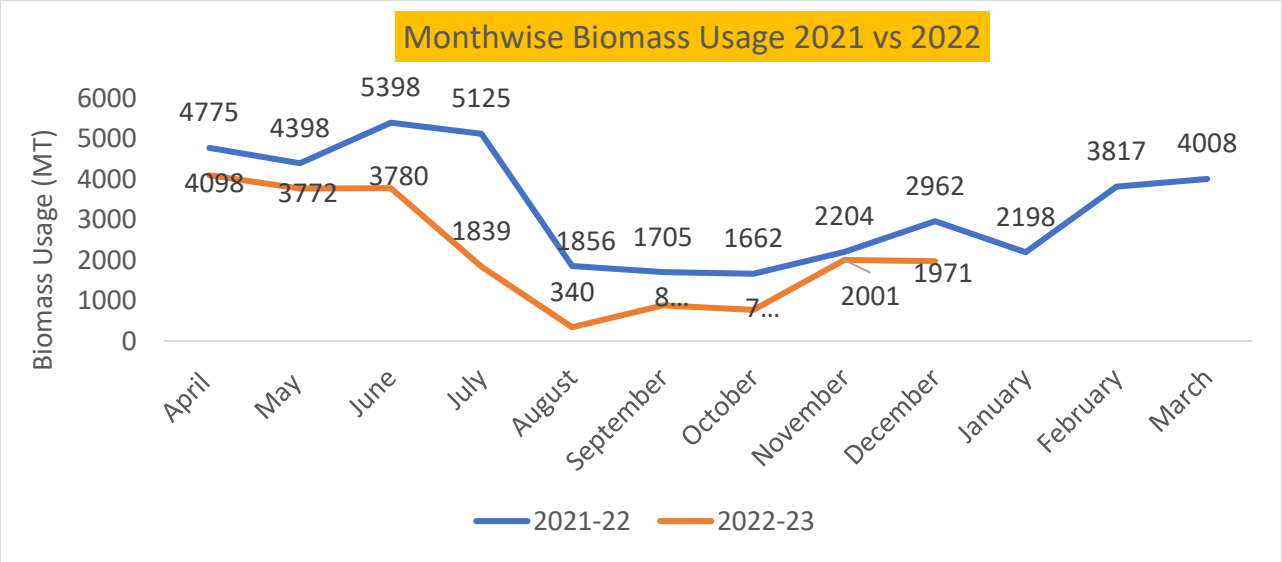
i. A handy solution for green energy transition: Minimal Infrastructure changes requiring miniscule investment
ii. Less dependability on coal
iii. Lesser Carbon Footprint
iv. Considered under RPO by MNRE
v. Cost effective solution for reducing GHG emission
vi. Lower sulphur & nitrogen content in biomass in comparison to coal which would result in low emission of SOx & NOx

Biomass Cofiring Present consumption and procurement (up to Dec 2022):

NCR power plants 10 Nos. plant out of 11nos have already made biomass cofiring of 26690 MT and procurement of biomass in short- and long-term basis at various stage for the quantity of 120 Lakh MT
In the similar manner other region 29 Nos of plant have made of cofiring of 61178 MT of biomass as of now and tender for the quantity of 1074 LMT is at different stage of procurement.

Table 3: Biomass Cofiring in coal power plants

SN.	YEAR	TARGETED CONSUMPTION @ 5%	ACTUAL CONSUMPTION	% BIOMASS CO-FIRING	NO. OF TPP INITIATING CO-FIRING
1.	2021	35.33 MMT	0.040 MMT	0.0063%	Cumulative 24
2.	2022	36.17 MMT	0.013 MMT (Till date)	0.0042%	Cumulative 39



5. SAMARTH MISSION POLICY INTERVENTIONS

Sn	Major Actions taken	Outcomes
1.	32 No.s of Capacity Building Program for Biomass Stakeholder.	Resulted in reach of Mission's objectives of Increasing Biomass co-firing to 1200 TPP Personnel, 1500 Farmers and 600 Pellet Manufacturers/ Entrepreneurs across 13 states.
2.	Model SOPs has been prepared & issued to all TPPs for their reference	Guidance for initiating co-firing across all major types of Milling systems encouraged more than 40 TPPs to initiate co-firing.

3.	Formulation & Issuance of Long-term Model contract for procurement of Biomass	TPPs across the country have issued Tender requirement for more than 111MMT of Biomass pellets
4.	Customized window for Biomass pellet procurement through GeM portal.	Have created ease of doing business for Pellet Manufacturers and TPPs. First major Tender has been placed by DVC through GeM.
5.	GST/HSN code for agro-residue based biomass pellets proposed to be issued along with budget 2023	GST/HSN code makes the process of levying GST easy and hassle-free FOR Pellet Manufacturer.
6.	Clearance of pellet manufacturing under PSL (priority sector lending) by MoA &FW and MSME.	"Priority Sector Lending" shall generate the much-needed thrust in lending to Pellet Manufacturing plants among the National Banks/ Financial Institutions.
7.	Clearance for inclusion of Pellet Manufacturing Plant at NSWS on UDYAM ADHAR Portal	Process for getting Important registrations/approvals are smoothened resulting in flourishing Pellet manufacturing business in the country.
8.	Awareness among Stakeholders	Awareness through Print media, Hoardings/Posters/Banners and social media is also being carried out across the NCR and adjoining states.

6. ISSUES & CHALLENGES SO FAR IN BIOMASS COFIRING:

Since inception of Mission, major steps in the direction of Policy formation & technical assistance have been taken up by issuance of dedicated Biomass Policy regarding mandatory Biomass cofiring and SOPs for TPPs. However, despite a good growth in the numbers of TPPs initiating Biomass Cofiring, utilization of biomass is yet to achieve the targets attributing to various reasons majorly mainly attributing to lack of robust Supply chain & low availability of processed Biomass. Further, Biomass being based on agriculture has frequent seasonal/demographic variation intrinsically which has been a major constraint for the development of steady Biomass supply-chain.

a. India's Pellet manufacturing capacity not enough to cater present TPP demand
b. Limited number of suppliers for pellet machines manufacturing.
c. Collection/ Aggregation / Transportation mechanism for handling Raw Biomass
d. Availability of Scattered Biomass and storage of raw biomass to ensure round the year.
e. Volatile raw biomass prices.
f. Diversion of Biomass pellets to other Industries at higher Prices.
g. Adequate financing for Working Capital Loans

7. SAMARTH ON-GOING TRANSFORMATIONAL INITIATIVES & EXPECTED OUTCOME

Sl. No.	Major On-going Actions	Expected Outcomes
1.	NTPC & CPRI initiative for increasing the number of Biomass testing labs.	Accessibility to Biomass testing facility shall enable the TPP for regular Biomass pellet testing & aim for higher co-firing ratios.
2.	12 no.s research projects are under progress under NPP and 08 R&D areas are being taken-up by DST	R&D areas will lead towards use of alternative sources of raw materials and higher co-firing ratios will minimum boiler modifications
3.	Developing Collection/ Aggregation/ Storage / Pellet manufacturing setup by new/existing FPOs.	Empower the Farmers to venture into lucrative business models for Aggregation of Raw biomass/ Biomass pellet manufacturing units leading to minimization of demand-supply gap of Biomass pellets.
4.	Development of Customer Hiring Center (CHC) for farm machineries for collection and aggregation of agro-residue.	To supply post-harvesting machineries to small, marginal and poor farmers at subsidized rates on hire for increasing the collection of Raw biomass.
5.	Nomination of Secretary level Nodal Officer from State for monitoring the progress and utilization of Biomass co-firing of the TPPs	Close monitoring, coordinating, and supervising the implementation of mission's actions at State level.
6.	Installation of Pellet manufacturing Plant by GENCOs	(a)Reduce the irregularities in supply of Biomass pellets to TPPs. (b) Reducing dependencies on Pellet vendors (c) Availability of Low-cost Biomass pellets
7.	Working closely with leading private industries already involved in Agri-business to explore the engagement of existing aggregation system/Farmers network for development of Biomass supply chain.	Build confidence among the private investors to come forward for venturing into Biomass value chain, keeping in view of the successful Business models implemented by leading private firms.
8.	Interaction with Pellet Manufacturers /FPOs / Aggregators to strengthen Biomass supply-chain	Building insights on present ecosystem and planning/implementation of action plans more efficiently.

8. ROADMAP FOR ACHIEVING 10% BIOMASS CO-FIRING BY FY 2025-26

1. **Proposed Interventions by State Governments for establishing mechanism for Collection/ Aggregation/Storage of Raw Biomass**:

Adding Economic Value & providing accessible Platform shall be the key driver to develop the Collection/aggregation/storage system at Farmer's level:

A. For Farmers, KCC (Kisan Credit Cards)[6] has been introduced by GOI, which provides adequate and timely credit support from Commercial Banks and Regional Rural Banks (RRBs). Presently, it covers more than 1.5 crore farmers, with a sanctioned credit limit of Rs. 1.35 lakh crore.
On the other hand, Thermal Power Plants also have provisions of giving payment as Credit to Coal suppliers based on the Heat rate of the Coal.

Mechanism 1:

Pellet Manufacturers having orders for supply of Biomass pellets to GENCOs, generally have MoU with FPOs/ SHGs/ Farmer's Co-operatives for supply of Raw Biomass. These Pellet Manufacturers are registered under State Government agencies like SPCB. Based on this, the State Government can do the part-payment for the Agro-residue to the Farmers having MoU with respective Pellet Manufacturer by using KCC infrastructure.

Mechanism 2:

As we are moving towards an ecosystem where, Thermal Power Plants should have Pellet Manufacturing Plants in their premises. The Thermal Power plants can establish their own links/MoU with the FPOs/ SHGs/ Farmer's Co-operative which are engaged for supplying Raw Biomass to the Pellet Plants owned/operated by TPPs. And, using the existing digital infrastructure of KCC, inject suitable Credit/pre-payment to Farmers for their Agro-residue.

These Mechanisms would bring following benefits:

i. Ensure supply of Biomass pellets for Co-firing
ii. Minimize the diversion of Raw Biomass to alternative industries
iii. Stop Burning incidences as Raw materials are now pre-booked
iv. Minimize the post-harvest price variation of Agro-residue
v. KCC has already identified Field officers, which will ensure the stability of this arrangement
vi. Provide much needed assistance to Farmers during the Sowing season, when a lot of investment is needed.

B. Development of Raw Biomass Purchase/Sale Platform accessible at Block level should be done. This can be done with the involvement of existing mechanisms like Panchayat/APMC/ FCI/e-NAM etc.
C. Allocation of land on lease /subsidized rate for Pellet manufacturing activities in the targeted stubble burning regions
D. Pellet Price Standardization: As per preliminary assessment, presently Biomass Pellet Manufacturing Capacity is approximately 7000 TPD. However, quantity being made available to TPPs is in the range of 100 TPD only. Vendors may provide pellets at different prices to various industries/buyers e.g. price of pellets provided to Pharmaceutical, Food & Beverage companies are generally on the higher side. Standardization of Pellets Price/Capping of Pellet Price for Biomass pellets and raw Agri-residue in bale form for Power Plant Application for initial years to ease the procurement & stabilize the Biomass market in their respective States.

2. **Strengthening Pellet Manufacturing Capability**
    a. Associating with MSME with a focus on:
        i. Development of Financial Schemes for collection/aggregation/transportation and setting of Pellet Plants
        ii. Capacity building for pellet manufacturers in Associating with incubation center.
        iii. Awareness Programs for Budding entrepreneurs, employment creations, Setting-up of Pellet Manufacturing plants.
        iv. Technical/Financial assistance for development of FPOs for collection/aggregation/ transportation and setting of Pellet Plants.

    b. Promotion & close monitoring of Financial Assistance Schemes and resolving of any issues faced by the Loan applicants.
    c. To ensure establishment of Pellet Manufacturing Plants by NCR GENCOs.
    d. Spreading awareness about various Government schemes/grants available for Pellet manufacturing activity pan India.

3. **Technological Advancement & associated Infrastructure development**
    a. Making the Farmers/Biomass Aggregators aware of advanced post-harvesting machineries.
    b. Set-up of adequate Biomass testing labs across the country.
    c. Finalization of Research projects under DST.
    d. Technology support for Torrefaction from Indo-Japan Cooperation for Efficiency and Environmental Improvement
    e. Associating with Strategic partners like BHEL/ISGEC/Thermax etc. for developing torrefier.

4. **Proposed Intervention by GENCOs**
    a. Establishment of Pellet Manufacturing Plant by all TPPs
    b. Identification of catchment area for the respective TPP
    c. Provide financial support for capacity building of Cooperative Societies/FPOs/Aggregators in the corresponding Catchment area.

5. **Proposed Interventions by MoA &FW:**
    i) Identification of surplus agri-residue and their availability at block level
    ii) Identification of Catchment area for Agri-residue in line with Sugarcane block
    iii) Raw Biomass Price Standardization: To establish the price for the different crop's residue for the Pellet Production dedicated for TPPs.
    iv) Backward integration with TPPs & development of alternative like energy crops in biomass scarce states

9. **CONCLUSION:**

Biomass would be a promising solution for the coal associated air pollution and emission. By effective utilization and with objective to increase the level of co-firing from present 5% to higher levels to have a larger share SMARTH Mission have to go longer to tap this bioenergy and to address the constraints in supply chain of biomass pellets and agro-residue. Biomass Utilization Eliminates / minimizes burning of agro residue and create economic value of agro residue by promoting its use as fuel in power plants in co-firing mode. It will also Improve the air quality index while creating additional income for farmers. It would encourage the manufactures for the establishment of decentralized pellets manufacturing units and generate local employment opportunities. For Power plants it is the opportunity for revival of old aged units conforming environmental norms with minimal investments. This is cost effective solution for reducing GHG emission.

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