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सत्यमेव जयते
नवीन एवं
नवीकरणीय ऊर्जा मंत्रालय
MINISTRY OF
NEW AND
RENEWABLE ENERGY

Decarbonizing MSMEs:
Use of Biomass for Green Steam and Heat Applications

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Decarbonizing MSMEs:
Use of Biomass for Green Steam and Heat Applications

श्रीपाद नाईक
राज्य मंत्री
नवीन और नवीकरणीय ऊर्जा एवं विद्युत
भारत सरकार

सत्यमेव जयते

SHRIPAD NAIK
Minister of State for
New and Renewable Energy & Power
Government of India

FOREWORD

India has embarked on ambitious journey towards energy independence by 2047 and achieving Net Zero by 2070. India has also set aggressive clean energy targets for 2030, including reducing its total projected carbon emissions by one billion tonnes and carbon intensity of its economy by 45 percent. Achieving the "Panchamrit" that the Hon'ble Prime Minister announced at COP26 in Glasgow, also requires that India aims for deep decarbonisation of industrial processes through use of clean and renewable energy resources.

Central to our energy transition is the increased use of domestically available renewable resources. As one of the world's largest producers of agricultural commodities, India generates substantial biomass, estimated at 750 million metric tonnes annually. Modern bioenergy, derived from the abundant biomass and waste materials within our country, presents a promising pathway towards achieving our energy goals. This biomass holds significant potential for replacing conventional fuels for steam application and generating Green Heat and Steam, which is crucial for decarbonizing industrial processes. With industries consuming a substantial portion of our energy, transitioning to biomass for heat and steam generation can substantially reduce our carbon footprint. However, raising awareness and promoting the use of biomass for Green Heat and Steam is crucial to capturing the lost energy from biomass and creating a sustainable market.

The Ministry of New and Renewable Energy (MNRE) is committed to promoting bioenergy through the National Bioenergy Programme, which includes the Waste to Energy Programme, Biomass Programme, and Biogas Programme. These initiatives support the establishment of biogas, BioCNG, and power plants, as well as the manufacturing of briquettes and pellets. The provision of Central Financial Assistance (CFA) further incentivizes the adoption of biomass technologies.

In this context, it gives me immense pleasure to learn about the study titled "Decarbonizing and Greening of MSMEs: Harnessing Biomass for Green Steam and Heat Application", which is a culmination of an extensive research and analysis aimed at providing a comprehensive understanding of the current state of green steam and heat technologies. It delves into the latest advancements, explores successful case studies, and offers strategic insights for stakeholder across industries. Through this report, we hope to inspire decision makers, industry leaders, and policymakers to embrace green steam and heat as a vital component of the transition to a sustainable energy future and at the same time also acknowledging the challenges that lie ahead in widespread adoption and integration.

The insights provided herein are intended to guide and inform strategies, investment, and innovations that will drive the adoption of green steam and heat applications, ultimately contributing to a cleaner, more sustainable planet.

I extend my gratitude to all contributors, researchers, and industry experts and especially the Ministry of New and Renewable Energy for their efforts in bringing out this valuable report.

(Shripad Naik)

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सचिव

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Secretary

International Year of Cooperatives
2025
Cooperatives Build a Better World

भारत सरकार
नवीन और नवीकरणीय ऊर्जा मंत्रालय
Government of India
Ministry of New and Renewable Energy

Foreword

India has set ambitious targets to accelerate energy independence by 2047 and Net Zero by 2070. The Government of India is committed to generating 50 percent of its cumulative power from non-fossil fuel sources by 2030. Decarbonizing industrial process heat is crucial for reducing industrial greenhouse gas (GHG) emissions, given the significant share of industrial energy consumption (56%) and fuel use (75%).

To meet these targets, increasing the use of domestically available renewable energy is essential. Modern bioenergy, derived from the abundant biomass in India, offers a practical solution. Biomass is carbon neutral, as the carbon dioxide released during combustion is offset by the amount absorbed during photosynthesis. This makes it an environmentally friendly alternative to traditional fuels. As an agricultural powerhouse, India produces substantial biomass from crops like rice, wheat, cotton, sugar, and horticultural products. According to a recent MNRE study, India generates approximately 750 million metric tonnes of biomass annually.

India's MSME (Micro, Small, and Medium Enterprises) sector, comprising about 63 million enterprises, is diverse in terms of products, sizes, manufacturing processes, and technologies. MSMEs account for about 33% of India's manufacturing output and 28% of GDP, consuming a quarter of the total industrial energy. However, many MSMEs still rely on old and conventional technologies and have not adopted modern decarbonization methods.

With numerous low-carbon technology options available, selecting the optimal fuel for an industry requires careful techno-commercial evaluation, considering factors like heat requirements, fuel availability and pricing, infrastructure needs, and technology integration. Biomass is a promising alternative that can replace up to 100% of fossil fuels used for heat and steam generation, known as Green Heat/Steam.

Green heat or steam generation using biomass or renewable energy involves sustainable methods to produce heat or steam, utilizing agricultural residues, biomass pellets and briquettes or dedicated energy crops. Implementing these systems in industrial processes reduces carbon footprints and supports sustainable business practices. Industries can lower their carbon intensity and emissions by using Green Heat/Steam, helping them meet sustainability goals.

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Biomass is gaining popularity as a cleaner fuel alternative to coal for industrial heat generation. Biomass-fired boilers have a lower environmental impact compared to coal, and the recent surge in coal prices has driven industries to seek cleaner, cost-effective fuel options. The availability of biomass-based boilers, retrofitting options for conventional boilers, and multifuel-based boilers further incentivizes the adoption of biomass.

In this context, the study titled "Decarbonizing and Greening of MSMEs: Harnessing Biomass for Green Steam and Heat Application" studies were conducted across various MSME clusters, including textiles, chemicals, food processing, pharmaceuticals, paper, footwear,foundries, plastics, rubber, and tea industries, reveal significant potential for integrating biomass for green steam requirements. Technical, economic, and financial assessments suggest that biomass can effectively replace up to 100% of fossil fuels used in these industries.

As we move forward, let us harness the power of bioenergy to build a sustainable, resilient, and energy-independent India. Together, we can achieve our ambitious targets and set an example for the world in sustainable energy practices.

6.1.2026

(Santosh Sarangi)

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1 Project Context and Background

As India has set an ambitious target of becoming energy independent by 2047 and achieving Net Zero by 2070. The Government of India is committed to set up 50 percent of cumulative power generation from non-fossil fuel based energy resources by 2030. India made commitment to become carbon neutral by 2070.

India made commitment to become carbon neutral by 2070 and five commitments as Panchamrit at COP26. The five commitments made at the global conference were:

Figure 1: Five commitments as Panchamrit at COP26

- India will its non-fossil fuel-based energy capacity to 500 GW by 2030
- India will meet 50 percent of its energy requirement with renewable energy by 2030
- India will reduce its total projected carbon emissions by one billion tonnes by the year 2030
- India will reduce the carbon intensity of its economy by 45 percent by 2030
- India will achieve net zero emissions by the year 2070

To achieve this target, increasing use of domestically available renewable energy is key to India's Energy Transition. One such alternative is modern bioenergy. Given the abundance of biomass and other waste materials within the country, harnessing energy from these resources presents a practical solution. An essential aspect of biomass fuel is its carbon neutrality, which means that the carbon dioxide released during combustion is equal to the amount absorbed during photosynthesis. This cycle makes biomass an environmentally friendly alternative to traditional fuels. India being an agriculture powerhouse, is one of the largest producers of rice, wheat, cotton, sugar, and horticulture and dairy products in the world. The crops also generate biomass, which has always been an important energy source for the country considering the benefits it offers. ***As per a recent study by MNRE, the current availability of biomass in India is estimated at about 750 million metric tonnes per year.***

In India, 'decarbonisation of industrial process heat' represents a critical component in eliminating industrial greenhouse gas (GHG) emissions, given the rising share of industrial energy consumption (56%) and associated fuel consumption (75%).

With plethora of low carbon technology options available, the optimal fuel choice for a given industry involves significant techno-commercial due diligence to account for different variables

- quantum and timing of heat requirement,
- fuel availability and pricing,
- infrastructural requirement, and associated modifications, and
- technology integration

In this context, biomass represents one of the promising alternatives that can substitute upto 100% of the fossil fuel consumed in the industries for heat/ steam generation. The heat/ steam thus produced using biomass is typically referred to as Green Heat/ Steam.

To promote the use of biomass, MNRE has notified the National Bioenergy Programme on November 2, 2022. MNRE has continued the National Bioenergy Programme for the period from FY 2021-22 to 2025-26.

The **National Bioenergy Programme**[1] will comprises of the following sub-schemes:

I. **Waste to Energy Programme** (Programme on Energy from Urban, Industrial and Agricultural Wastes / Residues) to support setting up of large Biogas, Bio-CNG and Power plants (excluding MSW to Power projects).

II. **Biomass Programme** (Scheme to Support Manufacturing of Briquettes & Pellets and Promotion of Biomass (non-bagasse) based cogeneration in Industries) to support setting up of pellets and briquettes for use in power generation and non-bagasse based power generation projects.

III. **Biogas Programme** to support setting up of family and medium size Biogas in rural areas.

1 https://pib.gov.in/PressReleasePage.aspx?PRID=1874209

Introduction to Green Heat/ Steam

Green heat or steam generation through biomass or renewable energy for industrial processes involves using sustainable and environmentally friendly methods to produce heat or steam. This typically includes utilizing biomass, such as organic materials like wood, agricultural residues, or dedicated energy crops, as well as other renewable energy sources. There isn't a universally accepted standard definition for "green heat" or "green steam." The terms are generally used to describe heat or steam production processes that prioritize environmental sustainability and have lower impacts on the environment compared to conventional methods.

Implementing green heat or steam generation in industrial processes not only reduces the carbon footprint but also contributes to sustainable and responsible business practices. It's essential to consider the specific needs and constraints of the industrial site when designing and implementing these systems.

Using Green Heat/ Steam in various operations, industries can reduce their carbon intensity and emissions from using fossil fuels. Such methods can also help industries to meet their sustainability goals.

To promote the uptake of biomass, MNRE has provisions for CFA under the programme. For Biomass Gasifier for electricity/thermal applications, standard CFA[2] applicable is:

- Rs. 2,500 per kWe with dual fuel engines for electrical application
- Rs. 15,000 per kWe with 100% gas engines for electrical application
- Rs. 2 lakh per 300 kWth for thermal applications

Modern bioenergy is particularly noteworthy in that it not only offers clean fuel options, but also numerous social and environmental advantages. For instance, implementing bioenergy applications can aid in the mitigation of air, water, and land pollution, while simultaneously generating local job and business opportunities, and lowering energy import expenses. Additionally, it can foster the growth of independent and decentralized communities. Furthermore, there are benefits for the private sector, including the ability to reduce industry carbon footprints. Additionally, savings on fertilizer subsidies and waste management costs can also be achieved.

The government's intention to promote biomass is evident through the mandate of 5-7% biomass co-firing in thermal power plants alongside coal, which would help to reduce GHG emissions from coal power plants.

However, there is pressing need to raise awareness and promote the use of biomass as a replacement fuel for production of Green Heat/ Steam which can create a sustainable market to capture the lost energy from biomass.

2 https://pib.gov.in/Pressreleaseshare.aspx?PRID=1885073

2 Our Detailed Approach and Methodology

The overall approach adopted to carry out the assignment is presented below. The firm will adopt and leverage the tested and established approach.

The firm carried out the desktop research to assess the biomass availability in India possible to estimate the quantum of biomass (largely agro residue) that could be potentially utilized for industrial operation. The firm also assess industrial applications where biomass could completely or partially substitute fossil fuel without compromising on the quality of the end product.

Further, the firm has also assessed the existing central-level and state-level, local bodies policies and schemes. Regulatory framework also being analysed related to the use of biomass for industrial steam applications. The findings shall be documented in the form of report and shall be shared with GIZ team.

Figure 2: Overall approach and methodology

Desktop Research
- Data Collection and analysis
- Review of Policies and Schemes
- Biomass resource availability
- Process application
- Operational SMEs

State Selection

Based on
- Crop residue availability
- Presence of clusters/ industries
- Presence of briquette, pellets manufacturing
- Supply chain details

Cluster & Industry Selection
- Region wise in the country, special economic zones
- Industries where bioenergy is already in usage
- Potential industries for bioenergy usage

Stakeholder Mapping & Consultation
- Identification and mapping of relevant stakeholders
- Questionnaire development for consultations
- Interview with relevant stakeholder to get their perspective

Techno-Economic Analysis
- Assessment of industrial application
- Retrofitting arrangement
- Potential energy output and efficiency
- Economic and financial analysis and cost assessment
- Assessment of financial incentives

Observation & Recommendation
- Cluster/sector wise set of recommendation
- Key steps required to promote the adoption of biomass
- Recommendation on the most suitable biomass conversion technologies
- Sustainability of biomass supply chains

For primary consultations, the firm in close coordination with GIZ will identify the focus states, industry cluster/ sectors and relevant stakeholder at central level, state level, local bodies, project developers etc.

The states will be shortlisted keeping in mind the various parameters where biomass can be deployed like different clusters in states including Maharashtra, Karnataka, Haryana/Punjab and Assam.

These are the proposed states and shall be finalised on the onset of assignment in close consultation with GIZ. Once the states are finalised, 4-5 different industry clusters shall be identified. The firm will then conduct primary and secondary research based on the data available in public domain. The firm will also make physical site visits wherever required for validating the data and assessment.

2.1 Review and Analyse the Current Status

The overall strategy to shortlist the potential industries for biomass co-firing mandates shall be driven by quantitative and qualitative assessment of performance of industries across key techno-commercial parameters affecting its uptake by industries. These shall be finalised based on primary level consultations with sector experts, historical precedents and rigorous literature review. Our methodology has been indicated below:

Figure 3: Methodology for shortlisting the potential industries

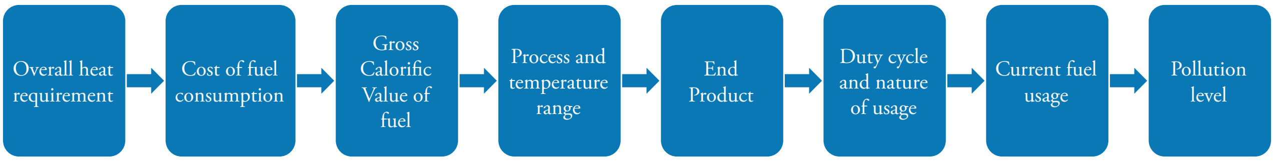
Selection and shortlisting of states (4/5) and identification of 4-5 industrial cluster in each state

The team shall analyse the set of parameters to initial shortlist the industries that has directly or indirectly influence the decision making. The performance measurement of industries across these parameters provides deep insights into the potential industries for mandates. To analyse the initial shortlist of industries, a set of quantitative and qualitative paramters were difined that directly or indirectly had a bearing on the decision making or rationale for adoptionof biomass by a given industry.

Some of the parameters were extracted during primary consultations while others were assessed through literature review of global deployements and industry practices. The performance measurements of industries across these parameters provides deep insights into the potential industries for mandates.

Various parameters are preseneted below:

Figure 4: Parameters for selection of potential industries for biomass mandates



The tentative list of industries is indicated below. These are the proposed list of industries and shall be finalised on the onset of assignment in close consultation with GIZ.

Table 1: Types of Industry Clusters

Type of Industry clusters
Agricultural and food processing,
Manufacturing, metallurgical/foundry
Chemical, process related using steam
Construction – Such as, brick kiln, cement, others
Institutional/cottage industries - cooking, jaggery making bakery others

An exhaustive list of industrial sector shall be developed based on the classification of various individual sub-industries by Annual Survey of India as per different industry codes into a given main industrial sector. For example, textile industry analysis requires grouping of 11 sub-industry analysis such as spinning, weaving of textiles etc. to assess the cumulative impact of the industry. These initial industries shall be selected by mapping the overall industry size (no. of operational units), coventional fuel consumption etc.

Data Collection and estimation of the quantum of biomass (largely agro residue) that can be utilized in industry as below in the selected states

Figure 5: Methodology for estimation of surplus residue for industrial usage

Determine crops wise annual production → Assessment of crop residue crop wise → Estimation of residue available → Analysis of crop wise surplus for industrial usage → Estimation of surplus residue available for industrial usage

The team shall collect the relevant insights via secondary research tools. The team shall go through key publications/ research work and review the data which shall include:

Data to be collected will include:

- Various central and state level policies and schemes
- State and sector specific industry cluster reports
- Recent trends in boiler technology and usage of alternate fuels

Documents that will be studied:

- Annual Survey of Industries (ASI) 2022
- MOSPI Energy Statistics 2023
- IEA report (Bioenergy Task 40)
- Industry level report by UNIDO etc
- Industry specific ministry reports
- Invest India Database of Industry Trends and Other relevant reports/ publications

Central and state level policies and schemes that will be studied:

- National Bioenergy Programme
- Biogas Power Generation and Thermal Energy Application
- Waste-to-Energy
- Fertilizer Control Order
- Sustainable Agrarian Mission on use of Agro Residue in Thermal Power Plants (SAMARTH) – Biomass Co-firing Policy

2.2 Stakeholder Identification and Mapping

Consultations with diverse set of stakeholders including government agencies, subject matter experts, think-tanks, national and regional industry associations, MSMEs etc. shall be carried out to understand their perspective regarding barriers, drivers, incentives and challenges related to uptake of biomass in their operations and including steam applications. A probable set of recommendations to scale up and improve the uptake of biomass and measure for mandating the use of biomass shall be gathered and their feedback shall also incorporated in the recommendations.

Figure 6: Stakeholder identification and mapping

Stakeholder Consultations

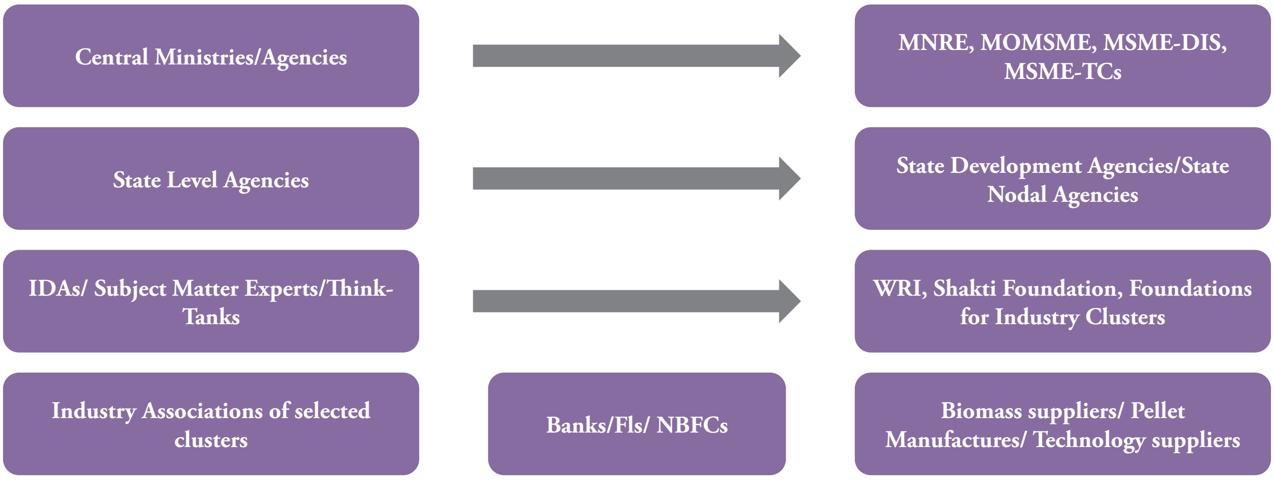
- Stakeholder mapping across central, state govt. and ministries and Subject Matter Experts/ Think-Tanks etc.
- In-person and video interviews and FDGs with identified stakeholders
- Collect and assess feedback of stakeholders on usage of biomass in industrial operations
- Conducting baseline assessment and cost benefit analysis and mandating obligation of biomass usage
- Conducting assessment based on information collected and data analysed

Set of stakeholders that shall be consulted is highlighted below. Various stakeholders from central ministries/ agencies like MNRE, MoMSME, MSME-TCs etc. shall be consulted to gather their inputs and suggestions. Similarly, relevant stakeholder from state level agnecies like state development agencies, state nodal agencies shall be consulted to capture their view. Other relevant stakeholders like IDAs/ Subject Matter Expert/ Think Tanks/ Industry Associations/ banks/ FIs shall also be appoached for the cosultations.

Biomass suppliers/ pellet manufacturers are also important stakeholder and shall also be part of the consultation process for gathering insights and taking inputs and suggestions form them.

A tentative list is indicated below:

Figure 7: Tentative set of stakeholders



Sample Industry level analysis

A sample analysis has been presented below for a food processing industry. The team shall conduct such assessment once the industries are finalised with close consultation with GIZ.

Table 2: Analysis of Food Processing industry

Sector	Food Processing
Annual Growth Rate	11.18%
Sub-segments	Fruits & vegetable, sugar, edible oil, beer & alcoholic, meat and poultry, grains, packaged foods etc.
Heat Demand	2.02 Giga Calories
Current fuel usage	Coal – 8.7% Electricity – 57.5% Petroleum Products – 13.8% Other fuels – 19.9%
Heat treatment process	Pasteurization, sterilization, food preservation, drying, freezing, canning etc.
Operational industries	~20,000
Cost Analysis – Fuel Price	Rs. 7.4 million per factory unit
GCV value of fuel used	>2000 Kcal/kg
Temperature range	~200 degrees

2.3 Technical Assessment and, Economic and Financial Analysis (Considering the Different Blending Options)

The team shall make physical site visits wherever possible to potential and identified industry sectors/ clusters to assess the technical assessment of the feasibility of using biomass for green heat/ steam in their operations.

The team will also assess different types of boilers and suggest any modifications if required for converting biomass into suitable form for industrial green heat/ steam application:

- For example, steam boilers are used in Paper and pulp industry.
  - Fuels like wood chips, wood logs, and sawdust and agro waste can be used in such boilers.
  - There is no modification required. Hence, no extra cost for conversion.
- Assessment for all the boiler types and develop a feasibility assessment report for using biomass in steam applications.
- Rank various boiler across industries and clusters and identify the best options, along with tentative costs for modifications.

The team shall conduct such assessment for all the boiler types and prepare a feasibility assessment report for using biomass in steam applications. The team shall rank various boiler across industries and clusters and identify the best options.

Biomass can be used as a fuel in the industry steam applications in various forms. The team shall conduct a detailed assessment of technical requirement of converting biomass into a suitable form for industrial applications. Biomass is available in pellet and briquette form which can be used as fuel in the boilers for steam applications.

Study the biomass availability and cost associated with conversion to pellet or briquette form. Key details shall be captured as below:

Table 3: Key details on various biomass available in India

Parameter	Output
Cost of raw biomass procured	**Agro based residue** – INR 2,000/MT – INR 3,500/MT **Industrial waste** – INR 4,000/MT – INR 5,000/MT **Pine wood/saw dust** – INR 5,000/MT – INR 7,000/MT
Selling price of pellet (ex-factory)	INR 9,000 – INR 14,000 / MT
GCV of pellet produced	3,600 kCal/Kg – 4,200 kCal/Kg, depending upon the type of raw material used
Moisture content	**Up to 15%; higher for crops like paddy straw**
Ash content of pellet produced	3 – 10 %
Wastage in conversion	Up to 3 %
Production cost	INR 1500 – 3000 / MT
Binding material	Lignin, saw dust, groundnut shell, inbuilt moisture, etc.
Labour requirement	Typically, 4-6 labourers: 1-2 for biomass cleaning and feeding; 1-2 operators for machine; 2 for packaging
Land requirement	400 – 800 square meter for 1 TPH of pellet manufacturing line

Economic and financial analysis of the feasibility of using biomass for green heat/ steam industrial applications

The team conducted an assessment for Pharma industry which is presented below (shifted to biomass from furnace oil). The team prepared a model for cost benefit analysis of using biomass in place of furnace oil. Various parameters considered for preparation of the models like cost of biomass, GCV of biomass, price escalation of biomass per annum etc. have been considered. Other parameters like the price of existing fuel used, GCV value of fuel used, upfront capex, contract life have also been considered.

Table 4: Economic and Financial analysis of Pharma Industry

Particular	Unit	Assumption
Cost of Biomass	Rs/kg	6
GCV of Biomass	Kcal/kg	2,800
Price Escalation per annum	%	2%
GCV of fuel used	Kcal/kg	10,500
Price of fuel used	Rs/kg	55
Fuel price escalation	%	4%
Upfront capex cost	Rs Crore	14.5
Contract life	Years	10
Discount rate	%	10%
NPV of savings of cash	Rs Crore	38
Incremental IRR	%	82.60%

From the above analysis incremental IRR is coming to be 82.60% considering the discount rate of 10%. The NPV of savings of cash is INR 38 crore.

A similar approach shall be followed to carry out the analysis of other industries/ MSME cluster once finalized with consultation of GIZ and MNRE.

The above exercise will help in identifying the industry/ MSME cluster where biomass in existing operation can be mandated and helps in assessing the viability in a particular selected MSME cluster.

3 Biomass Availability Assessment

Biomass is rapidly gaining popularity as a source of fuel due to its ability to substitute polluting fossil fuels, such as coal, with a cleaner option for heat generation in industry. An essential aspect of biomass fuel is its carbon neutrality, which means that the carbon dioxide released during combustion is equal to the amount absorbed during photosynthesis. This cycle makes biomass an environmentally friendly alternative to traditional fuels. Firing biomass as a fuel in boilers has a lower environmental impact compared to coal, in terms of emissions released into the environment. Furthermore, it serves as an ideal renewable energy source for various process applications in industries. With the recent surge in coal prices, industries are increasingly seeking cleaner and more cost-effective fuel options for steam production. The availability of biomass-based boilers, retrofitting options for conventional boilers, and multifuel-based boilers have also incentivized industries to adopt biomass as a fuel.

As per a recent study by MNRE, the current availability of biomass in India is estimated at about 750 million metric tonnes per year. The Study indicated estimated surplus biomass availability at about 230 million metric tonnes per annum covering agricultural residues corresponding to a potential of about 28 GW. This apart, about 14 GW additional power could be generated through bagasse based cogeneration in the country's 550 Sugar mills, if these sugar mills were to adopt technically and economically optimal levels of cogeneration for extracting power from the bagasse produced by them.

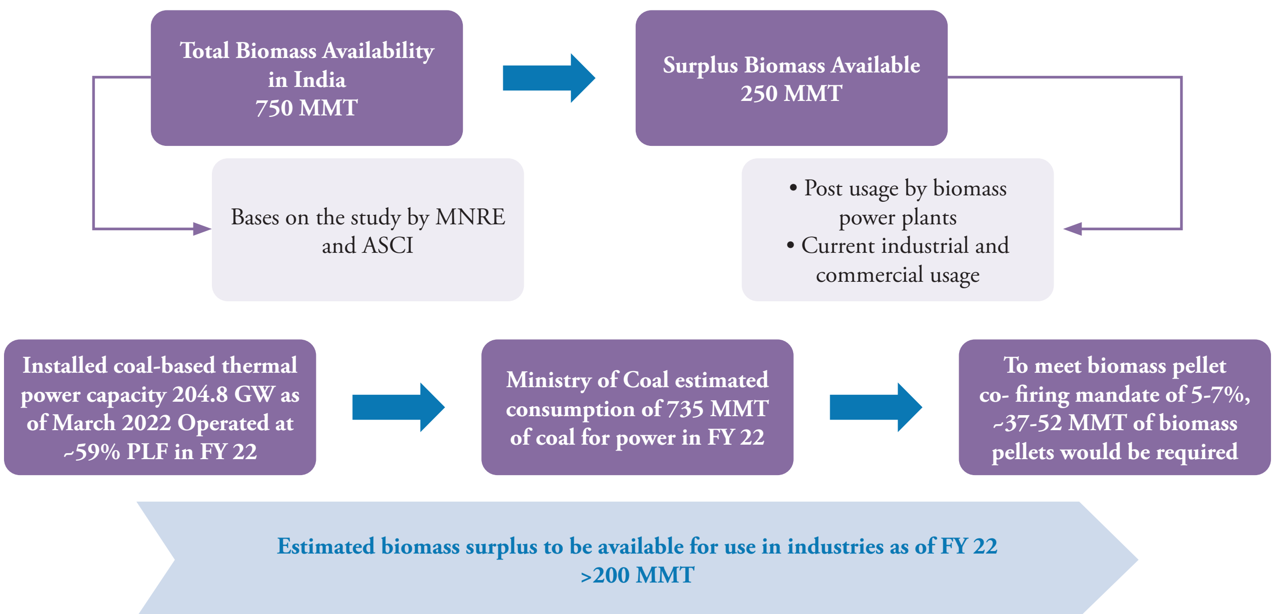
Biomass Availability for Industries

The recent push from the ministry on mainstreaming the role of biomass as a critical component in power generation through co-firing mandates in coal based power plants represents a vital step in addressing the issue of stubble burning and associated environment and health concerns. At the same time the blending action is anticipated to optimize the operations of thermal power plants by improving the economics, reduction in amount of coal used for power generation resulting in corresponding savings in CO_2 emissions, extending lives of plants set to retire, reduction in air pollution due to reduction in stubble burning, reducing emissions of PM, SO2, NOx, CO abd deffering additional investment on newer biomass/ coal-based plants.

However to fully analyse the situation and success of such tranistion, it is essential to investigate the procurement process, overall supply chain, efficacy to deliver large volume of biomass in various forms etc.

As per the report by Ministry of Coal, coal based thermal plants operated at ~59% PLF in FY22. The installed capacity of coal-based thermal power plant is 204.8 GW as of March 2022. The estimated coal consumption was 735 MMT in FY 22. To meet the co-firing mandate from biomass of 5-7%, the biomass pellets required would be 37-52 MMT. India has surplus of 230 MMT of biomass.

Figure 8: Biomass surplus available for industries



After taking out the biomass used by coal-based plants, there is surplus of around 200 MMT of biomass. This can be utilized by various industries to bring down the consumption of fossil fuels and opt for a cleaner fuel option.

3.1 Availability of crops region wise that can be used for pellets

Biomass availability for prominent crops for key states in India is as discussed below:

Table 5: Biomass availability for prominent crops for key states in India

Crop	Top three states	Dry Biomass	Residue	Surplus
Castor	Gujarat, Rajasthan, Andhra Pradesh	4.44	17.76	11.64
Cotton	Gujarat, Maharashtra, Telangana	44.77	170.13	75.99
Gram	Madhya Pradesh, Rajasthan, Maharashtra	17.77	19.55	6.43
Groundnut	Gujarat, Tamil Nadu, Rajasthan	7.80	17.95	5.39
Maize	Karnataka, Maharashtra, Telangana	10.41	23.94	5.18
Rapeseed & mustard	Rajasthan, Haryana, Madhya Pradesh	12.10	21.78	6.57
Rice	West Bengal, Uttar Pradesh, Punjab	81.42	138.41	26.92
Soybean	Madhya Pradesh, Maharashtra, Rajasthan	26.24	44.61	15.98
Sugarcane	Uttar Pradesh, Maharashtra, Karnataka	87.91	33.40	11.65
Tur	Maharashtra, Karnataka, Madhya Pradesh	5.28	14.79	2.83
Wheat	Uttar Pradesh, Punjab, Madhya Pradesh	91.00	136.50	23.53

(*The residue reflects the crop residue available from each of these crops post harvesting, based on crop specific CRR. This residue is utilised for all purposes such as domestic, animal fodder. Post this utilisation, surplus biomass is left for industrial purpose and the same is estimated based on crop specific surplus factor).*

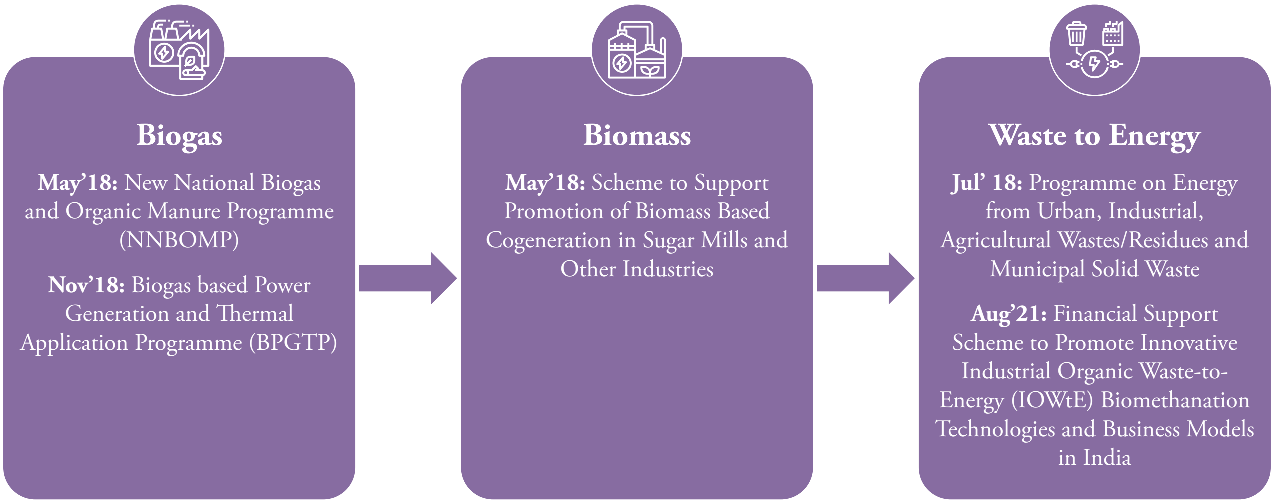
4 Review of Policies and Schemes for Biomass Deployment in Industries

As a part of the assignment, the team shall also analyse the existing policies and regulatory framework at central and state level to the use of biomass for industrial steam applications.

Various policies and schemes have been launched by the central and state government to promote the usage of biomass. Few of the central and state level policies have been analysed here. A detailed analysis shall be done during the project phase. Some of the leading states in the biomass and feedstock and biomass based projects in India are Punjab, Haryana, Rajasthan, Maharashtra and Karnataka. The policies here are supportive in adopting biomass based projects by providing incentives, providing subsidies, technical and financial support to help biomass uptake.

- Few states like Punjab, Haryana, Rajasthan, Maharashtra and Karnataka are leading in the biomass & feedstock availability and biomass-based projects.
- There have been supportive policies in terms of incentives, subsidies, technical and financial support to help biomass-based projects come up in their states.

The steps taken by government for Bioenergy development in the country are as mapped below:



In order to reduce stubble burning and to manage carbon footprint of Thermal Power Plants while increasing the income of farmers, Government of India has taken various proactive steps with the establishment of National Mission on Use of Biomass in Thermal Power Plants. The agro-residue/ biomass earlier considered as a waste product has now begun to produce zero-carbon electricity for the citizens of the country. In turn, farmers are getting additional income by selling the stubble/ biomass for conversion into biomass pellets. Ministry of Power's policy on "Biomass Utilization for Power Generation through Co-firing in Coal based Power Plants" issued in October 2021 mandates all thermal power plants in the country to use 5 to 10% biomass along with coal for power production in the following manner:

- All coal based thermal power plants of power generation utilities with bowl mill, shall on annual basis mandatorily use 5% blend of biomass pellets made, primarily, of agro residues along with coal with effect from year 1. The obligation shall increase to 7% with effect from 2 years after the date of the order and thereafter.
- All coal based thermal power plants of power generation utilities with ball & race mill, shall on annual basis mandatorily use 5% blend of biomass pellets (torrefied only) made, primarily, of agro residues along with coal with effect from year 1. The obligation shall increase to 7% with effect from 2 years after the date of the order and thereafter.
- All coal based thermal power plants of power generation utilities with ball & tube mill, shall on annual basis mandatorily use 5% blend of torrefied biomass pellets with volatile content below 22%, primarily made of agro residue along with coal. This is to be complied within one year.
- Generating utilities having certain units under Reserve Shutdown or not being dispatched due to MOD consideration would ensure to increase the percentage of co-firing up to 10% in their other operating units / plants (5% in plants having ball and tube mills) .
- As of July 2022, approximately 80,000 MT of biomass has been co-fired in thermal power plants in the country,

while tenders for 24.8 MMT are at different stages of process for short term & long-term duration. Out of these, around 12 MMT are under award while order has already been placed for 1.3 MMT worth of biomass tenders.

Review of policies and schemes for biomass deployment in industries

The policies and the schemes depicted below are launched by the central and state ministries to promote usage of biomass. The state level policies for key states that support biomass adoption and usage have been analyzed.

State level policies in biomass rich states

Some of the leading states in the biomass & feedstock availability and biomass-based projects in India are Punjab, Haryana, Rajasthan, Maharashtra and Karnataka. The policies in these states have been supportive in adopting biomass-based projects by incentivizing them, providing subsides, technical and financial support to help biomass-based projects come up in their states. These state models can also be adopted by other agri-rich states where biomass production remains underutilized.

Table 6: State Policies for Bioenergy

State	Policy
Punjab	**Biomass/Agro residue/Biofuel Based Projects:** It is proposed to achieve a target of 800 MW power generation in this sector by 2030.
	Biofuel based projects (Bioethanol, Biodiesel & Bio-CNG): The Policy aims to facilitate the production of biofuels through the utilization of locally available biomass feedstocks.
	Biogas: Production of Biogas from fermentable organic wastes through anaerobic digestion of cattle dung, and other loose and leafy organic matters/biomass wastes shall be promoted & facilitated in Punjab as it is clean low carbon technology for efficient management and conversion into clean, cheap & versatile fuel and bio/organic manure. The Policy mentions that PEDA will facilitate in setting up of biogas power projects in the state. Bagasse/ Biomass Co-generation Power Projects: The state has an estimated combined potential of 500 MW for Bagasse/Biomass co- generation, which is still to be realized. It is proposed in the policy to encourage the industry to set up co-generation plants and achieve a capacity addition of 500 MW by 2030. These projects shall meet the qualifying criteria under the topping cycle as per CERC regulations. Co- generation projects under bottoming cycle or based on backpressure turbines and tri-generation projects utilizing the waste heat for heating/cooling/ chilling purposes shall also be encouraged.
Rajasthan	Rajasthan has a dedicated policy for promoting the generation of electricity from biomass. It specifies that the power producers may use the power for captive consumption or for sale to third party /licensees including Discomsa. The grid interfacing arrangements for power using Biomass as RE sources will be made by Power Producer/RVPN/Discom as under: • Biomass Power Producer will terminate their 33kV (minimum voltage level) power evacuation feeder to nearby RVPN's 132/33kV or 220/132/33kV GSS or any other RVPN's GSS -n consultation with RREC. • For the creation of a proper facility for receiving power, the Power Producer shall pay Grid Connectivity charges as finalized by RERC from time to time to VPN/ Discoms as the case may be. These charges, paid within 3 months of the signing of PPA, shall include the cost of the complete line bay (including civil works) and its interconnection with the existing electrical system at RVPN GSS. • The evacuation system beyond Generating Plant Sub Station till the nearest RVPN's 220/132/33kV or 132/33kVgrid sub-station shall be developed by Biomass Power Producer as per Rajasthan Electricity Regulatory Commission (RERC) regulation dated 23.1.2009 and amended from time to time. • For augmentation of transmission/ distribution systems to evacuate the power from receiving station, RVPN / Discom shall develop/ augment the necessary transmission/ distribution network within the mutually agreed timeframe.

State	Policy
	The Government of Rajasthan also offers certain incentives to the power producers in this regard: • **Exemption from Electricity Duty**: Consumption of electricity generated by Power Producers for its captive use will be exempted from Electricity Duty @ 50% for a period of 7 years from COD. • **Grant of incentives available to industries**: Generation of electricity from Renewable Energy Sources shall be treated as an eligible industry under the schemes administered by Industries Department and incentives available to industrial units under such schemes shall also be available to the Power Producers. • **Land on Concessional Rate**: The Government land required for the Biomass Power Plant shall be allotted to the Power Producer at concessional rates of 10% of DLC rates. • **Availability of Water for Power Generation**: The Power Producer shall be allowed to use water from sources of the Water Resource Department subject to the availability of water for power generation.
	Sulphur content should not exceed 0.5% in the coal for use in the coal fired boilers to control particulate emissions within permissible limits (as applicable). The gaseous emissions shall be dispersed through stack of adequate height as per CPCB/SPCB guidelines.
Haryana	Haryana has developed a dedicated Bio-energy Policy, 2018 with the objective of harnessing biomass-based power/ biogas/bio-CNG/bio- manure/biofuels and creating a conducive environment to attract private investment in biomass projects. According to the policy document and state analysis, Haryana has surplus biomass availability of 8416 thousand tonnes. which has tremendous potential for utilization of the residues of these crops to generate electricity/biogas/ bio-CNG/bio-manure/biofuels. Further, the State has the potential to generate about 1000 MW of power or 11.5 lac tonne of bio-CNG10. Some of the key incentives offered by Haryana Government for the development of biomass projects include: • Exemption from Land Use approval, External Development Charges, scrutiny fee and infrastructure development charges: These projects shall not require any change of Land Use approval from the Town & Country Planning Department/Urban Local Bodies (ULB) Department. The project shall also be exempted from External Development Charges (EDC), scrutiny fee and infrastructure development charges but if special service is required for the biomass project, then EDC charges shall be charged on a pro-rata basis. Further, the land used in biomass projects will be out of the purview of the Land Ceiling Act of the government. 100% exemption from payment of fee and stamp duty charges will also be allowed for registration of rent/lease/sale deed for the land required for setting up of these projects in B, C and D category blocks as defined in the Haryana Enterprise Promotion Policy 2015.
	• **Third party Sale, Wheeling, Banking and Open Access:** Discoms/Licensees shall permit electricity generated by eligible producers to be wheeled and banked without any charges. The biomass project developer as per the entitlement under the policy will also be allowed inter/Intra State open access for Captive (within and outside the premises), sale of power to Discoms and Third-party Sale simultaneously.
	• **Exemption of transmission & distribution, cross subsidy charges, surcharges and Reactive Power Charges**: All cross-subsidy charges, transmission & distribution charges, surcharges and reactive power charges will be totally waived off for any biomass projects set up in the State.
	• **VAT/GST/ Tax Holidays:** Octroi on biomass fuels for all projects including bio-CNG, bioethanol and biofertilizer shall be fully exempted. 100% exemption from entry tax will also be allowed in respect of all supplies (including capital goods, structure and raw materials) made for setting up and trial operations of the projects. For the efficient collection of biomasses for the approved projects, reaper, raiker, baler and trawlers will be provided either on rent or on upfront subsidy as per the schemes of the Agriculture & Farmer Welfare Department, Haryana, in force from time to time. The projects set up under this, policy shall also be eligible for Central and State Financial Assistance and other exemptions like excise duty and customs duty, as applicable from Central and State Governments, subject to eligibility.
Maharashtra	Maharashtra The Government of Maharashtra has been promoting energy generation from biomass power projects. Maharashtra Energy Development Agency (MEDA) is giving technical support and guidance to induce private investment into this sector and ensures speedy implementation of the projects. MEDA has so far sanctioned 37 biomass-based power projects totalling 410.5 MW capacities projects in the state12. Some of the key incentives offered under the policy include: • The project developer, as per the availability of funds, shall be given financial assistance as reimbursement by MEDA from the green cess fund, up to a maximum of INR 1 crore per project expenditure made on evacuation arrangement. • A capital subsidy of INR 1 Crore per project shall be given for biomass- based power projects • Electricity duty shall not be levied for the first 10 years in respect of the biomass-based power projects established under the policy for captive use. • The project developer shall be granted infrastructure clearance by MEDA for availing benefits under the policy.

<table>
<tr><th>State</th><th>Policy</th></tr>
<tr><td>Karnataka</td><td>Karnataka had come up with the Draft Karnataka Renewable Energy Policy 2016-2022 covering Wind, Wind-Solar Hybrid, Small Hydro, Biomass, Cogeneration, Waste-to-Energy, and Tidal. In order to encourage the developer, the security deposit clause is waived-off for the projects related to Biomass, Waste-to-Energy and Cogeneration.

Further, the Government of Karnataka is considering setting up “Biomass Parks” in rural areas of the State, dedicated to the supply of biomass fuel to designated biomass power projects. Under the policy, the state Government is also encouraging the plantation of biomass fuel in the dedicated zones identified by the Gram Panchayats of villages where such potential exists.

Other than this, the Government of Karnataka (GoK) contemplates licensing / registering of biomass material trading companies/traders to bring in the consolidation of biomass trading as well as help organize the process effectively. Gok will also draw plans for investment to set up, marjage and use biomass resources available in the state for power generation-projects. Appropriate rates and payment mechanisms for the fuel sold to the biomass power producers shall also be worked out.

In addition, some fiscal incentives available from GoK to promote biomass- based projects include:
• Projects implemented under the said policy shall receive the status of the industry and shall be eligible for all the incentives provided under the State Government’s ‘Karnataka Industrial Policy 2014’.
• No green energy cess shall apply to the power procured from biomass- based power projects in the state.

The industrial consumers opting to procure power from projects set up under this policy, through captive/group captive route or IPP route shall be allowed corresponding pro-rata reduction in contract demand on a permanent basis but subject to the decision of KERC in this regard.</td></tr>
<tr><td>Uttar Pradesh</td><td>Biogas based power generation program
Under this scheme, as per the ministry approved design and drawing installation of 3 to 250 KV capacity plants at the sites like dairy etc. is being conducted by gas produced from biogas plant by the generator. After the construction plant is undertaken by the beneficiary, the grant of Rs 40,000/- to Rs 30,000/- per KV in descending order is admissible on a reimbursement basis by the Ministry for this purpose.

Bagasse based cogeneration projects in sugar mills
Plenty of bagasse available in the sugar mill of the state has a potential of 1500 megawatt additional power generation through co-generation. UPNEDA started its efforts in 1994 as a catalyst/facilitator to set up power generation projects based on co-generation through bagasse available in the various sugar mills of Uttar Pradesh.</td></tr>
<tr><td>Telangana</td><td>Telangana has substantial availability of Biomass / Agro waste in the state is sufficient to produce about 350 MW of electricity. TSREDCO has planned to develop some of the available potential talukas/tehsils with the aim to promote and install biomass / agro waste-based projects.</td></tr>
<tr><td>Madhya Pradesh</td><td>Industrial units who are the consumers of Madhya Pradesh State Electricity Board installing biomass plants for captive use or purchasing power generated from third party, shall be provided a reduction in contract demand.

Use of govt. and non-forest wastelands
• On govt. land, maximum 2 acres per megawatt may be used for biomass projects.
• For non-forest wastelands, the maximum area of land for the project will be 100 acres per MW and land will be made available for a maximum of 5 MW.
• The state-owned power trading company shall have the first right to purchase electricity generated from these projects.

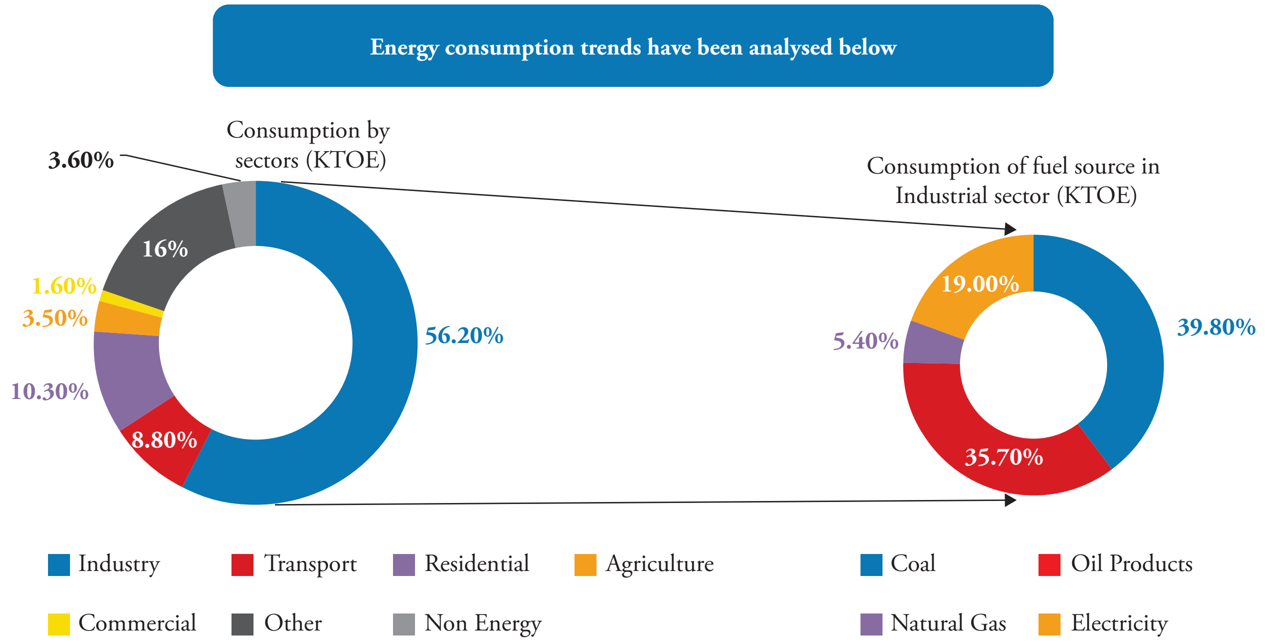
Incentives by the state government
• 50% stamp duty exemption on the purchase of private land.
• The state govt. will provide a grant of 4% for wheeling charges applicable as specified by MPERC, for a period of 10 years from the date of commissioning.
• Electricity duty and cess exemption for all projects (including captive) for 10 years from the date of commissioning.
• Third party sale, within or outside MP, shall be allowed as per MPERC regulations as issued from time to time.</td></tr>
</table>

5 Value Proposition with use of Biomass

5.1 Energy consumption trends in industrial sector

As per the recent report of IEA, industrial emissions will have to decrease by more than 90% globally between 2020 and 2050 for the world to have 50% chance of limiting global warming to 1.5°C above pre-industrial levels. Similar trends will have to replicated for India as well, where today industrial sector consumes over 50% of the total energy sourced through coal (39.8%) and oil products (35.7%) accounting for one-fourth of total GHG emissions.

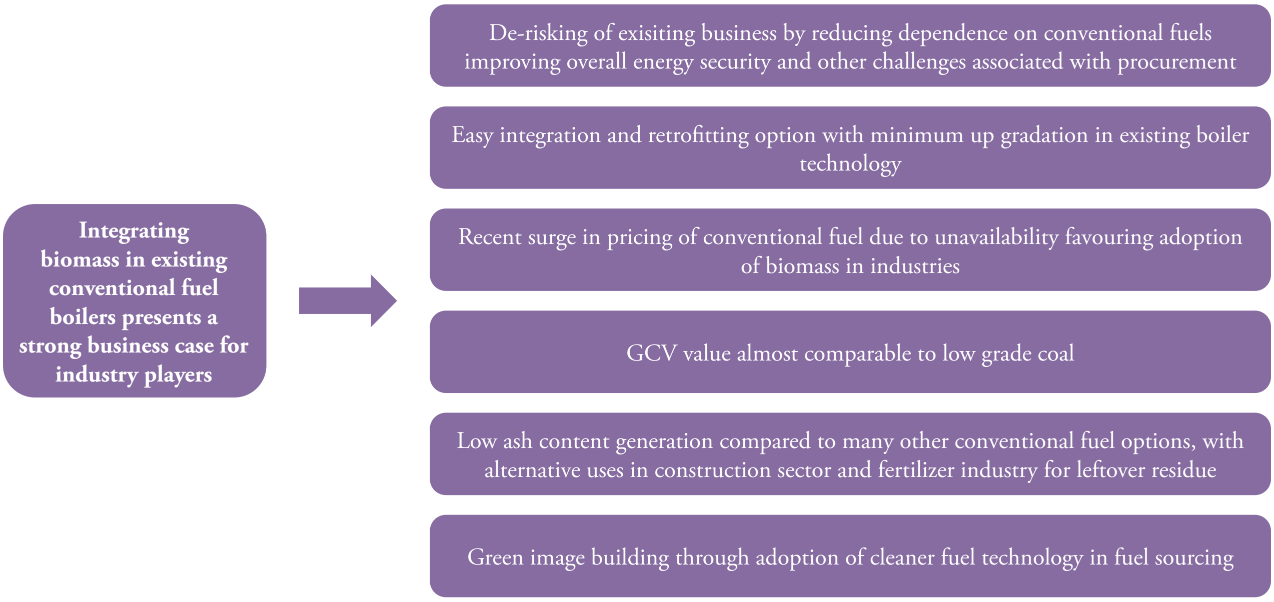
Figure 9: Energy consumption trends in industrial sector



5.2 Value proposition of integrating biomass in existing conventional fuel boilers

Apart from adoption of low carbon technology options for power generation, decarbonisation of industrial process, heat generation represents a critical component in eliminating GHG emissions. Deep reductions in CO_2 emissions from generation of industrial process heat can be achieved by shifting to non-fossil means of generating heat. Biomass is one of the most promising alternatives.

Figure 10: Value proposition of integrating biomass in existing conventional fuel boilers



5.3 Use Case: Inputs from Industries Using Biomass for Heating Applications

- Typical **off takers** of the biomass in industries include **chemical, pharmaceuticals, food processing, dairy and cement.**
- A few companies using biomass for heating – Amul, Unilever, Patanjali, Zydus, Haldiram's, HUL, Kellogs, privately owned thermal power plants, etc.
- Pellet manufacturers have a typical **production capacity ranging between 1000-3000 MT / month**.
- Raw Material processed – rice husk, mustard husk, paddy straw, groundnut shells, soya husk, cotton stalks, sugarcane leaves and trash, coconut shells, bamboo sticks, bamboo dust, coffee waste, corn cobs waste, saw dust, pine wood, pine needle, etc.
- Pellet manufacturers in India are **supplying** the pellets even to a **distance up to 1000 km.**
- In terms of payment, the **industrial customers are typically providing 50% upfront payment** and 50% payment within one week's timeline

Table 7: Key stats for biomass

Parameter	Output
Cost of raw biomass procured	• Agro based residue – INR 2,000/MT – INR 3,500/MT • Industrial waste – INR 4,000/MT – INR 5,000/MT • Pine wood/saw dust – INR 5,000/MT – INR 7,000/MT
Selling price of pellet (ex-factory)	INR 9,000 – INR 14,000 / MT
Transportation cost	INR 1,000-1,500/MT for a 200 kms distance for a 10MT truck
GCV of pellet produced	3,600 kCal/Kg – 4,200 kCal/Kg, depending upon the type of raw material used
Moisture of the pellet produced	Up to 15%; higher for crops like paddy straw
Ash content of pellet produced	3 – 10 %
Wastage in conversion	Up to 3 %
Pellet production cost	INR 1500 – 3000 / MT

5.4 Biomass Pellet Manufacturers Supplying to Industries in India

Biomass pellet production has increased considerably in recent years, mainly due to the demand created by policies and bioenergy-use target. Biomass pellets are majorly used for electricity generation in India produced from biomass surplus available from agriculture and forestry/wasteland. The rise in pellet consumption has resulted in a wider variety of materials used for pellet manufacture.

Currently in India, there are:

- **Nearly 250 pellet manufacturers** and **>1100 briquette manufacturers**
- **20+ pellet equipment manufacturers** (concentrated in Gujarat and Punjab)
- Current **biomass pellet manufacturing in India ~ 2.38 MMT/annum**

And there are over **800+ biomass aggregators** present in the country.

The table below represents the state wise annual pellet production capacity (MT):

Table 8: State wise annual pellet production capacity (MT)

State	Annual Pellet Production Capacity (MT)
Gujarat	624,250
Rajasthan	294,600
Haryana	164,400
Tamil Nadu	132,000
Andhra Pradesh	89,200
Maharashtra	2,54,400
West Bengal	1,30,000
Chhattisgarh	43,200
Bihar	31,800
Telangana	75,000
Punjab	1,86,000
Uttar Pradesh	1,52,400
Karnataka	186,000
Other states	130,200
Total	**2,493,450**

The total annual pellet production is 2,493,450 MT. The major concentration of pellet manufacturing is across the 13 states as highlighted in the table above and rest are in the other states. It is evident from the table above that the states like Gujarat, Rajasthan, Maharashtra, Punjab, Haryana have highest pellet manufacturing capacity. And constitutes around 60% of the pellet manufacturing capacity in India.

6 Potential MSME Clusters for Biomass Utilization

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6.1 MSMEs in India and Biomass Utilisation

The MSME (micro, small and medium enterprises) sector, is a heterogeneous sector in terms of the products manufactured, sizes, manufacturing processes, output and technology used in manufacturing. MSMEs engaged in manufacturing, account for about 33%[3] of India's manufacturing output and around 28% contribution in the GDP as whole. The MSME sector account for a quarter of the total industrial energy consumption in India[4]. They are the backbone of the OEMs and with the projected growth in the large industries sector, the MSMEs are also projected to grow in terms of their economic output. MSMEs typically are characterized with a high degree of heterogeneity within the manufacturing processes across various geographic locations even for similar product offerings.

The MSMEs in India are about 63 million – and a majority of them have not been implemented any modern (or) decarbonization technologies and/or process, they largely rely on vintage technologies.

The MSMEs consume about 80 million tonne of oil equivalent energy in FY19[5]. The MSMEs can be categorized based on their energy intensity (share on energy in overall cost of production):

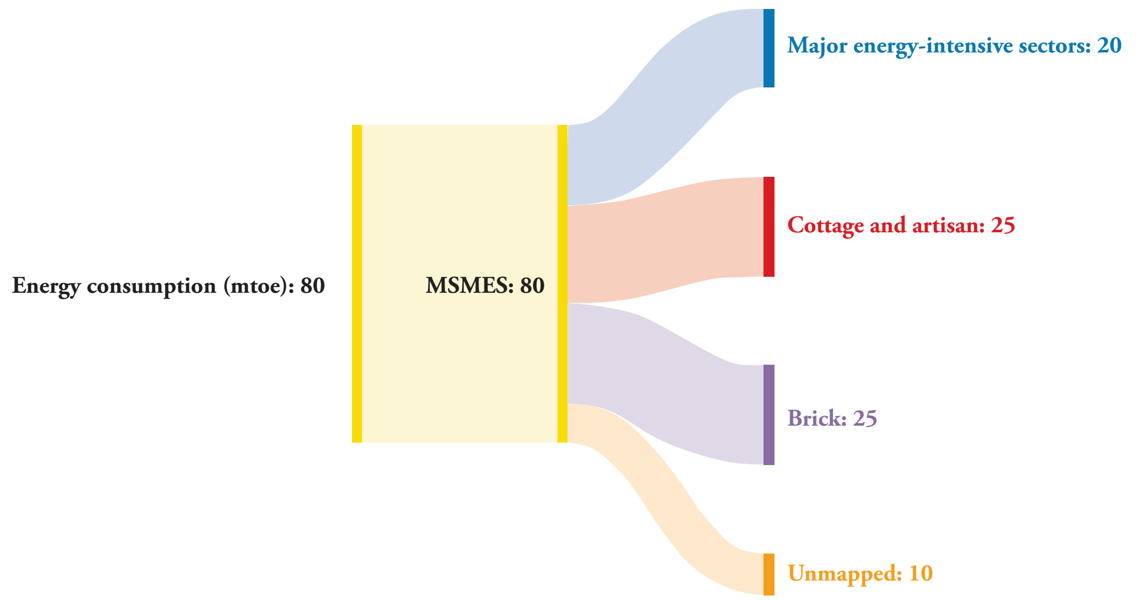
(a) <5%,

(b) 5-10%, and

(c) >10%.

The cottage industries and artisan units are largely under category (a), meaning are low energy intensive. Brick is a major MSME sector and has high energy intensity i.e. >25% share of energy cost. There are about 10% of unmapped MSME clusters/sectors. About 20 mtoe equivalent energy is consumed by MSMEs in major energy-intensive sectors.

Figure 11: Energy consumption in MSMEs



The industrial sector accounts for a lion's share of global GHG emissions. From As per BEE UNNATEE study, from 1990 to 2014, the overall increase in direct GHG emissions from this sector was a whopping 70%, which comes to 2.2% per year on average. This was faster than the increase in global GHG emissions, which was comparatively 30%, or 1.1% per year on average. Direct GHG emissions from industrial processes, along with indirect GHG emissions resulting from the generation of electricity used by industry, accounted for 28% of global GHG emissions.

CO_2 emissions were the maximum contributor to GHG emissions from industrial processes. The other 10% comprised methane (e.g., from black carbon production), fluorinated gases (used in refrigeration) and nitrous oxide (e.g., from the production of glyoxylic acid and nitric acid).

3 https://beeindia.gov.in/sites/default/files/Annexure%201.pdf

4 https://www.oecd.org/environment/cc/cefim/india/roadmap/CEFI-Roadmap-MSME-Energy-Efficiency-Workshop-Summary.pdf

5 https://beeindia.gov.in/sites/default/files/press_releases/UNNATEE%20Report.pdf

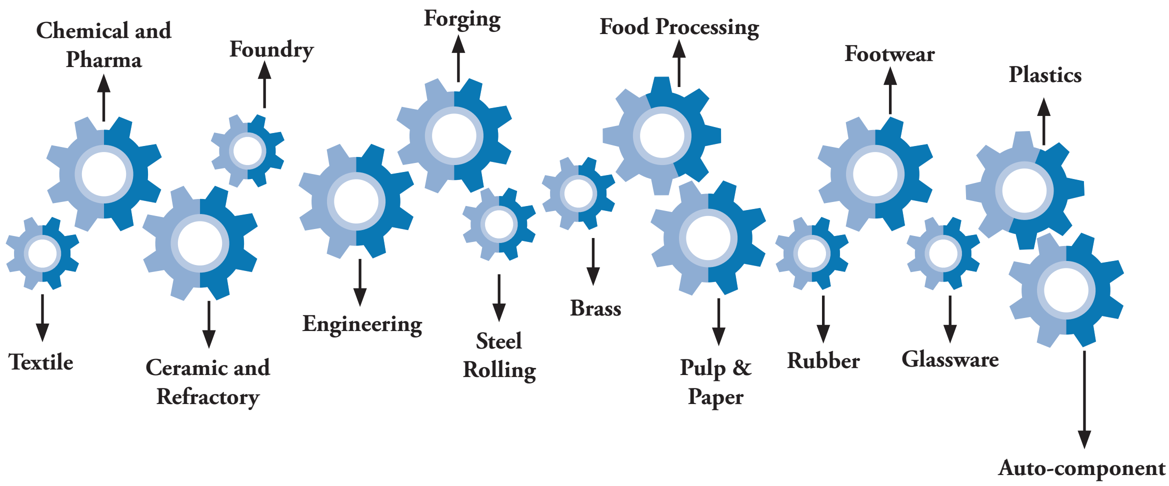
Biomass utilization in such MSMEs can be beneficial in various ways:

- **Energy Production and heat requirement**: MSMEs can use biomass as a renewable energy source. Biomass in the form of biomass pellets, or briquettes can be used to generate electricity or heat for their operations, reducing their reliance on fossil fuels.
- **Waste Management:** Biomass can be used to manage organic waste generated by MSMEs. This can include converting food waste or agricultural residues into compost or biogas, reducing waste disposal costs.
- **Product Manufacturing:** Some MSMEs, particularly those in the agro-processing sector, can utilize biomass as raw material or fuel for their production processes. For example, rice mills can use rice husks as fuel for boilers.
- **Economic Benefits:** Biomass utilization can help in fuel cost savings looking at the rising cost of conventional fuels
- **Environmental Benefits:** Using biomass as an energy source or raw material can reduce greenhouse gas emissions and contribute to a more sustainable business model.

6.2 Major MSMEs sectors in India

There are over 1000 MSME clusters covering numerous sectors spread across the country. The top 15 MSME sectors based on energy intensity, number of MSME units and sheer quantum of energy consumption are as presented below[6]. An approximate estimate of number of units in each sector along with total energy consumption of the sector is presented in Table. This is based on data available in BEE UNATEE report and studies provided in TERI Sameeeksha portal[7] and BEE-WB-GEF Sidhiee portal[8].

Figure 12: Major MSMEs sectors in India



Energy consumption in manufacturing processes forms a significant share of MSMEs' overall production cost, with sometimes the share of energy cost being as high as 50% of total manufacturing cost.

The table below highlights the energy consumption across major MSME sectors.

6 https://beeindia.gov.in/sites/default/files/press_releases/UNNATEE%20Report.pdf
7 http://www.sameeeksha.org/
8 https://sidhiee.beeindia.gov.in/

Table 9: Key stats for major industrial MSME clusters in India

#	Sector	No. of units	Approx. major no. of clusters	Energy consumption (toe)
1	Textile	3400[9]	8	5,590,000
2	Engineering	4400[10]	8	2,365,000
3	Steel Re-rolling	1800[11]	12	2,074,000
4	Ceramics and Refractory	2300[12]	16	1,655,000
5	Foundry	4500[13]	20	1,290,000
6	Chemicals and Pharma	3000[14]	5	1,080,500
7	Plastics	10000+[15]	15	997,900
8	Food Processing	10000+[16]	25	940,500
9	Paper	500[17]	10	726,000
10	Forgings	1000[18]	15	460,000
11	Glassware	1300[19]	3	276,500
12	Brass	5500[20]	5	117,400
13	Auto-comp	900[21]	5	74,000
14	Rubber	6000[22]	5	10,000
15	Footwear	400[23]	5	8,600

As per BEE's estimates, there are about 180 energy intensive MSME clusters in the country, which consume approximately 40% of the overall energy consumption by industrial MSMEs in 400 clusters, estimated at 68 Mtoe.

From the above table it is quite evident that sectors like textile, engineering, steel rolling, foundry, ceramics, pharma are highly energy intensive. And the share of their energy cost is also high. Switching to biomass fuel for green heat/ steam generation, as a cleaner option for their electricity and heat requirement can significantly reduce their operations cost.

Whereas the sectors like plastics, food processing, rubber etc. have moderate energy consumptions but at the same time the number of factory units are thrice than highly energy intensive sectors.

Biomass adoption in such industries will help in reducing their dependency on fossil fuels and reduce their emissions.

9 https://www.gartexindia.com/textile-industry-in-india-an-overview/#:~:text=Now%20168%20years%20later%2C%20India,million%20spindles%20and%20842%2C000%20rotors.

10 BEE SME Programme

11 https://www.ispatguru.com/important-issues-related-to-re-rolling-mills-in-sme-sector/

12 https://www.indian-ceramics.com/wp-content/uploads/2018/10/Ceramics_Industry_Report.pdf

13 BEE Energy Mapping Study, 2021

14 https://www.investindia.gov.in/sector/pharmaceuticals#:~:text=India%20also%20has%20the%20highest,in%20the%20global%20API%20Industry.

15 https://www.ibef.org/research/case-study/india-s-plastic-industry#:~:text=Currently%2C%20the%20Indian%20plastic%20processing,capita%20consumption%20is%20rising%20quickly.

16 https://pib.gov.in/PressReleasePage.aspx?PRID=1883151#:~:text=As%20per%20the%20latest%20Annual,units%20existed%20in%20the%20country.

17 BEE Energy Mapping Study, 2021

18 BEE Energy Mapping Study, 2021

19 https://rentechdigital.com/smartscraper/business-report-details/india/glass-manufacturers

20 https://www.business-standard.com/article/sme/jamnagar-brass-units-seek-government-support-110031600017_1.html

21 https://www.business-standard.com/article/sme/jamnagar-brass-units-seek-government-support-110031600017_1.html

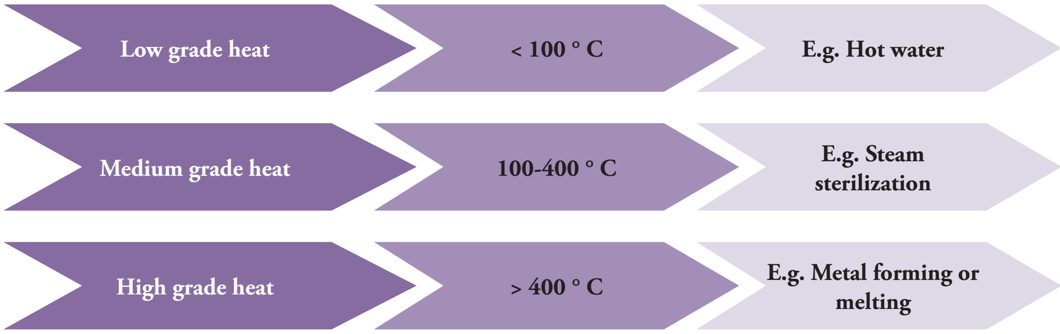
22 http://www.industrialrubbergoods.com/rubber-industry.html#:~:text=There%20are%20about%206000%20unit,qualified%20support%20personnel%2C%20contributing%20Rs.

23 https://msme.gov.in/indias-footwear-industry#:~:text=There%20are%20nearly%2015000%20units,Rs%2018%2C000%20Crores%20for%20exports.

6.3 Thermal energy and steam requirement

Each sector's energy needs depend on the type of process and equipment adopted. The energy needs can be categorized into two parts: electrical energy and thermal energy. Among the energy intensive sectors, thermal energy accounts for about 60% of total energy needs, rest 40% being electricity. Further the thermal energy requirement can be spilt into three parts:

Figure 13: Classification of thermal energy requirement



The share of thermal and electrical energy along with grade of heat requirement is presented in next table.

Table 10: Share of thermal and electrical energy in MSMEs Clusters in India

#	Sector	Thermal	Electrical	Grade of heat
1	Textile	35%	65%	Low to medium grade
2	Engineering	14%	86%	Medium grade
3	Steel Re-rolling	61%	39%	High grade
4	Ceramics and Refractory	98%	2%	High grade
5	Foundry	44%	56%	High grade
6	Chemicals and Pharma	85%	15%	Low to medium grade
7	Plastics	96%	4%	Medium grade
8	Food Processing	50%	50%	Low grade
9	Paper	85%	15%	Medium grade
10	Forgings	72%	28%	High grade
11	Glassware	98%	1.8%	High grade
12	Brass	86%	14%	High grade
13	Auto-comp	0%	100%	-
14	Rubber	14%	86%	Medium grade
15	Footwear	13%	87%	Medium to high grade

From the above it is visible that the sectors like textile, chemicals, pharma, plastics, and paper require low to medium grade heat requirement.

Such industries are best suited for substituting conventional fuel with biomass in their existing operations as it favours the internal processes.

6.4 Criteria for Identification of the Sectors/Clusters with Thermal Applications and use of Biomass

For identification of sectors/ clusters with thermal applications and use of biomass, the selection criteria have been presented below:

Four-pronged approach have been adopted as below:

- Shortlisting of the sectors which have the thermal applications
- Shortlisting the sector with low-medium and high grade of the heat application
- Potential for technology used in the sector and replication of thermal fuel with biomass
- Potential clusters with different sectoral mix and regional biomass availability

Figure 14: Criteria for identification of the sectors

Shortlisting of the sectors which have the thermal applications	• Textile, Food Processing, Tea, Foundry, Forging, Rubber, Plastic, Brass, Footwear, Steel re- rolling, Chemicals, Pharma, Paper, Automobile etc.
Shortlisting the sector with low- medium and high grade of the heat application	• High grade Heat (>400 deg C) - Foundry, Forging, Steel re-rolling • Medium grade heat (100-400 deg C) - Food processing, Textile, Rubber, Footwear, Chemical, Pharma, Bricks etc.
Potential for technology used in the sector and replication of thermal fuel with biomass	• Boilers (Reciprocating, Grate boilers) • Thermo-packs • Hot water generators • Furnaces / Kilns for High grade heat requirement • Cold storage using VAM technology
Potential clusters with different sectoral mix and regional biomass availability	• Ludhiana / Jalandhar - Textile, Food Processing, Footwear, Paper, Bricks • Delhi - Food Processing, Textile, Bricks • Ahmedabad / Surat - Chemicals, Textile, Pharma, Ceramics • Pune - Textile, food Processing, Rubber • Darjeeling- Tea industry • Hosur-Aluminum Die casting • Bengaluru- Plastic-roto moulding, Automobile electroplating

The major parameter influencing the industrial biomass uptake are overall heat demand (Kcal), cost of fuel consumption, GCV of fuel used, process and temperature range and deployment of existing installations. Few parameters have been described below:

Table 11: Parameters for selection of industries for biomass mandate

Parameter	Description
Overall Heat Demand	Generally, higher the heat demand, as in case with energy intensive industries, MSMEs are more likely to opt for fuels with higher quality (such as high-grade coal) to meet their overall heat demand
Cost of fuel consumption	A higher cost of fuel consumption (especially recent coal crisis spurring rapid increase in prices) furthers the case for switching to cheaper biomass-based alternatives
Gross Calorific Value (GCV)	An industry having GCV value (upwards of 4200Kcal/kg) lowers the business case for adoption of biomass as more business might be needed for same heat requirement leading to further challenges associated with supply chain and procurement
Process and Temperature Range (Degree Celsius)	A thorough literature review of international deployments featuring biomass utilization in industries reveals that majority of the installations have been commissioned for applications requiring steam at temperatures below 200 degrees Celsius
Deployments	Successful historical precedents with respect to existing installations also makes it viable for such industries to adopt biomass

6.5 Prioritization of MSME Clusters

Among the 15 most energy intensive sectors only 7 require low to medium grade heat.

The low to medium grade heat can be easily supplemented by biomass instead of fossil-based fuel common among MSMEs such as coal, coke, furnace oil, LDO, LSHS etc.

The 11 sectors where steam is used and could use biomass as source green heat/ steam generation are as follows and detailed analysis of these are presented in next sections:

Figure 15: Top 5 Industry for biomass mandate

1. Textile
2. Food Processing
3. Pharmaceutical
4. Pulp & Paper
5. Chemicals
6. Dairy
7. Ceramics
8. Leather & Footwear
9. Rubber
10. Aluminium Die Casting
11. Tea Processing

7 Technical Assessment, Economic and Financial Analysis

7.1 Review of Existing Boilers Used in the Select MSMEs for Industrial Steam Applications

7.1.1 Introduction and Classification of Boilers used in MSMEs

A boiler is an enclosed vessel that provides a means for combustion heat to be transferred into water until it becomes heated water or steam. The hot water or steam under pressure is then usable for transferring the heat to a process. Water is a useful and cheap medium for transferring heat to a process. When water is boiled into steam its volume increases about 1,600 times, producing a force that is almost as explosive as gunpowder. This causes the boiler to be extremely dangerous equipment that must be treated with utmost care.

The process of heating a liquid until it reaches its gaseous state is called evaporation. Heat is transferred from one body to another by means of (1) radiation, which is the transfer of heat from a hot body to a cold body without a conveying medium, (2) convection, the transfer of heat by a conveying medium, such as air or water and (3) conduction, transfer of heat by actual physical contact, molecule to molecule.

According to Indian Boilers Act, 1923 –

Boiler means a pressure vessel in which steam is generated for use, external to itself, by application of heat which is wholly or partly under pressure when steam is shut off but does not include a pressure vessel –

- *With capacity less than 25 litres (such capacity being measured from the feed check valve to the main steam stop valve)*
- *With less than one kilogram per centimetre square design gauge pressure and working gauge pressure; or*
- *In which water is heated below one hundred degrees centigrade*

The boilers are widely used across power sectors and in process plants for generation and for various process applications respectively

Power Sector	Process Plants
Independent Power Plant (IPP) and Captive Power Plant (CPP)	Paper and Pulp Industry, Chemical Industry, Food Processing, Dairy etc.

Boiler Systems

The boiler system comprises of:

1. Feed water system
2. Steam system
3. Fuel system

These are briefed below:

The **feed water system** provides water to the boiler and regulates it automatically to meet the steam demand. The water supplied to boiler that is converted to steam is called feed water. The sources of feed water are:

- Condensate or condensed steam returned from the processes
- Makeup water which is the raw water which must come from outside the boiler room and plant processes.

The **steam system** collects and controls the steam produced in the boiler. Steam is directed through a piping system to the point of use. Throughout the system, steam pressure is regulated using valves and checked with steam pressure gauges.

The **fuel system** includes all equipment used to provide fuel to generate the necessary heat. The equipment required in the fuel system depend on the type of fuel used in the system.

Boilers are widely used across the process industries for generation and for various steam applications. The multiple boiler designs and their classification on various criterions are presented below:

Classification of Boilers

Figure 16: Classification of Boilers

Content of tube

- Fire Tube Boiler
- Water Tube Boiler

Type of Firing

- Solid
  - ✓ Atmospheric fluidised bed combustion,
  - ✓ Circulating fluidised bed
  - ✓ Pulverized coal fired
- Liquid
- Gas
- Waste heat recovery boiler

Type of circulation

- Natural Circulations
- Controlled Circulations
- Forced Circulation

Steam Pressure

- Low-pressure
- Medium pressure
- High-pressure
- Sub-critical
- Super Critical

Draught Type

- Natural and
- Mechanized Draught (Forced, Induced and Balanced)

Some of the boiler technologies and its features are explained below:

Fire tube or "fire in tube" boilers: They contain long steel tubes through which the hot gasses from a furnace pass and around which the water to be converted to steam circulates. Fire tube boilers, typically have a lower initial cost, are more fuel efficient and easier to operate, but they are limited generally to capacities of 25 tons/hr and pressures of 17.5 kg/cm2.

Water tube or "water in tube" boilers in which the conditions are reversed with the water passing through the tubes and the hot gasses passing outside the tubes. These boilers can be of single- or multiple-drum type. These boilers can be built to any steam capacities and pressures and have higher efficiencies than fire tube boilers.

Packaged Boiler: The packaged boiler is so called because it comes as a complete package. Once delivered to site, it requires only the steam, water pipe work, fuel supply and electrical connections to be made for it to become operational. Package boilers are generally of shell type with fire tube design so as to achieve high heat transfer rates by both radiation and convection.

The features of package boilers are:

- ✓ Small combustion space and high heat release rate resulting in faster evaporation.
- ✓ Large number of small diameter tubes leading to good convective heat transfer.
- ✓ Forced or induced draft systems resulting in good combustion efficiency.
- ✓ Number of passes resulting in better overall heat transfer.
- ✓ Higher thermal efficiency levels compared with other boilers.

These boilers are classified based on the number of passes – the number of times the hot combustion gases pass through the boiler. The combustion chamber is taken, as the first pass after which there may be one, two or three sets of fire-tubes. The most common boiler of this class is a three-pass unit with two sets of fire-tubes and with the exhaust gases exiting through the rear of the boiler.

Stoker Fired Boiler: Stokers are classified according to the method of feeding fuel to the furnace and by the type of grate. The main classifications are:

- **Chain-grate or traveling-grate stoker:**
  Coal is fed onto one end of a moving steel chain grate. As grate moves along the length of the furnace, the coal burns before dropping off at the end as ash. Some degree of skill is required, particularly when setting up the grate, air dampers and baffles, to ensure clean combustion leaving minimum of unburnt carbon in the ash.

The coal-feed hopper runs along the entire coal-feed end of the furnace. A coal grate is used to control the rate at which coal is fed into the furnace, and to control the thickness of the coal bed and speed of the grate. Coal must be uniform in size, as large lumps will not burn out completely by the time, they reach the end of the grate. As the bed thickness decreases from coal feed end to rear end, different amounts of air are required-more quantity at coal-feed end and less at rear end.

- **Spreader stoker**
  Spreader stokers utilize a combination of suspension burning and grate burning. The coal is continually fed into the furnace above a burning bed of coal. The coal fines are burned in suspension; the larger particles fall to the grate, where they are burned in a thin, fastburning coal bed. This method of firing provides good flexibility to meet load fluctuations, since ignition is almost instantaneous when firing rate is increased. Hence, the spreader stoker is favoured over other types of stokers in many industrial applications.

Pulverized Fuel Boiler: Most coal-fired power station boilers use pulverized coal, and many of the larger industrial water-tube boilers also use this pulverized fuel. This technology is well developed, and there are thousands of units around the world, accounting for well over 90% of coal-fired capacity.

The coal is ground (pulverised) to a fine powder, so that less than 2% is +300 micro metre (μm) and 70-75% is below 75 microns, for a bituminous coal. It should be noted that too fine a powder is wasteful of grinding mill power. On the other hand, too coarse a powder does not burn completely in the combustion chamber and results in higher unburnt losses.

The pulverised coal is blown with part of the combustion air into the boiler plant through a series of burner nozzles. Secondary and tertiary air may also be added. Combustion takes place at temperatures from 1300-1700°C, depending largely on coal grade.

Particle residence time in the boiler is typically 2 to 5 seconds, and the particles must be small enough for complete combustion to have taken place during this time.

This system has many advantages such as ability to fire varying quality of coal, quick responses to changes in load, use of high pre-heat air temperatures etc. One of the most popular systems for firing pulverized coal is the tangential firing using four burners corner to corner to create a fireball at the centre of the furnace.

Fluidized Bed Combustion (FBC) Boiler: When an evenly distributed air or gas is passed upward through a finely divided bed of solid particles such as sand supported on a fine mesh, the particles are undisturbed at low velocity. As air velocity is gradually increased, a stage is reached when the individual particles are suspended in the air stream. Further, increase in velocity gives rise to bubble formation, vigorous turbulence and rapid mixing and the bed is said to be fluidized. If the sand in a fluidized state is heated to the ignition temperature of the coal and the coal is injected continuously into the bed, the coal will burn rapidly, and the bed attains a uniform temperature due to effective mixing. Proper air distribution is vital for maintaining uniform fluidisation across the bed.). Ash is disposed by dry and wet ash disposal systems.

- ➢ **Atmospheric FBC** - Bed material used are crushed refractory of size varying of 0.8 mm to 2.8 mm. The air velocity is maintained at 3-5 m/sec. The combustion efficiency is around 80-85%
- ➢ **Circulating FBC** - Bed material used are crushed refractory of size varying of 0.8 mm to 2.8 mm. The air velocity is maintained at 7-8 m/sec. The combustion efficiency is around 95%.
- ➢ **Pulverised Coal Fired** - The combustion efficiency is 99%. These boilers do not require bed. The coal fired in the boiler is of F Grade (3000-3500 kcal/kg). The size varies from 65p to 80μ.

Fluidised bed combustion has significant advantages over conventional firing systems and offers multiple benefits namely fuel flexibility, reduced emission of noxious pollutants such as SQx and NOx, compact boiler design and higher combustion efficiency.

The details of boilers being used in various industries is presented in the next section.

Boilers used in Industries

Based on our study and consultation with various industries like pharmaceuticals, paper and pulp, food processing etc., the details of type of boilers deployed in industries, are presented below:

Pharmaceutical industry deploys Steam boilers. They are crucial in the drug manufacturing industries for sterilizing, purifying, and drying. Steam boilers are essential to ensure precision in the compiling of the components in the manufactured drug. Clean Steam or Pure Steam is of vital importance for the superior quality of the drugs produced. Fuel used in such boilers are either solid fuel (coal, wood, briquettes etc.), oil fired (Light Diesel Oil, High-Speed Diesel, Furnace Oil) or multi-fuel.

Paper and Pulp industry also uses steam boilers. As they require a considerable amount of energy, paper processing plants have switched to power generation boilers that aid them in generating both steam and electricity. The steam is essential in paper processing for operations such as debarking and chipping, digesting, and washing, pulping, bleaching and paper drying. Fuels like wood chips, wood logs, sawdust, and agro waste are used in paper and pulp process plants.

7.1.2 Type of Boilers Used in Select MSME Clusters

Boilers play a crucial role in a wide range of industries by providing a reliable and efficient source of heat or steam generation. Their primary function is to convert water into steam, which can then be used for various industrial processes. Boilers are essential to the efficient and continuous operation of many industrial processes. The choice of boiler type, size, and design depends on the specific requirements of the industry and the intended application, and it plays a vital role in the overall efficiency and productivity of industrial operations.

There are many factors to consider when deploying a boiler for a process plant. These factors include the plant's steam requirements, the fuel type that will be used, and the environmental regulations that apply to the area. It is important to consider various factors to ensure that the right boiler is being deployed for the application.

The following are the most essential factors to be considered before Boiler selection:

- **Net Steam flow requirement(in kgs or ton per hour)**: Determining the capacity of the boiler is very important for optimum production and can be determined by evaluating proper heat/steam loads based on the process parameters of the product to be manufactured.
- **Pressure required for Process(in kg/cm2)**: Determining the amount of the pressure required by the process is important as it pays back to the company immediately in terms of cost of per Kgs Steam produced, thereby improving the operation efficiency of the unit.
- **Availability of fuel**: Fuel selection is the most important factor and should always be based on current and future fuel supply, as well as the area's emission standards, so that pollution equipment may be ordered appropriately.

Boilers deployed across industries is presented below:

i. Textile Industry

Boilers are an essential part of the Textile industry. The textile manufacturing industry requires an uninterrupted supply of hot water and steam. Steam is integral for various purposes of heating, drying, processing, sterilizing, etc. The textile industry is one such example that requires steam for its major processing stages.

Majority of the textile units use **Steam Boilers,** which plays a significant role in the manufacturing of textile. Steam Boiler is widely used for:

- Pre-treatment
- Dyeing
- Printing and finishing

Steam boilers are indispensable in textile processing as the major process operations depend on steam or hot water generated from boilers. Textile processing units consider every factor before selecting a steam boiler that meets their demands effectively.

Packaged steam boiler is used to generate wet steam required for the process in textile units. Steam is used at a working pressure of 4-5 kg/cm2. Generally, pet-coke is used as the fuel for the steam boiler. **The heating chamber consists of a fluidized bed wherein air is supplied from bottom.** The heat generated by combustion of coke and air is used to heat water to form steam. The steam generated is used in various processes across the unit. The steam boiler operating in the unit is a packaged boiler with **water tube design**. Steam is the main agent of energy used in the textile processing unit. Thus, the boiler is the major energy utilizing source in these units.

The steam requirements in textile process operations are fluctuating and require robust steam boilers that can effectively handle the changing demands. In such situations, steam boilers with a quick start or shut-off are best-suited for processing. Comparatively, water tube boilers perform better than fire tube boilers with the fluctuating load.

Some use cases are presented below:

Panipat Textile Cluster

The most common capacity of the steam boiler in the cluster is 1.5 tonne per hour (tph) used mainly by micro and small enterprises. Most of the boilers are three pass, solid fuel fired boilers. Few smaller units use single pass boiler, which exhibit higher heat losses and poor quality of steam. Micro and small units use biomass (wood, upla) as fuel in boilers; medium size units are using wood and pet coke as fuel. The boilers are operated at 6.5–10 kg/cm2 drum pressure whereas the end use steam pressure requirement is 3.5–4 kg/cm2. Some of the boilers have economizer to recover the heat from waste flue gases. Few units also using thermic fluid to generate hot water as well as steam at 3.5–4.0 kg/cm2 pressure to cater to the intermittent steam requirement of the process.

Surat Textile Cluster

The Surat Textile cluster units require significant quantum of thermal energy in the form of steam and electricity. At present, the steam is generated in low pressure boilers and coal is used as fuel. Majority of the units deploy steam boilers. The maximum capacity of the steam boiler in the cluster is up to 15 TPH capacity (maximum units are using 3 to 5 TPH capacity steam boilers in the cluster). Lignite and imported coal are used in boilers for steam generation. Natural gas is used in Stenter's (for heat setting) and natural gas-based generators.

ii Food Processing

Heat is a heart of industrial food processes. The food industry needs heat at every stage of the process. Direct heat or heat from the hot water is an essential factor of food processing industry. **The food processing industry also uses steam boilers for its various processes**.

Boilers generate steam that aids in the cooking, sanitizing, processing, and packaging in the food industry. Processing in this industry takes place by direct heating or heating through hot water. Food processing industries generally use coals, natural gas, liquid fuel, and biomass as the fuels in the steam boiler.

The food processing sector requires various types of steam for different purposes. Here are some of the steam types that aids the processing of food,

Plant steam: Plant steam, in other words, is the usual steam generated in the boilers by the burning of fuels. Plant steam does not come in direct contact with the food items and is instead used for indirect heating purposes.

Culinary steam: This type of steam is administered directly to the food, and therefore, it is purified before utilization.

Pure steam: Pure steam is free of any contaminated particles and is generally used for sterilization and disinfection purposes.

As steam is paramount for the food industry, steam boilers serve various purposes in the sector. Some of them are as follows:

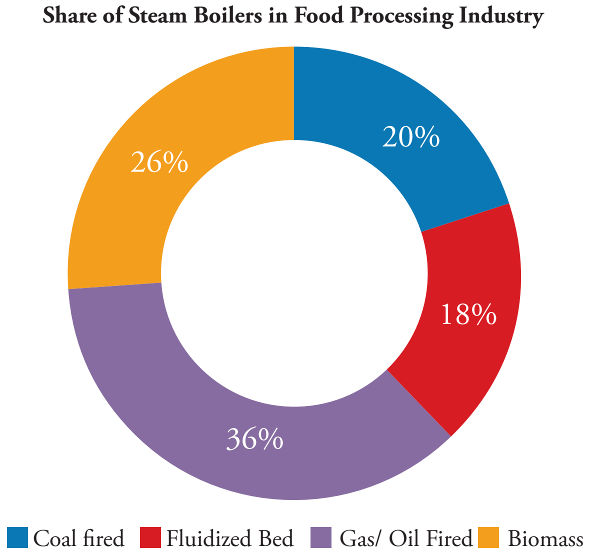
- Cooking and drying
- Sterilizing the process plants
- Packaging

These food industry boilers generally use fossil fuels to produce heat & hot water for cleaning and cooking purpose. The fuels used in the boilers to generate steam:

- Coal
- Natural gas
- Fuel oil
- Biomass

The food processing industry deploys various types of steam boilers such as, coal fires, gas/ oil fired, biomass etc. The percentage share of boilers deployed in the food processing industry is presented below. As per the data, it is evident that the industry is extensively using biomass-based steam boilers for their heating applications.

Figure 17: Share of Steam Boilers in Food Processing Industry



iii Pharmaceutical Industry

Pharmaceutical industry deploys **Steam boilers**. They are crucial in the drug manufacturing industries for

- sterilizing,
- purifying, and
- drying.

Steam boilers are essential to ensure precision in the compiling of the components in the manufactured drug. Clean Steam or Pure Steam is of vital importance for the superior quality of the drugs produced. Fuel used in such boilers are either solid fuel (coal, wood, briquettes etc.), oil fired (Light Diesel Oil, High-Speed Diesel, Furnace Oil) or multi-fuel.

Clean steam is produced from uncontaminated water that is free of additives such as amines. It is mainly because the disinfection and sterilization process must be absent of any form of contamination that may hamper the quality of the manufactured product. Apart from these, clean steam is required for a sterile surrounding to encourage the growth of yeasts or cells. It is also required for the processing of eye or ear drop solutions.

Pharmaceutical industries generally use Solid Fuel Boilers, Oil fired Boilers, and Multi Fuel Boilers for manufacturing depending on their requirements.

- **Solid Fuel Boilers**: Solid fuel steam boilers are efficient and economical compared to other types of boilers and burn on fuel like wood, coal, wooden chips, briquettes, etc.
- Solid fuel boilers are beneficial because of their low operating costs, range of fuel choice, and optimum efficiency. Solid fuel boilers are used for manufacturing generic medicines, IV fluids, capsule covering, and so on.
- **Oil fired Boilers:** Oil fired boilers are an ideal choice where there is low availability of Natural Gas and Solid Fuels. Oil fired boilers are highly effective with optimal combustion and work with fuels like Light Diesel Oil, High-Speed Diesel, Furnace Oil, Low Sulphur Heavy Stock, and Industrial Diesel Oil.
- In drug manufacturing, it is mainly utilized for sterilization, disinfection, and mixing of components.
- **Multi fuel Boilers:** As the name suggests, multi fuel boilers work with various types of fuels. Multi fuel boilers are efficient and reliable, and mainly used in manufacturing products like tablets, medicinal syrups, injections, and ointments.

Some use cases are presented below:

Dehradun Pharma Cluster

Boiler is used for generation of steam and hot water for process requirements. Coil type vertical baby boilers are used in the cluster. Steam is generated at a pressure of about 8-10 kg/cm2 (g). The average capacity of boilers used in pharma units of cluster is 1 tonne per hour (tph). The boilers are generally LPG or LDO fired. Majority of the boilers do not have air to fuel ratio controller or burner system to maintain the optimum combustion. A forced draught fan is used for supply of combustion air and oil pump is used to provide fuel in case of LDO fired boilers. The average operating hours of boiler is estimated to be 8–12 hours per day. Steam is used mainly for drying purposes in formulation and is used in coils to provide indirect heating in fluidised bed dryers and tray dryers.

iv. Paper and Pulp Industry

Paper and Pulp industry also uses steam boilers. As they require a considerable amount of energy, paper processing plants have switched to power generation boilers that aid them in generating both steam and electricity. The steam is essential in paper processing for operations such as

- debarking and chipping,
- digesting, and
- washing,
- pulping,
- bleaching and
- paper drying.

Fuels like wood chips, wood logs, sawdust, and agro waste are used in paper and pulp process plants.

Reciprocating grate firing systems are common popular combustion technology for burning biomass fuels. The pulp and paper industry is a significant producer of renewable energy. The plant receives biomass feedstock in the form of wood chips, sawdust, and logs. Some mills process agro-waste.

Reciprocating grate boilers are suitable to burn a range of biomass fuels. The fuel moves progressively within the combustion chamber. The primary air is forced into a plenum under the reciprocating grate to encourage drying and gasification of the fuel. The secondary air is fed through high-velocity jets placed over the grates across the combustion chamber to promote complete oxidation of the flue gas.

Some use case is presented below:

Muzaffarnagar paper cluster

Paper units have installed steam boilers to meet the steam demand of the paper unit. If the unit has captive thermal power generation facility, the steam demand is met through the cogeneration system installed. In other mills where the electricity is supplied through grid, low or medium pressure boilers are installed for steam generation. Medium scale Agro based mills and all the RCF (Recycled Fiber Based Mills) based industries depend on the Biomass fuel readily available locally like Bagasse, Firewood chips, wood dust, husk etc for generation of steam. For the steam requirement these mills use biomass, based on availability and the technology used in the boilers. On an average about 60% -70% energy requirement is met from biomass rest 30%-40% is met with Coal.

v. Chemical Industry

Various sectors such as oil refining, energy, medicines, military, petrochemical, food processing, etc., depend on the chemical industry.

Chemical industry also deploys Steam Boiler for their steam requirement. Steam is extensively useful in chemical processing for various operations ranging from heating fluids to driving equipment. Chemical industries require an ample amount of high-temperature steam for effective operations. Secondly, chemical industries tend to generate a large number of emissions and waste heat. The steam boiler system that generates the steam from water comes in many different varieties and sizes.

Steam boilers depend on the combination of radiant and convective heat transfer, consisting of a furnace section and steam-containing parts. A lower mean temperature difference between the hot gas and the steam generally requires an increase in the surface of tubing and boiler weight. High-temperature boilers need special alloys like nickel-based for their hot section.

Boilers play a vital role in both the processing operations of chemicals and for the process plant itself. The main functions of a boiler in the chemical plant are,

- Heating and Cooling Reactors
- Disinfecting and Sterilizing
- Heating and Cooling of Process Plant

Among various types of designs in steam boilers for the chemical industry, a commonly used configuration uses a steam drum. It involves the water entering the boiler through the economizer and passing to the steam drum. The water passes through the down comers to the lower inlet water-wall headers, rises through the water walls, and changes to steam due to the heat generated. The steam enters the steam drum and moves through multiple steam and water separators and dryers in the steam drum. It eliminates the water droplets from the steam and the cycle. Forcing the water into the steam boiler requires a special set of feedwater pumps.

Another variant is a basic design termed once-through boilers. The system does not include a steam drum. The water travels through the economizer, the furnace wall tubes, and the super heater section in a continuous pass without recirculation. A set of feedwater pumps supplies the required force for the flow through the steam boiler.

Two of the most preferred boilers used are:

Fluidized Bed Combustion Steam Boiler Steam Boilers with Fluidized Bed Combustion or FBC are an ideal choice since it has a large capacity of generating steam (approximately 10 to 280 tons per hour) that helps in the hassle-free operation of chemical plants. Secondly, it is effective for the proper combustion of fuels like coal and biomass that result in meeting the high heat demands, saving excess cost and energy.

Waste Heat Recovery Boilers As chemical industries generate ample amounts of waste heat, the ideal boiler for chemical plants is Waste Heat Recovery Boiler. The system would extract the excess heat and reuses it for other process operations or power generation, thus ensuring optimal use of heat energy and preventing harmful emissions in the environment.

7.1.3 Details of Current Fuels Used for Steam Applications

This section presents the detailed analysis of the select industry and analysis of fuel types being used in the industry. The section also presents actual situation in the various clusters as use cases to understand the fuel consumption pattern and identify opportunity to use biomass for steam generation.

7.1.3.1 Textile Industry

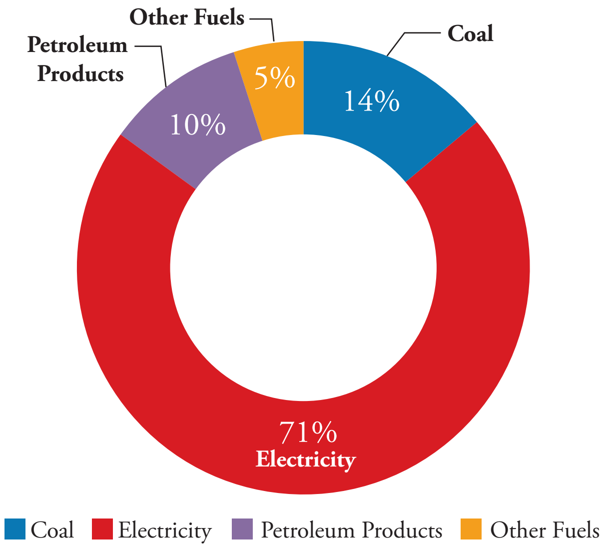
Fuel Consumption and Price Economics

The Indian textile industry stands as one of the largest and most established sectors in the country, playing a pivotal role in the economy regarding its contribution to output, investment, and employment. It comprises key sub-sectors, including spinning, processing, and weaving. Presently, the industry predominantly relies on oil-based products and lignite for its energy needs, serving various processes.

In the fiscal year 2021, the textile industry accounted for a modest 0.73% of the total industrial energy consumption, signifying its status as a moderately energy-intensive sector. According to the MOSPI Energy Statistics for 2022, the textile industry consumed 55 thousand joules equivalent (KJE) of oil products and 308 thousand tons of oil equivalent (KTOE) of coal in the same fiscal year.

The sector currently operates with a network of over 20,000 factories, which utilize energy to generate the heat necessary for their processes. This is achieved through the combustion of conventional fuels, including relatively expensive options such as lignite, high-speed diesel, light diesel oil, fuel oil, and coal, known for their higher gross calorific values (GCV). The overall cost of fuel consumption in the industry exhibits a trend, which is depicted below.

Figure 18: Trend for overall cost of fuel consumption



Cost of Fuel Consumption

The cost analysis indicates that the textile industry currently spends approximately Rs 16.08 million per factory unit on conventional fuel consumption. This cost falls within the moderate energy price range compared to other industry sectors.

GCV Values of Fuel Consumption

The textile industry has substantial energy demands, primarily relying on lignite fuels with a gross calorific value (GCV) of 4,000 Kcal/kg. All the energy needs within the plants are satisfied using conventional fuels. Thermal energy requirements are fulfilled using oil-based fuels, which have minimal ash content and a sulfur content falling within the range of 2-4%. However, there is a potential risk of corrosion due to the formation of sulfuric acid during combustion.

Internal Industrial Process Mapping and Deployments

The major process involves weaving (warping, sizing, winding and weaving) and spinning (preparatory steps and final spinning). The sizing step of the weaving process requires hot water at a temperature of 80-85°C.

Figure 19: Internal industrial process for textile industry

Desizing	Scouring	Bleaching	Mercerizing	Finishing
Up to 90°C	90°C to 110°C		60°C to 70°C	40°C to 100°C

Assessing Potential for Biomass-cofiring for Green Heat/ Steam Generation

Economically, the adoption of biomass in the textile industry appears favorable, given the significantly high current fuel consumption costs. According to data from MOSPI, the use of coal and lignite has been on the decline over the years. However, various factors, such as the total heat requirements, internal processes, gross calorific value (GCV) criteria, and historical practices, suggest limited potential for adoption.

Although the cost of conventional fuel usage is the lowest among all industries, other considerations, including low heat requirements, GCV alignment with biomass, internal processes demanding temperatures below 100°C, and existing deployments, all make a compelling case for biomass utilization in these sectors.

Taking into account the cumulative influence of these parameters, it is evident that the textile industry holds significant potential for biomass-based co-firing operations. This conclusion is further supported by consultations with key boiler industry players and sector experts, who identify the textile industry as a high-potential sector for biomass integration.

Fuel usage and energy scenarios for some clusters are presented below

Panipat Textile Cluster

Panipat textile cluster, located in the state of Haryana involved in the business of blankets which expanded very fast, and in due course, Panipat became famous for blanket market. Panipat accounts for about three-fourth of total blankets produced in the country. The textile units are involved in manufacturing of cotton durries, carpets (woollen, cotton based and synthetic); furnishings (bed covers, cushion covers, mats, etc.), woollen blankets, and cotton and woollen yarns. Most of the manufacturers are concentrated in industrial areas in Haryana Urban Development Authorities (HUDA) in Sector 25 (I & II) and Sector 29 (I & II) and Panipat industrial area. The other enterprises including job work units are primarily located in and around Panipat Town.

There are about 8500 organized & unorganized industries operating representing various sectors including textile. Out of these, there are about 4600 micro, small, and medium enterprises (MSMEs) in the Panipat textile cluster with more than 70% of the industries are involved in home furnishing. About 65% of the units fall under micro category. The breakup of textile units operating in the cluster is given in the following table. Classification of the textile units in Panipat is based on product manufacturing, and investment towards plant and machinery is shown in the figure below.

Table 12: Classification of units in Panipat textile cluster

Category	Total
Home Furnishing & Floor covering	3260
Dyeing and printing	720
Yarn processing/looms	620
Total	**4600**

Energy scenario in the cluster

The primary source of energy for boilers & TFH is biomass consisting of wood chips, bagasse. Earlier industries were using pet coke as fuel which is banned due to pollution issues. Few units are also using PNG for hot air generation in stenter, dryers. Additionally, electrical is secondary source of energy for operating electrical utilities such as pumps, motors, compressors etc.

The cluster has an estimated overall energy consumption of 396288 tonne of oil equivalent (toe) per annum leading to carbon emissions of 12.82 Lakh tonnes of CO_2.

Table 13: Estimated overall energy consumption and CO_2 emissions

Production category	Electrical energy, Million kWh/year	Thermal energy, toe/year	Total energy, (toe/year)	Total CO_2 emissions, (t CO_2/year)
Home furnishing & Floor covering	93	230736	238728	783732
Dyeing and printing	20	154607	156341	484721
Yarn processing/looms	14		1219	13605
Total	**127**	**385343**	**396288**	**1282057**

The home furnishing & floor covering units consumes about 60% of the total energy consumption of the cluster, which is mainly due to use of the thermal energy in dyeing, aging, washing, and printing as well as electrical heating system in polishing section.

The thermal energy accounts for about 90-95% of total energy consumption in the cluster for biomass (bagasse, wood chips, upla), diesel, PNG consumption. Higher thermal energy consumption may be attributed to factors such as large heating requirement during the dyeing, printing, aging, and drying process. The share of the grid electricity and backup power generation is less than 5-10%.

The cluster is already using biomass for its thermal requirement. Textile processing units are equipped with boilers which are typically fired using solid fuel i.e., biomass (Bagasse, Wood Chips). most of the units fail to maintain the correct amount of air in the combustion chamber, required for optimum combustion. This leads to incomplete combustion with a significant percentage of the heat loss through dry flue gas loss.

Surat Textile Cluster

One of the largest textile manufacturing clusters in India is located in Surat (Gujarat). The Surat cluster accounts for over 18% of the total manmade (synthetic) fibre exports and 40% of manmade fibre production in the country. The products primarily comprise synthetic sarees & dress materials and cotton dress materials. There are about 400 textile processing units in the cluster, operating over 600,000 power looms.

Large number of small and medium textile processing units are located in Surat. The cost of energy as a percentage of manufacturing cost varies anywhere between 12% to 15%. Majority of the industries located in Surat are of wet process and a very few units are engaged in the production of grey fabric with power looms. Wet process requires high amounts of thermal energy in the form of hot water and steam, inducing a high share of energy cost. The energy cost is next to the raw materials cost. Processing is the weakest link in the supply chain of textile industry. Majority of the industries in the cluster units are dependent on local technologies of low end and with little investment initiatives and technology up-gradation. The units started recently employing latest technologies and equipments for better quality, production and efficiency. These units are in Palsana industrial area.

Out of 400 textile units, one hundred and forty-six (146) units are of small scale, one hundred and sixty-eight (168) are medium size and the balance eighty six (86) units fall under large scale category.

Table 14: Classification of clusters based on micro, small, medium and large

Category	Numbers
Small	146
Medium	168
Large	86
Total	**400**

Around 37% of the total units are small whereas 42% are medium units in the Surat Textile Cluster.

Also, in Surat Textile Cluster, out of 400 units, about 70 units are having only dyeing facility, 330 units are of integrated type having both dyeing and printing facilities.

Figure 20: Classification of Units in the Cluster

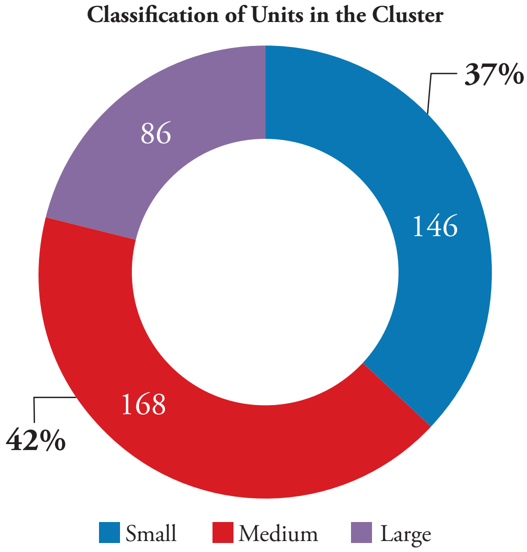
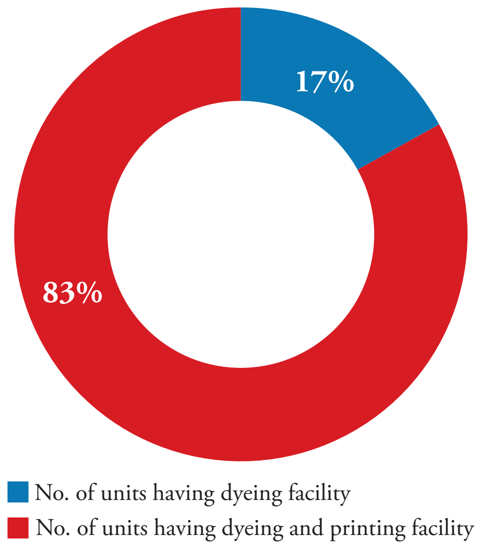


Figure 21: Classification of units having dyeing and printing facility



Energy Scenario in the Cluster

The cluster units require fuels and electricity for sourcing, dyeing, printing and weaving. Heat is used for scouring, dyeing and printing process for application and dye fixation. Electricity is required for operating the electrical motors and lighting. The major fuels used in the cluster units are Imported Coal, Lignite, Natural gas and Biomass (Groundnut husk briquettes and Wood).

The major fuels used in the cluster units are:

Table 15: Major fuels used in the Surat textile cluster

S. No.	Fuels Used
1	Lignite
2	Imported coal
3	Natural gas
4	Biomass (Groundnut husk briquettes & Wood)
5	Electricity

The main energy forms used in a typical unit of the cluster are electricity, natural gas, lignite, biomass materials such as non-renewable wood and imported coal. Electricity is used for driving the prime movers of pumps, fans, drives, and for lighting. Lignite and imported coal are used in boilers for steam generation. Natural gas is used in Stenter's (for heat setting) and natural gas-based generators.

The annual consumption of fuels and electricity of the total cluster units are

Table 16: Annual consumption of fuels and electricity

Type of energy	Annual Consumption	Tons of Oil Equivalent (TOE)
Electricity	725.7 GWh	62,411
Natural gas	3,147 lakh scm	2,83,230
Imported Coal	23, 00,972 tons	9, 43,398
Total		**12, 89,039**

The majority units of the cluster use lignite and imported coal as fuel for boilers and thermic fluid heaters. The coal consumption in cluster units varies from 1800 to 19000 tons per annum depending on production capacity and production facilities of the plant. Natural gas is used in stenters, printing, loop machine, and zero-zero machines and also used in generators for electricity generation. The natural gas consumption varies from 1.66 lakhs SCM to 16.41 lakhs SCM per annum depending on the production capacity and equipments installed.

The cluster presents huge opportunity for the units to use biomass for their steam requirement as the cluster is highly dependent on lignite and imported coal.

7.1.3.2 Food Processing Industry

Fuel Consumption and Price Economics

India's food processing sector ranks among the world's largest and is on a consistent growth trajectory, averaging an annual rate of approximately 11.18%. It is anticipated to reach a substantial valuation of $535 billion by the fiscal year 2025-26. The industry exhibits a high degree of fragmentation, encompassing various sub-segments, including fruits and vegetables, sugar, edible oil, beer and alcoholic beverages, meat and poultry, grains, packaged or convenience foods, and packaged beverages.

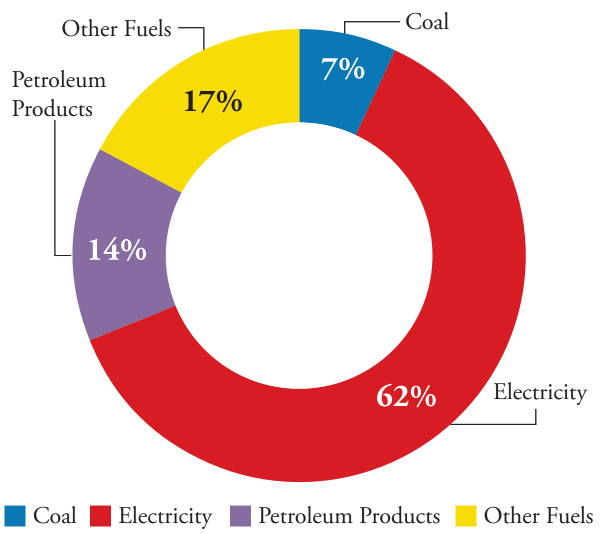
The sector's expansion is closely linked to the escalating demand for energy consumption, with both heat and electricity being imperative for its internal operations. The overall heat demand for the industry is relatively modest, standing at 2.02 Giga Calories, owing to the relatively low energy-intensive nature of its internal processes.

Concerning the present fuel consumption, the industry predominantly relies on a mix of coal, gas, diesel oil, electricity, and biomass to fulfill its energy requirements. Key heat treatment processes like pasteurization, sterilization, and food preservation through methods such as drying, freezing, chilling, packaging, and canning are common across major sub-segments. These processes account for the majority of the energy consumption within the food processing industry.

Currently, more than 25,017 operational factories in the sector maintain energy costs at a nominal level. This is primarily because the industry does not demand high-grade coal or other fuel options with elevated gross calorific values, unlike some other industrial sectors. Notably, several players in the food processing and brewery sectors have already adopted alternative energy sources, such as biomass (paddy husk-based) or concentrated solar thermal (CSTs), to fulfill their process heating requirements.

The trend for overall fuel consumption for the industry has been illustrated below.

Figure 22: Overall fuel consumption for the Food processing industry



The cost analysis reveals that Food Processing industry is currently paying a price of Rs 4.9 million per factory unit for conventional fuel usage annually, which is the lowest across all industry sectors, owing to the minimal need of high-grade coal for fuel sourcing.

GCV Values of Fuel Consumption

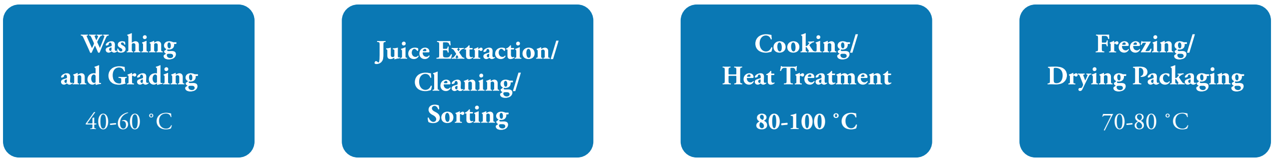
The food processing industry is characterized by its low energy intensity, as the majority of its operations are conducted at temperatures below 100°C. In terms of fuel usage, the industry relies on a gross calorific value (GCV) of approximately 2020 Kcal/kg, while the food processing industry's GCV for fuel usage falls within a similar range, at less than 3000 Kcal/kg.

Internal Industrial Process Mapping and Deployments

The key internal processes involved in food processing and brewery industry have been presented below:

- **Food Processing Industry (Fruits and Vegetable)**

Figure 23: Internal process mapping for Food Processing Industry (Fruits and Vegetable)



The food processing industry stands out for its minimal energy requirements, as the majority of its operations are conducted at temperatures below 100°C. Both the brewery and food processing sectors use fuels with a gross calorific value (GCV) that falls within a comparable range, with the brewery industry using approximately 2020 Kcal/kg and the food processing industry utilizing fuels with a GCV of less than 3000 Kcal/kg.

Assessing Potential for Biomass-cofiring for Green Heat/ Steam Generation

Although the cost of using conventional fuels is the lowest across all industries, several other factors strongly favour the adoption of biomass in such sectors. These factors include a low heat requirement, a gross calorific value (GCV) of fuel usage comparable to that of biomass, internal processes that operate at temperatures below 100 degrees Celsius, and existing deployments of biomass solutions.

When considering the cumulative impact of these factors, it becomes evident that the food processing industry holds significant potential for biomass co-firing operations. This conclusion is further substantiated by consultations with key players in the boiler industry and experts within the sector, all of whom identify the food processing industry as a high-potential sector for the deployment of biomass solutions.

7.1.3.3 Pharmaceutical Industry

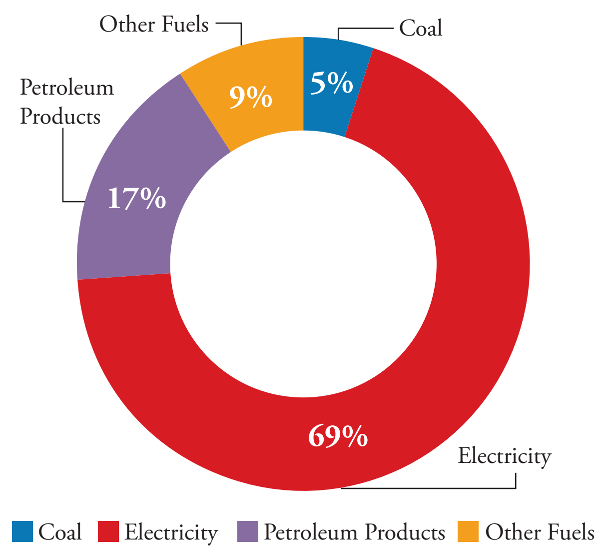
Fuel Consumption and Price Economics

The Indian pharmaceutical industry holds a prominent position on the global stage, ranking third in production volume and 14th in terms of domestic consumption value. According to ASI data from 2018-19, there are a total of 5,161 pharmaceutical companies in India, with approximately 4,434 of them currently operational. In the same fiscal year, the ASI reported a total fuel consumption value of Rs. 105,506,368 Thousand within the pharmaceutical industry.

Regarding the industry's current fuel usage, it primarily relies on petroleum products and coal to meet its heating requirements. In FY 2018-19, the sector accounted for the consumption of 1,075 thousand tonnes of coal and incurred an expenditure of Rs. 17,678,083 Thousand on petroleum products.

To understand the cost allocation among the various fuels used in the sector, the quantities of fuels utilized (sourced from ASI's 2018-19 database) were considered alongside their respective monetary values. The distribution of cost shares is illustrated in the accompanying graph.

Figure 24: Overall trend for fuel consumption in Pharmaceutical industry



The cost analysis reveals that the industry is currently paying a price of ~Rs 21.7 million per factory unit for conventional fuel usage, which lies in the moderate energy price range across all industry sectors.

GCV Values of Fuel Consumption

The pharmaceutical industry has substantial heat and steam demands, necessitating fuels with a gross calorific value (GCV) ranging from 4,000 to 5,000 Kcal/kg, as indicated by consultations with several pharmaceutical companies. The entirety of the energy requirements within pharmaceutical plants is currently fulfilled using conventional fuels. Solid fuels such as wood, coal, wood chips, briquettes, and liquid fuels like Light Diesel Oil, High-Speed Diesel, Furnace Oil, Low Sulphur Heavy Stock, and Industrial Diesel Oil are employed in the boilers to generate the steam required by the pharmaceutical industry.

Internal Industrial Process Mapping and Deployments

Pharmaceutical manufacturing encompasses multiple stages, including milling, blending, granulation, coating, drying, encapsulation, and tablet pressing, all of which necessitate operating temperatures below 120 degrees Celsius. These processes make use of fuels with moderate calorific content to meet their energy requirements.

The pharmaceutical sector employs both electrical and thermal energy in various phases of its operations. Consequently, there is significant potential for substituting conventional energy sources with biomass, particularly for thermal energy needs, which can be achieved more economically and feasibly than for electrical energy. Most thermal energy applications within pharmaceutical facilities involve lower temperature ranges, which are readily attainable. A process-wise breakdown is provided below for reference:

Figure 25: Internal process mapping for Pharmaceutical industry

Distillation
50-80 °C

Evaporation
>120 °C

Evaporation
>120 °C

Assessing Potential for Biomass-cofiring for Green Heat/Steam Generation

The pharmaceutical industry typically utilizes coal with an average gross calorific value (GCV) ranging from 3200 to 4000 Kcal/kg. Biomass, on the other hand, possesses a lower GCV, averaging between 3000 and 3300 Kcal/kg. The reduced GCV of biomass results in greater fuel consumption, leading to increased ash deposition and higher costs for treatment.

From an economic perspective, there is a compelling case for the adoption of biomass within the industry. The current cost of conventional fuels, primarily coal, is notably higher compared to the average cost of biomass pellets and briquettes available in the market. The relatively low temperature requirements for generating heat in the form of steam during various processes can be readily met by burning biomass, albeit with a higher consumption of biomass raw material compared to coal.

Taking into account the collective impact of these factors, it is evident that the pharmaceutical industry holds substantial potential for biomass-based co-firing operations. This conclusion is further substantiated by consultations with key players in the boiler industry and industry experts, some of whom have already transitioned to biomass-based boilers, covering a significant portion of their steam requirements, ranging from 20% to 30%.

Fuel Usage and Energy Scenarios for Some Clusters are Presented Below

Dehradun pharmaceutical cluster[24]

Dehradun is capital city of the state of Uttarakhand in Northern India. The pharmaceutical cluster is located at about 25 kilometers from Dehradun known as "Pharma City" in Selaqui industrial area. The industrial is area is spread in about 50 acres of land. The pharmaceutical industries were set up during 2003-04 when a policy stimulus package including new industrial policy and other concessions were announced for the state of Uttarakhand.

The units in the cluster are mainly engaged in production of allopathic formulation in various dosage forms such as tablets, capsules and liquid orals. About 52 pharmaceutical units are situated in the cluster of which more than 30 units belong to small scale category. About 5 cluster units come under large scale.

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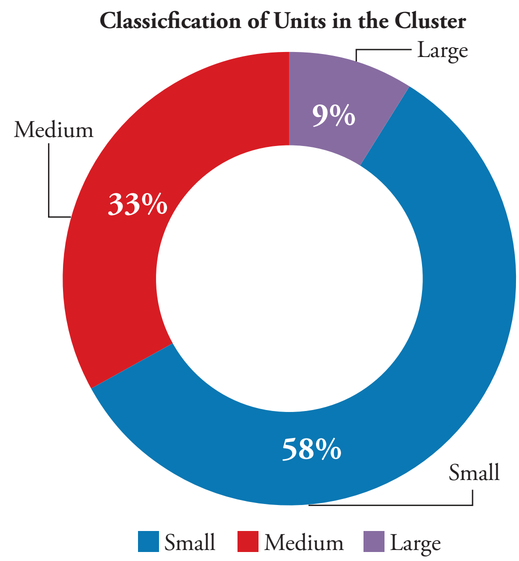
Table 17: Classification of units in Dehradun pharmaceutical cluster

S. No.	Category	Units
1	Small	30
2	Medium	17
3	Large	5
Total		**52**

In the cluster, around 58% units falls under small category and 33% are medium category.

The major product of the cluster is allopathic formulation in various dosage forms such as tablets, capsules, liquid orals, ointments and injectable. The cluster falls within the Doon valley region, as such the production of bulk drug is restricted by the state environment protection and pollution control board. The tablets are produced by direct compression, dry granulation and wet granulation process.

Figure 26: Classification of Units in the Dehradun Pharma Cluster



The cluster uses various fuels for its energy use. The different fuel and energy types used in the cluster are shown below.

Table 18: Various fuels for its energy use in Dehradun Pharma cluster

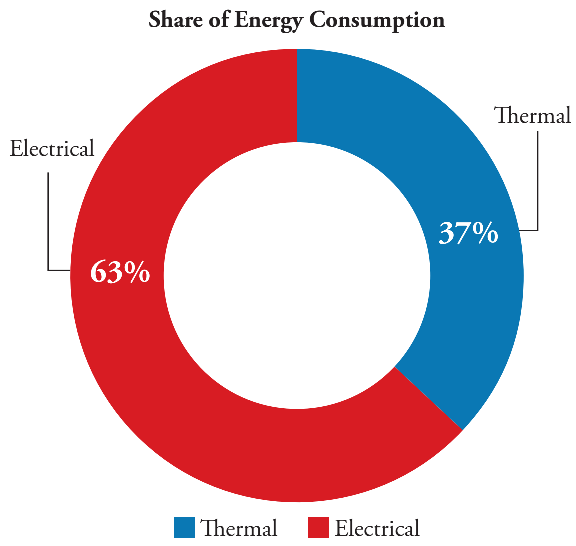
S. No.	Types
1	HSD/ LDO
2	LPG
3	Electricity

Boiler is used for generation of steam and hot water for process requirements. Coil type vertical baby boilers are used in the cluster. Steam is generated at a pressure of about 8-10 $kg/cm^2(g)$. The average capacity of boilers used in pharma units of cluster is 1 tonne per hour (tph). The boilers are generally LPG or LDO fired. Majority of the boilers do not have air to fuel ratio controller or burner system to maintain the optimum combustion. A forced draught fan is used for supply of combustion air and oil pump is used to provide fuel in case of LDO fired boilers. The average operating hours of boiler is estimated to be 8–12 hours per day. Apart from pressure gauge and water level controller, the boiler system have not been equipped with any instrumentation for monitoring and control of operating parameters. The units also do not collect condensate, which is generally drained out. Steam is used mainly for drying purposes in formulation and is used in coils to provide indirect heating in fluidised bed dryers and tray dryers.

Energy Consumption

The major energy forms used by pharmaceutical units in Dehradun Pharma cluster include electricity, LPG and HSD/LDO. Electricity from grid is used for different motive loads in the processing sections, chillers and air compressors. Thermal energy in the form of steam/ hot water is used for formulation process and drying. HSD/LDO and LPG is primarily used as the fuel in boiler for generating steam. Apart from steam generation, HSD is also used in the DG sets to cater the necessary power requirements during grid staggering.

Figure 27: Share of Energy Consumption in Dehradun Pharma cluster



The typical energy consumption and share of thermal and electrical energy for different capacities of pharma units are shown in table.

Table 19: Energy consumption and share of thermal and electrical energy in Dehradun Pharma cluster

Unit Size	Electricity (kWh)	HSD (Litre)	LPG (kg)	Equivalent energy (toe)
Small	13,62,720	42,000	11,571	167
Medium	34,06,800	76,364	1,63,636	552

The energy consumption pattern shows a majority share (63%) is accounted by electricity. The average specific energy consumption (SEC) at cluster level is estimated to be 16.2 toe per million pieces final drug (tablet, capsule and sachet).

Table 20: Annual consumption by fuel type in in Dehradun Pharma cluster

Energy type	Annual consumption	Equivalent energy (toe)	Annual energy bill (million INR)
Electricity	59.6 million kWh	5,126	387.4
HSD/LDO	1,573 kL	1,332	81.8
LPG	1365 tonne	1,616	88.7
Total		**8,074**	**557.9**

The Dehradun Pharma Cluster also presents huge opportunity where the biomass use for steam generation is possible. As the boilers in the clusters use fossil-based fuels like HSD/LDO, LPG for steam generation, and presents and opportunity where renewable based fuels can be deployed and helping these industries reduce GHG emissions.

7.1.3.4. Paper and Pulp

Fuel Consumption and Price Economics

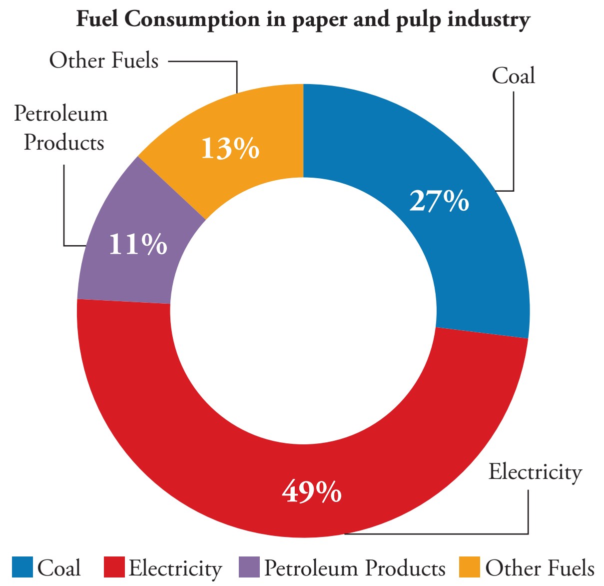
The paper & pulp industry utilized only 0.82% of the total industrial energy usage in FY 2021, highlighting that it is a low energy intensive sector[25]. The energy consumption in the form of heat in most of the paper and pulp industry in India is high at 10 - 12 Giga Calorie per tonne of paper which is almost 2 times as compared to American and Scandinavian countries[26]. The paper production (paper, paperboard and newsprint in the country has nearly doubled in the past decade from 10.99 million tonnes in 2010 to 21.36 million tonnes in 2020[27]. Considering the production of 21.36 million tonnes of paper in FY 2020, the total heat requirement is estimated at ~260 million Giga Calories.

In terms of current fuel usage, the industry primarily relies on coal for meeting heating requirements. As per MOSPI Energy Statistics 2022[28], paper and pulp sector accounted for 1,174 KToE of coal consumption in FY 2021.

Currently, there are over 9,000 factories in operation in the sector encompassing manufacture of pulp, paper, paperboard, corrugated paper, items of paper and paperboard, and printing activities. These industries consume energy to meet heat requirements of processes like pulping, bleaching and drying which requires combustion of costlier conventional fuel options (such as coal, fuel oil, etc.) having higher gross calorific values (GCV). The trend for overall cost of fuel consumption for the industry has been illustrated below[29]

The cost analysis reveals that paper and pulp industry is currently paying a price of ~Rs 12.76 million per factory unit for conventional fuel usage.

Figure 28: Fuel Consumption in paper and pulp industry



The major factors that affect energy consumption in the Indian pulp and paper industry are low level of capacity utilization, quality and type of paper produced, number and multiplicity of machinery, paper machine runnability and down time, finishing losses, boiler type and pressure levels, level of cogeneration, and power generation.

The cost of energy is estimated to be 16 to 25 percent of the total production cost of paper, and the component of energy cost is expected to increase over other inputs in near future. Energy consumption in paper mills varies in accordance with the type of raw material and technology in use. Coal and electricity are the main sources of energy used in paper production.

Table 21: Typical energy consumption details of India paper Mills

S. No	Types of Mill	Electrical Energy KWH/T	Thermal Energy GJ/T
1	Integrated Wood/Bamboo based	1400-1500	27.3
2	Agro based mill without recovery	1200-1300	27.3
3	Waste paper based	600-850	11.3

25 Ministry of Statistics and Programme Implementation, Energy Statistics India (2022)
26 Ministry of Steel, Energy and Environment
27 CPPRI Annual Report FY 2020-21
28 MOSPI Energy Statistics 2022
29 Annual Survey of Industries, 2019

Table 22: Energy Consumption data of Paper Mills (2018-19)

Type of raw material	No of mills	Total Production in ton/year	Average Mkcal/ton of paper	Total Energy consumption in Mkcal	Equivalent Coal consumption in tons	Average equivalent coal consumption per ton of paper
Wood based	17	3385147	10.77	36458033	13138030	3.88
Agro based	29	1630020	9.698	15807939	5696555	3.49
Waste paper based (W/P)	57	2230362	4.153	9262693	3337908	1.50
Waste paper based (Packaging)	423	14227787	2.263	32197482	11602696	0.82
Total	480	16,458,149		41,460,175	14,940,604	

Table 23: Carbon Dioxide Emission of Indian Paper Industry (Raw Material Wise) 2018-19

S. No.	Type of raw material	No of mills	Total Production in ton/year	Average Mkcal/ton of paper	Total Energy consumption in Mkcal	Total Energy consumption in Mkcal	Total CO_2 emission by the sector
1	Wood based	17	3385147	10.77	36458033	13138030	18787383
2	Agro based	29	1630020	9.698	15807939	5696555	8146073
3	Waste paper based (W/P)	58	2230362	4.153	9262693	3337908	4773208
4	Waste paper based (Packaging)	422	14227787	2.263	32197482	11602696	16591856
	Total	**526**	**21473316**				**48298519**

Table 24: Future Projection of CO_2 Emission Up to 2029-30

S. No.	Type of raw material	Total Production in ton/year (2018-19)	Total Production in ton/year (2029-30)	Average Mkcal/ton of paper	Total Energy consumption in Mkcal (2029-30)	Equivalent Coal consumption in ton (Year 2029-30)	Total CO_2 emission by the sector
1	Wood based	3385147	4126475	10.77	44442139	16015185	22901715
2	Agro based	1630020	1800557	9.698	17461799	6292540	8998332
3	Wastepaper based (W/P)	2230362	2997420	4.153	12448285	4485869	6414792
4	Wastepaper based (Packaging)	14227787	21060600	2.263	47660139	17174825	24559999
	Total	**21473316**	**29985052**		**122012362**	**43968419**	**62874839**

GCV Values of Fuel Consumption

The heat requirements of paper & pulp industry are moderate requiring coal with GCV of 3,200-4,000 Kcal/kg. The entire energy consumption in the plants running on conventional fuel is met through use of coal with use of furnace oil restricted to lighting of the boiler furnace. The non-coking grade of coal used in the plants has high ash and moisture content of 34-40% which necessitates use of ash handling mechanisms. Further, integrated paper manufacturers also utilize black liquor produced as a by-product of pulping process as a source of fuel that has a calorific value of 3300 Kcal/kg40. The ash content of black liquor is relatively higher at more than 30%.

Internal Industrial Process Mapping and Deployments

The process of paper making in a factory involves digestors for pulp manufacturing, chippers, evaporators, washers, press rollers, dryers, rollers and finishing sections. The internal processes in the various stages like pulping, bleaching and paper drying require low temperatures of around 200 degree Celsius and employ mainly non-coking grade coal for meeting the direct heating requirements.

Figure 29: Internal process mapping in Paper & Pulp industry

Debarking and chipping	Digesting and washing	Pulping	Bleaching	Paper drying
40-60 ˚C	>90 ˚C	70 - 120 ˚C	70 ˚C	>120 ˚C

Assessing potential for Biomass-cofiring for Green Heat/Steam Generation

The price economics favours a strong business case for adoption of biomass in paper & pulp industry as the current cost of conventional fuel, mainly coal, is significantly higher than the average cost of biomass pellets/briquettes available in the market. The low temperature requirements for heat in the form of steam in paper & pulp manufacturing processes can be achieved easily through burning of biomass, albeit with a higher consumption of biomass raw material as compared to coal. The experience of raw material sourcing in paper & pulp industry, mainly of forest produce like raw timber, can be leveraged to procure agricultural produce biomass for fuel. The average GCV for coal usage in the industry is 3200-4000 Kcal/kg and black liquor is 3300 Kcal/kg which can be substituted by GCV of biomass (average of 3000-3300 Kcal/kg). The lower GCV of biomass will mean greater fuel usage leading to additional ash deposition and increase in costs for treatment. Further, majority of the biomass projects deployed for meeting industrial heat globally (in EU-28[30]) have operating temperatures of below 200 degree C, which is similar to the process heating requirement for paper and pulp industry.

Considering the combined impact of all the above parameters, it can be ascertained that paper and pulp industry does present a significant potential for biomass based cofiring operations. The result is further backed up by consultations with select boiler players and industry consultations, that have highlighted that some players have switched to 100% biomass-based boilers.

Fuel and Energy Consumption in Some Select Clusters

Muzaffarnagar Paper Cluster[31]

Muzaffarnagar is situated in Western Uttar Pradesh and is important industrial town with paper, sugar and steel being the major products. Muzaffarnagar paper cluster has around 29 paper units. In terms of raw material usage, mills can be broadly put in two categories – waste paper based, and agro-waste based. Similarly, for finished products too, though bulk of the mills produces only kraft paper, a few of them have started producing writing paper. The total installed capacity of all the paper mills in Muzaffarnagar is approximately 542700 MTPA. These mills are a mix of waste paper & agro.

Energy Situation in the Cluster

Energy is an essential input and a major cost driver in Paper manufacturing. Nearly 26% of the Indian paper Plants have the energy cost to the total cost falling in the range of 20-30%.

30 IEA Bioenergy Task 40 (2021), Role of Biomass: Decarbonising Industrial Process Heat Report
31 Sameeksha Portal

75-85% of the energy requirement in the paper manufacturing process is in the form of process heat (made available through steam) while 15-25% is needed as electrical power.

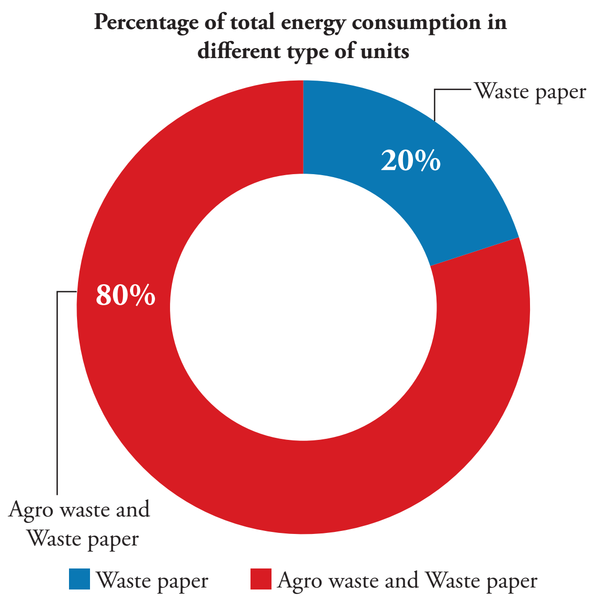
The paper mills in the Muzaffarnagar cluster use various types of fuels like coal, biomass, pet coke etc. The primary fuel used in all the mills is coal and biomass. Rice husk, pith and bagasse are the major biomass used in the cluster. In few mills wood chips are also used as a supplementary fuel. The details are of the same are provided in table below:

Table 25: Fuel Details in Muzaffarnagar Paper cluster

S. No.	Fuel	Approx. Calorific Value of Fuels, kCal/kg
1	Coal	3,800
2	Rice Husk	3,300
3	Bagasse	2,000
4	Wood	3,500

Total annual energy consumption in cluster is around 102,645 MTOE (Metric Tonne of oil equivalent). Percentage of total energy consumption in different type of units in cluster is presented in figure below:

Figure 30: Percentage of total energy consumption in different type of units in Muzaffarnagar Paper cluster



All the units have installed boilers to meet the steam demand of the paper unit. If the unit has captive thermal power generation facility, the steam demand is met through the cogeneration system installed. In other mills where the electricity is supplied through grid, low or medium pressure boilers are installed for steam generation. The specific energy consumption of a typical mill in the cluster is represented below:

Table 26: Specific energy consumption in Muzaffarnagar Paper cluster

Parameter	Value
Specific Electricity Consumption	550 to 1,080 kWh/MT
Specific Fuel Consumption	10.13 to 18.15 GJ/MT

Considering the combined impact of all the above parameters, it can be ascertained that paper and pulp industry does present a significant potential for biomass based cofiring for steam operations. The result is further backed up by consultations with select boiler players and industry consultations, that have highlighted that some players have switched to 100% biomass-based boilers.

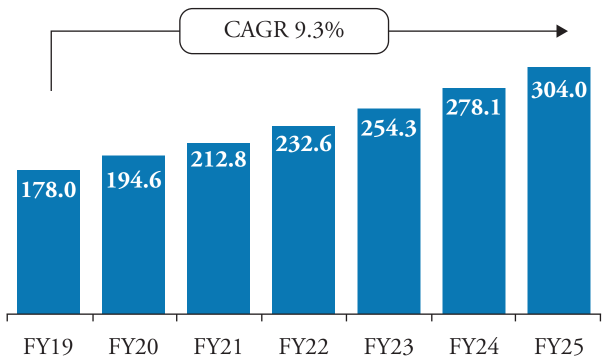
7.1.3.5. Chemical Industry

The chemical industry of India is a major industry in the Indian economy and as of 2022, contributes 7% of the country's Gross Domestic Product (GDP). India is the world's sixth largest producer of chemicals and the third largest in Asia, as of 2022. The value of the Indian chemical industry was estimated at $100 billion dollars in 2019. The chemical industry of India generates employment for five million people. The Indian chemical industry produces 80,000 different chemical products. India was also the third largest producer of plastic in 2019. As of September 2019, the alkali chemical industry produced 71% of all chemicals produced in India. India's chemical industry accounts about 14% of production in Indian industries.

The Indian chemical industry mainly produces basic types of chemicals as well as knowledge type chemicals and specialty type chemicals as of 2018. In India, Gujarat was the largest state contributor to the chemical industry of India in 2018. India also produces products related to petrochemicals, fertilizers, paints, varnishes, glass, perfumes, toiletries, pharmaceuticals, etc.

The chemicals industry in India is very diversified and can essentially be classified into 6 categories: bulk chemicals, specialty chemicals, agrochemicals, petrochemicals, polymers and fertilisers.

Chemical industry market size (US$ billion)



Basic Organic Chemicals

The organic chemicals industry is one of the most significant sectors of the chemical industry in the world. It plays a vital role in providing inputs for other industries of paints, adhesives, pharmaceuticals, dyestuffs and intermediates, leather chemicals, pesticides, etc. Methanol, acetic acid, formaldehyde, pyridine, phenol, alkylamines, ethyl acetate, and acetic anhydride are major basic organic chemicals that are produced in India.

Six major chemicals are produced in India: methanol, aniline, alkylamines, and its derivatives formaldehyde, acetic acid, and phenol contributing to nearly 2/3 of Indian basic organic chemical industry. The country has several basic organic chemical companies that are among the largest companies globally in their chemical productions. These companies include:

Balaji Amines. The world's largest producer of Dimethylamine hydrochloride.

Inorganic Chemicals

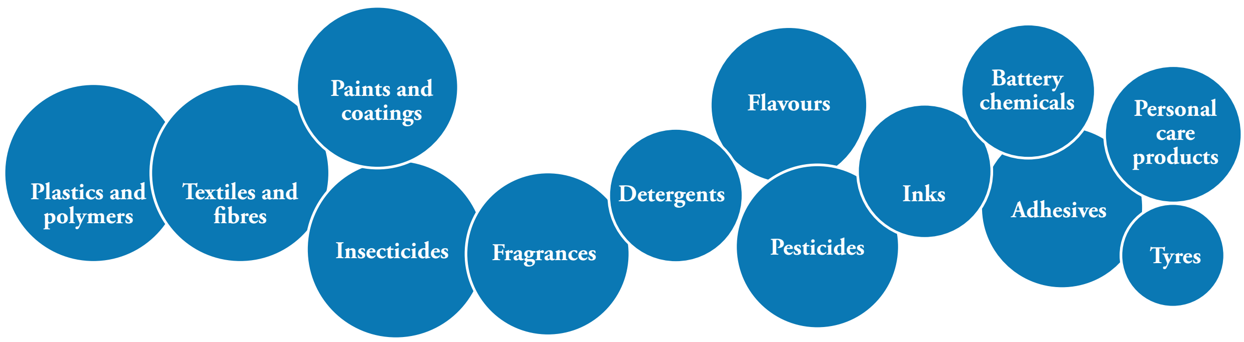
Chlor-alkali Chemicals

In India, chlor-alkali the sector mainly consists of the production of three inorganic chemicals; caustic soda (NaOH), chlorine (Cl_2) and soda ash (Na_2CO_3). Hydrogen is also produced in this industry in small amounts. The chlor-alkali industry inputs are mainly used in soaps and detergents, pulp and paper, textiles, aluminium processing industry for caustic soda and for soda ash in glass, silicate production etc apart from soaps and detergents. In the financial year 2019–2020 of chlor-alkali industry of India over four million metric tons of alkali chemicals were produced. The products that are produced in this industry are soda ash, caustic soda, and liquid chlorine. Tata Chemicals, a diversified Indian chemicals company, is also the world's third largest manufacturer of soda ash.

Speciality Chemicals

As of December 2021, the speciality chemicals segment comprised 22% of India's overall chemicals market. In 2019, India's share of the global speciality chemicals market stood at 4%, however India's market share is projected to stand at 5.5% by 2025. India has several niche specialty chemical companies that are among the largest companies globally in their specific niche sectors. These companies include:

- Camlin Fine Sciences. The world's third largest manufacturer of vanillin.
- Clean Science and Technology. The world's third largest producer of guaiacol.
- Tatva Chintan. The world's second largest manufacturer of structure directing agents for zeolites.



India's chemical industry has significant importance in the country's economy. It contributes to approximately 3% of India's GDP and is projected to reach $304 billion by 2025. However, the industry also has significant environmental implications due to the use of toxic chemicals, water consumption, and greenhouse gas emissions.

Currently, the Indian chemical industry faces several sustainability challenges. Firstly, the industry is highly energy-intensive, with around 12-15% of the total energy consumption in the country attributed to the chemical industry. This high energy consumption results in significant greenhouse gas emissions, contributing to climate change.

Secondly, the chemical industry is one of the largest water consumers in India, with around 20% of the total industrial water consumption attributed to the sector. This high-water consumption puts pressure on scarce water resources, leading to water scarcity in some regions.

Thirdly, the chemical industry produces large amounts of hazardous waste and emissions, which can cause serious environmental and health problems if not managed properly. The industry is also vulnerable to accidents and incidents, such as leaks, spills, and explosions, which can cause significant damage to the environment and human health.

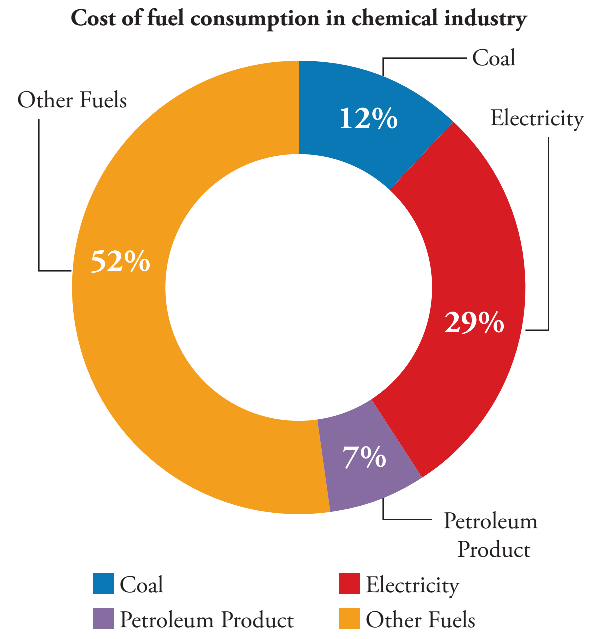
Fuel Consumption and Price Economics

Chemicals industry covers various sectors like bulk chemicals, agrochemicals, petrochemicals, fertilizers and polymers. The chemicals industry utilized 3.55% of the total industrial energy usage in FY 2021, highlighting that it is a moderate energy intensive sector[32].

In terms of current fuel usage, the industry primarily relies on oil products and coal for meeting heating requirements. As per MOSPI Energy Statistics 2022, chemicals industry accounted for 12,637 KTOE of oil products consumption and 1,161 KJOE of coal consumption in FY 2021.

Currently, there are over ~10,000 factories in operation in the sector. These factories consume energy to meet heat requirements of processes through combustion of costlier conventional fuel options (such as naphtha, high speed diesel, light diesel oil, fuel oil, coal, etc.) having higher gross calorific values (GCV). The trend for overall cost of fuel consumption for the industry has been illustrated below[33]

Figure 31: Cost of fuel consumption in chemical industry



The cost analysis reveals that chemicals industry is currently paying a price of ~Rs 25.71 million per factory unit for conventional fuel usage, which lies in the moderate energy price range across all industry sectors.

GCV Values of Fuel Consumption

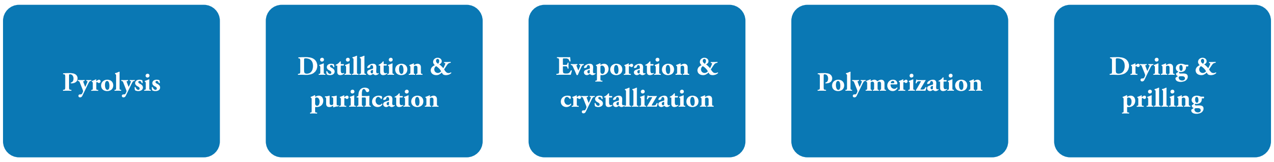
The heat requirements of chemicals industry are considerable requiring oil fuels with GCV of 10,000 Kcal/kg and above. The entire energy consumption in the plants is met through conventional fuels. The ash level in oil fuels is negligible and sulphur content is in the range of 2-4% There is risk of corrosion due to sulphuric acid formed during combustion.

Internal Industrial Process Mapping and Deployments

The chemicals industry across its different sub-sectors like bulk chemicals, polymers, petrochemicals, etc. requires high temperature of more than 200 degree Celsius and employs mainly high calorific content oil-based fuels for meeting the direct heat requirements.

32 MOSPI Energy Statistics India (2022)
33 Annual Survey of Industries, 2019

Figure 32: Internal process mapping for chemical industry



Assessing Potential for Biomass-cofiring for Green Heat/Steam Generation

The price economics does favour a strong business case for adoption of biomass in chemicals industry as the current cost for fuel consumption is significantly higher. However, other factors in the form of total quantum of heat, internal processes, GCV requirements and historical precedents point to the low potential for adoption.

Firstly, the industry requires high grade heat at very high temperatures having very low ash deposition rates. The average GCV values of fuel used in the industry is well above 10,000 Kcal/kg, which is beyond the GCV value for biomass-based fuel (GCV of 3500 Kcal/kg). The lower GCV of biomass will mean greater fuel usage leading to additional ash deposition and increase in costs for treatment. Further, majority of the biomass projects deployed for meeting industrial heat globally (in EU-28) have operating temperatures of below 200 C, which is well below process heating requirement for chemicals industry.

Also, significantly high quantum of heat delivery is required for operations in the industry, and hence would entail procurement of significant amount of biomass feedstock, which may further pose a challenge on procurement side.

Considering the combined impact of all the above parameters, it can be ascertained that chemicals industry have some potential for biomass based cofiring operations. The result is further backed up by consultations with select boiler players and sector experts, that label chemicals industry as low potential sector for biomass deployment.

Fuel and Energy Consumption in Some Select Clusters

Ahmedabad Chemical Cluster

Ahmedabad chemical cluster is one of the important chemical clusters in Gujarat. The cluster houses a number of large scale and MSME units, manufacturing various types of chemical products. There are about 750 dyes and chemical manufacturing units in Ahmedabad cluster. All these chemical manufacturing units are located in Vatva, Naroda and Odhav industrial areas. There are about (i) 600 chemical units in GIDC, Vatva, (ii) 100 units in GIDC, Naroda and (iii) 50 units in GIDC, Odhav. Most of these manufacturing units are operational for the last 20 years.

The chemical units in Ahmedabad cluster can be classified either on the basis of the type of products or production capacities. About 80% of the total units in the cluster produce dyes and dye intermediates while rest of the units are involved in production of other chemicals (organic and inorganic chemicals). On the basis of production capacity, about 76% of chemical units fall under the "small" enterprise category with production capacity of 200-600 tonne per year while 5% of the total unit fall into the "medium" sized enterprise category.

Figure 33: Classification of units based on product types in Ahmedabad chemical cluster

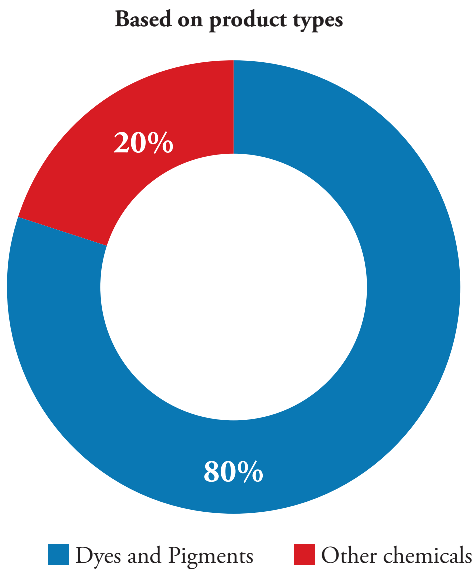
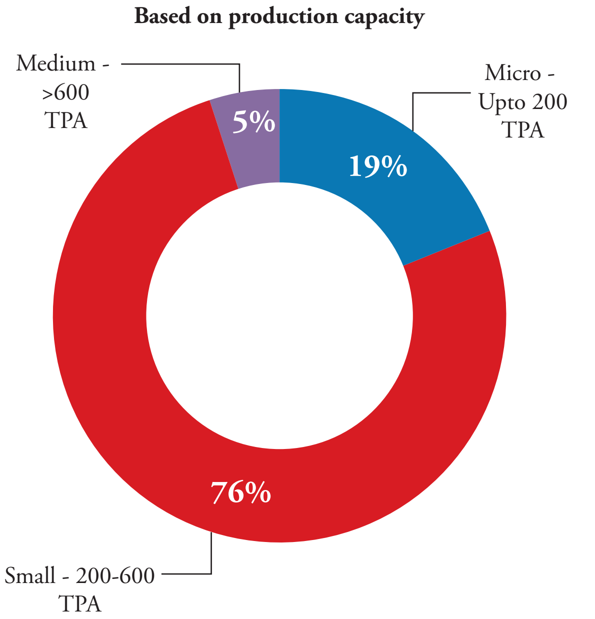


Figure 34: Classification of units based on production capacity in Ahmedabad chemical cluster



Energy Consumption Profile

The chemical industries in Ahmedabad cluster use both thermal energy and electricity in the manufacturing processes. Energy accounts for a sizeable portion of manufacturing costs of the chemical units of Ahmedabad cluster. The energy costs are 5–7% of the manufacturing costs for inorganic chemicals and about 12–15% for dyes and chemicals. The levels of energy consumption in these units are dependent on the type of products and the process followed. Different types of energy used in the cluster include natural gas, coal, firewood, and electricity.

Thermal energy is used to meet the heating requirements of the processes followed in chemical industry. The details of thermal energy use in the cluster are provided in Table

Table 27: Details of fuels used for thermal energy requirements

Energy type	Source	Calorific value	Landed cost
Natural gas	Adani Gas	8,750 kCal/SCM	Rs 38-42 /SCM
Coal	Local market	4,200-4,800 kCal/kg	Rs 6-8 /kg
Firewood	Local market	2,700-3,200kCal/kg	Rs 3-4 /kg
HSD	Retail outlets		

The energy consumption pattern of the chemical units varies based on product type, technology employed and production capacities. The unit level energy consumption of typical production capacities and cumulative cluster level energy consumption of the Ahmedabad chemical industries are summarised below.

The energy consumption of typical chemical units in Ahmedabad chemical cluster varies from 15.1 .to 2080.6 tonnes of oil equivalent (toe) per year Thermal energy accounts for 89.2% of total energy consumption, with natural gas used as the main fuel.

Table 28: Unit level energy consumption

Category	Thermal energy (toe/year)	Electricity (toe/year)	Total energy consumption (toe/year)
Dyes and pigments	478.2	53.6	531.8
Other chemicals	129	52.8	181.8

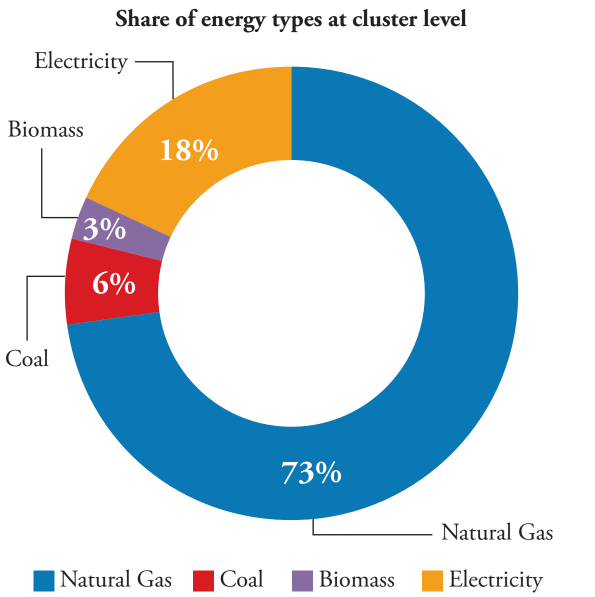
The cumulative annual energy consumption of Ahmedabad chemical cluster during 2020-21 is estimated to be 1,44,624 toe

Table 29: Cluster level energy consumption

Energy type (Unit)	Unit	Energy consumption	Equivalent toe
Natural gas	(Million SCM per year)	121	105,872
Coal	(Tons per year)	18,000	8,125
Biomass	(Tons per year)	10,800	4,024
Electricity	(Million kWh)	308	26,529
Total			**144,624**

Natural gas accounts for maximum share in the total energy consumption (73%) followed by electricity (18%) as shown in figure

Figure 35: Share of energy types at cluster level



The steam boilers, as per Indian Boilers Regulations (IBR), are mainly used for low and medium pressure (i.e., 3.5-10.5 kg/cm2) applications in the chemical units. The natural gas is the major fuel used in boilers to generate the steam. However, some of the micro and small size chemical units also use firewood or coal as in the boilers. Most of the chemical processes require low pressure steam (i.e., 3.5-5.5 kg/cm2) for jacket heating and direct purging into the reactor vessels. The capacities of IBR type boilers range from 1-5 tonne per hour (tph).

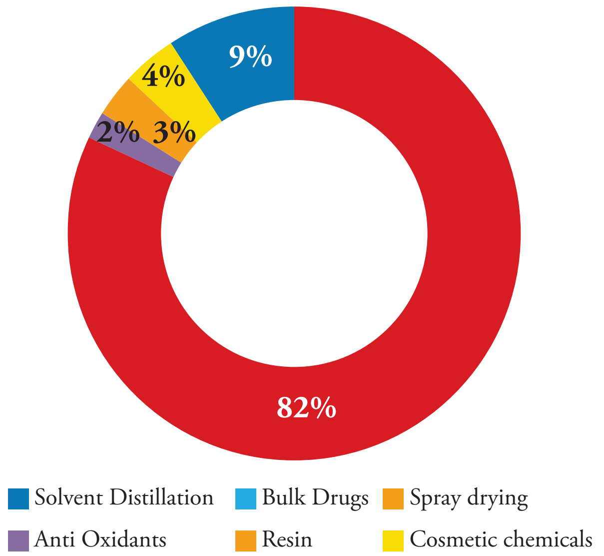
The non-IBR boilers (up to 750 kg per hour evaporation rate) are also used in the chemical units to meet intermittent steam requirements. These boilers are of single pass, once through type and primarily use natural gas or liquid fuels as energy source.

Thane Chemical cluster

Thane chemical cluster is one of the important chemical clusters in Maharashtra. The cluster houses a number of large scale and MSME units, manufacturing various types of chemical products.

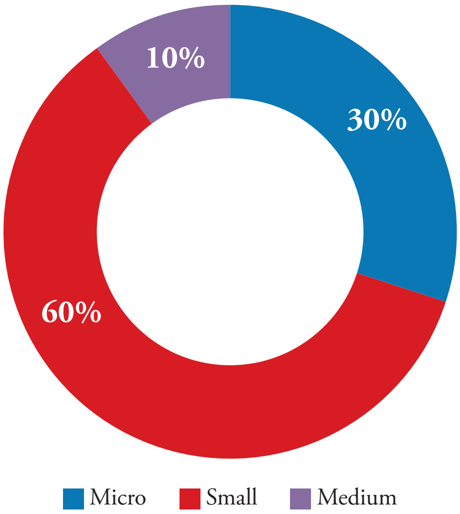
The chemical units in Thane cluster can be classified either on the basis of the type of products or production capacities. More than 80% of the units in the cluster produce Bulk drugs and 20% of the units in the cluster is Solvent distillation, Resin, Cosmetic chemicals and spray drying as shown in figure

Figure 36: Major Products manufacturing in Thane cluster



The Chemical industries in the cluster can be divided into three different type based on production capacity of the units as shown in figure

Figure 37: Production Capacity in Thane cluster



The steam boilers, as per Indian Boilers Regulations (IBR), are mainly used for low and medium pressure (i.e., 3.5-10.5 kg/cm2) applications in the chemical units. The natural gas is the major fuel used in boilers to generate the steam. However, some of the micro and small size chemical units also use firewood or coal as in the boilers. Most of the chemical processes require low pressure steam (i.e., 3.5-5.5 kg/cm^2) for jacket heating and direct purging into the reactor vessels. The capacities of IBR type boilers range from 1-5 tonne per hour (tph). The non-IBR boilers (up to 750 kg per hour evaporation rate) are also used in the chemical units to meet intermittent steam requirements. These boilers are of single pass, once through type and primarily use natural gas or liquid fuels as energy source.

Energy consumption profile

The chemical industries in Thane cluster use both thermal energy and electricity in the manufacturing processes. Energy accounts for a sizeable portion of manufacturing costs of the chemical units of Thane cluster. The energy costs are 5–7% of the manufacturing costs for inorganic chemicals and about 12–15% for dyes and chemicals. The levels of energy consumption in these units are dependent on the type of products and the process followed. Different types of energy used in the cluster include natural gas, coal, firewood, and electricity.

Thermal energy is used to meet the heating requirements of the processes followed in chemical industry. The details of thermal energy use in the cluster are provided in table

Table 30: Details of fuels used for thermal energy requirements in Thane Chemical Cluster

Energy type	Source	Calorific value	Landed cost
HSD	Retail	10800	80 Rs. per liter
Briquette	Local market	4380	4200 Rs. per tonne
FO/LSHS/LDO	Local distributor	10000	55 Rs. Per liter

The energy consumption pattern of the chemical units varies based on product type, technology employed and production capacities. The unit level energy consumption of typical production capacities and cumulative cluster level energy consumption of the Thane chemical industries are summarized below.

The energy consumption of typical chemical units in Thane chemical cluster varies from 150.2 to 190.6 tonnes of oil equivalent (toe) per year based on the type of industries. Thermal energy accounts for 73% of total energy consumption, with LDO (Light Diesel Oil) as one of the main fuel.

Table 31: Unit level energy consumption in Thane Chemical Cluster

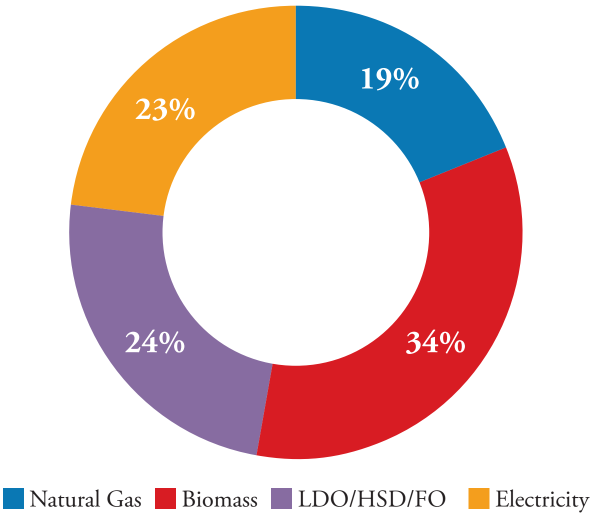
Category	Thermal energy (toe/year)	Electricity (toe/year)	Total energy consumption (toe/year)
Category	Thermal energy (toe/year)	Electricity (toe/year)	Total energy consumption (toe/year)
API/Pharmaceuticals	112.4	78.1	190.6
Other Chemicals	128.6	21.6	150.2

The cumulative annual energy consumption of Thane chemical cluster is estimated to be 36,590 toe **Biomass accounts for maximum share in the total energy consumption (34%)** followed by electricity (23%) and Natural gas (19%) as shown in figure

Table 32: Cluster level energy consumption in Thane Chemical Cluster

Fuel type	Unit	Annual Consumption	Annual Consumption (toe/year)
Natural gas	Million SCM/year	8	7,012
Biomass	Tonnes/year	33,048	12,314
LDO/FO/HSD	kL/year	10081	8,889
Electricity	Million kWh/year	97.4	8,375
Total			**36,590**

Figure 38: Share of energy on Thane cluster



The MSMEs chemical clusters are already using biomass in various forms like firewood, briquettes etc. for their thermal requirement. Thus, it is quite evident that the biomass has potential in these chemical clusters and has the potential to blend some portion of biomass as fuel in their steam requirements.

7.1.3.6. Dairy Industry

India has emerged as the largest milk producing country in the world with the present level of annual milk production estimated at 100 million tonnes. The dairy industry is dominated by the co-operative sector with 60% of the installed processing capacity in this sector.

Milk processing in India is around 35% of total milk production, of which the organised dairy industry accounts for 13% of the milk produced while the rest of the milk is either consumed at farm level or sold as fresh, non-pasteurised milk through unorganised channels[34]. Table shows the product mix of the Indian dairy industry.

Table 33: India's Dairy product mix

Products	Percentage Share
Fluid milk	46.0
Ghee	27.5
Butter	6.5
Curd/Yogurt	7.0
Khoa (Partially Dehydrated Condensed Milk)	6.5
Milk powder and Dairy whiteners	3.5
Paneer and Chhana (Cottage Cheese)	2.0
Others, including Cream, Ice Cream	1.0

Fuel Consumption and Price Economics

Presently, the sector boasts a network of more than 2850 operational factories, which benefit from cost-effective energy consumption. This advantage stems from the sector's reliance on energy sources that do not require high-grade coal or other fuels with elevated Gross Calorific Value (GCV) characteristics, as compared to some other industries. In

34 Source: MoFPI

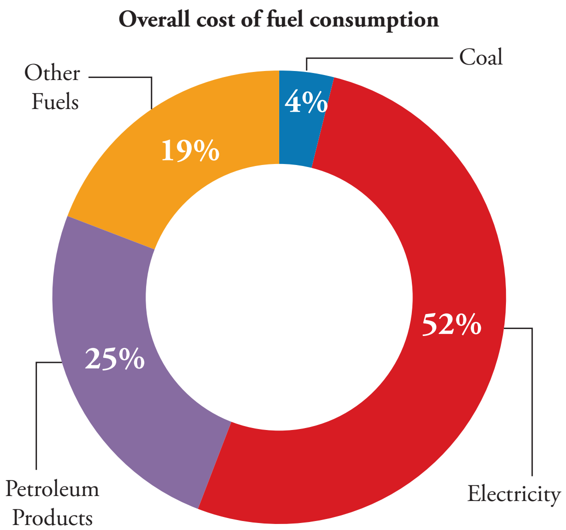
fact, many participants within the dairy industry have proactively embraced alternative energy solutions. For instance, some have adopted biomass, particularly paddy husk-based sources, to fulfill their process heating requirements. Additionally, there is a growing trend in the industry to incorporate Concentrated Solar Thermal (CST) systems, harnessing the power of solar energy for their heating needs. These sustainable energy choices not only reduce operational costs but also contribute to environmental conservation.

In recent years, India has consistently held the top position in global milk production, making a significant contribution of 23% to the world's total milk output. This remarkable growth has been sustained, with a compounded annual growth rate (CAGR) of 6.2%, culminating in a production of 209.9 million tonnes in the fiscal year 2020-21, a substantial increase from the 146.3 million tonnes recorded in FY 2014-15. However, this surge in milk production has led to an increased demand for energy, with thermal energy accounting for 70% of the energy requirements throughout the entire value chain.

The industry's total heat demand is estimated to be around 1.4 Giga Calories, which is relatively modest due to the comparatively low energy-intensive internal processes involved in milk production.

The trend for overall cost of fuel consumption for the industry has been illustrated below

Figure 39: Overall cost of fuel consumption in Dairy sector



The cost analysis shows that the dairy industry is currently spending just Rs 15.3 million per factory unit on annual conventional fuel usage, making it one of the most cost-effective sectors among all industries. This cost-efficiency is primarily attributed to the industry's limited reliance on high-grade coal as a fuel source.

GCV Values of Fuel Consumption

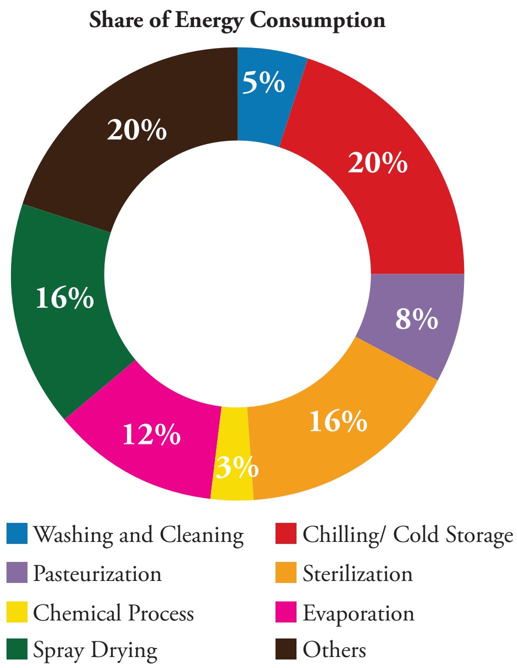
The dairy industry stands out as a sector characterized by remarkably low energy intensity, primarily due to the majority of its operational processes occurring at temperatures below 200 degrees Celsius. Typically, the Gross Calorific Value (GCV) of the fuels used in this industry falls within the range of 3300-4000 Kcal/kg, underscoring its efficient and resource-conscious operational approach. This unique positioning offers an opportunity for optimization and sustainability initiatives within the dairy sector, aimed at enhancing energy efficiency and environmental stewardship.

Internal Industrial Process Mapping and Deployments

The dairy industry has a notable demand for thermal energy, primarily utilized in various milk processing activities such as pasteurization, sterilization, spray drying, and evaporation. Additionally, electrical energy is essential for refrigeration purposes, including milk pre-chilling, post-pasteurization cooling, cold storage of packaged milk, as well as for operations like pneumatic milk packaging machines, milk homogenization, and clarification processes. This dual energy requirement encompasses a wide spectrum of activities within the dairy sector, highlighting the industry's diverse and significant energy needs.

Figure 40: Internal Industrial Process and temperature range for dairy industry

Figure 41: Share of Energy Consumption across various processes in Dairy Industry



The dairy industry has already demonstrated successful adoption of biomass-based boilers for meeting indirect process heating requirements. Salient features of one of these projects undertaken by a leading FMCG player for dairy operations is summarized below.

Table 34: Case for biomass adoption in dairy

ITC Plant	
Commissioning Date	August 2015
Key applications	Manufacturing of skimmed milk powder, dairy whitener, Ghee
Biomass fuel type	Paddy husk
Boiler specifications	Capacity: 8 TPH Boiler Type: Fluidised Bed Combustion Temperature: 100 Degrees Pressure: 21kg/cm2
CO_2 emission reduction	7740 tons
Cofiring	100% Biomass (10-year steam supply agreement)

Assessing Potential for Biomass-cofiring for Green Heat/Steam Generation

The dairy industry enjoys the advantage of already having a relatively low cost associated with conventional fuel usage, which somewhat diminishes the immediate incentive for adopting biomass as an alternative energy source. However, when we examine the various factors involved, such as heat requirements, Gross Calorific Value (GCV), internal processes, temperature range, and the existing successful biomass deployments within the sector, it becomes clear that there is a compelling case for considering biomass adoption.

One of the primary reasons for this is that the dairy industry's use of fuels with lower GCV values aligns well with the characteristics of biomass-based fuels, making the transition relatively seamless in terms of supply chain and procurement. Furthermore, the industry primarily employs low-temperature processes that demand relatively modest heat input, making biomass co-firing a promising and practical solution. This assertion is reinforced by the numerous successful biomass co-firing installations that continue to operate within the dairy sector.

Considering the collective impact of these factors, it is evident that the dairy industry holds substantial potential for biomass-based co-firing operations. This conclusion is further substantiated by consultations with key boiler manufacturers and industry experts who categorize the dairy sector as highly conducive to biomass deployment.

7.1.3.7. Ceramic Industry

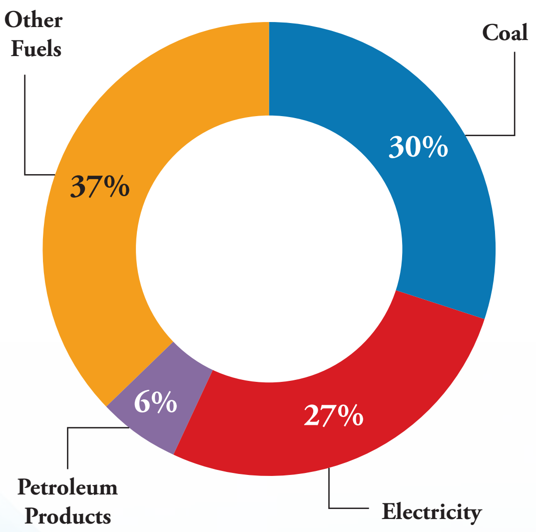
Fuel Consumption and Price Economics

The ceramic industry is a diverse sector encompassing the production of refractory items, clay-based construction materials, and various porcelain and ceramic products. To sustain their operations, this industry heavily relies on the consumption of coal and petroleum-based products as primary sources of fuel to generate the necessary heat and energy.

Within this sector, there are currently in excess of 10,000 operational factories. These factories consistently grapple with energy consumption challenges as they cater to the demanding needs of their processes. To meet these demands, they resort to the combustion of conventional but expensive fuel sources like natural gas, lignite, and Indonesian coal. These fuels possess significantly higher gross calorific values (GCV), making them viable choices despite their costliness.

In essence, the ceramic industry's fuel consumption is intricately linked with the economics of fuel pricing. Their need to utilize fuels with elevated GCV levels showcases the industry's emphasis on maintaining optimal thermal efficiency, even at the expense of higher fuel costs. Understanding this interplay between fuel choice and pricing dynamics is essential for both the industry's sustainability and for broader discussions on energy economics. The trend for overall cost of fuel consumption for the industry has been illustrated below

Figure 42: Fuel consumption in ceramic industry



The cost analysis highlights that the ceramic industry currently spends approximately Rs 7.1 million per factory unit on conventional fuel, placing it within the higher cost bracket in comparison to other industry sectors.

GCV Values of Fuel Consumption

The ceramic industry demands substantial heat, necessitating the utilization of gaseous and liquid fuels such as natural gas and high-speed diesel, boasting a gross calorific value (GCV) exceeding 11,000 Kcal/kg. These traditional fuels entirely satisfy the energy needs within the plants. In specific processes like spray drying, solid fuel, such as coal with a GCV surpassing 6,000 Kcal/kg, is employed to meet the requirements.

Use of solid fuel (lignite/coal/Indonesian coal/biomass) is cheaper as compared to use of gaseous (Natural Gas, LPG) or liquid fuel (Kerosene/LDO/LPG). Therefore, using these solid fuels for generation of hot air at about 300 degrees and used it as a combustion air in kiln, dryer and spray dryer can result in reduction in energy cost. If biomass is used, then it reduces GHG emissions also.

Internal Industrial Process Mapping and Deployments

The ceramic industry involves process like wet grinding, spray drying, pressing, drying, firing and baking, sizing and polishing. The process generally involves a temperature range from 1100 °C to 1150 °C in the kiln. Natural gas as well as producer gas from gasifier is used as fuel in the kiln. There are no significant indirect heating processes involved at lower temperatures that typically use steam as medium of heat transfer.

Spray drying uses thermal energy at a temperature of 500-600 °C, hot gases are generated by combustion of variety of fuels such as lignite, Indonesian coal, saw dust, briquette, natural gas through direct combustion as well as through gasifier.

Figure 43: Internal process mapping for ceramic industry

Assessing Potential for Biomass-cofiring for Green Heat/Steam Generation

Evaluating the feasibility of biomass co-firing, the economic aspect does appear promising for the ceramic industry due to the existing high fuel costs. Nevertheless, several factors, including the total heat requirements, internal processes, gross calorific value (GCV) prerequisites, and historical trends, suggest significant potential for implementation.

To begin with, the industry necessitates top-tier heat levels at exceedingly high temperatures. The GCV of their current fuels ranges from 3000 to 6000 Kcal/kg, and the GCV of biomass-based fuel at 3500-4000 Kcal/kg.

Considering the collective impact of these factors, it becomes evident that the ceramic industry has significant potential for adopting biomass co-firing practices. This conclusion is further substantiated by consultations with select boiler experts and industry specialists, who classify the ceramic industry as a sector with medium potential for biomass integration.

Fuel and Energy consumption in some select clusters

Morbi Ceramic Cluster

Morbi Ceramic cluster account for 90% of total ceramic production of India with 610 units in this cluster which are engaged in manufacturing of Wall Tiles, Vitrified Tiles, Floor Tiles, Sanitary wares, Roofing Tiles and others.

Different types of ceramic products manufactured in Morbi SME cluster are as follows:

Table 35: Ceramic Industrial Units at Morbi & their % share

S. No.	Type of Industry	%share
1	Wall Tiles	37%
2	Vitrified Tiles	8%
3	Floor Tiles	11%
4	Sanitary Wares	9%
5	Spray Dryer Mud Manufacturing Units	8%
6	Roofing Tiles (seasonal operation)	25%
7	Third Firing Manufacturing (Producing pictures on tiles)	2%

The ceramic units can be categorized based on the basis of type of product and the production capacity of the plant, viz.

1. Wall Tiles
2. Floor Tiles
3. Vitrified Tiles
4. Sanitary Wares

Table 36: Category wise Ceramic Units at Morbi

Type of Product	Scale of Units		
	Micro	Small	Medium
Wall Tiles	25%	56%	19%
Floor Tiles	16%	73%	11%
Vitrified Tiles		85%	15%
Sanitary Wares	23%	56%	21%

Energy Situation in the cluster

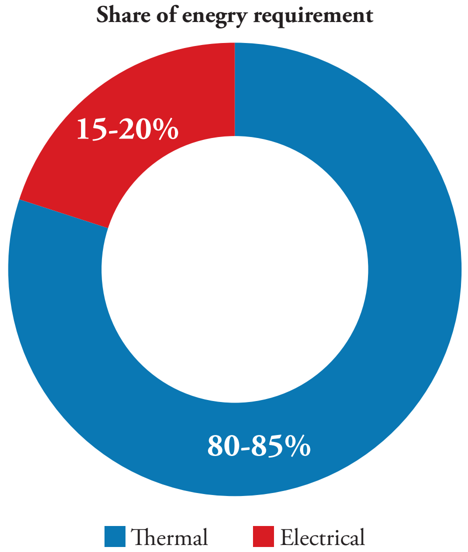
Details of different types of fuels used in Morbi ceramic cluster along with their calorific value is as follows

Table 37: Types of Fuel Used in Morbi Ceramic Custer

Type of Energy Source	Calorific Value
Electricity	
Natural Gas	8,800 Kcal/SCM
Charcoal	6,500 Kcal/Kg
Lignite	3,500 Kcal/Kg
Saw Dust	4,801 Kcal/Kg
Indonesian Coal	5,500 Kcal/Kg
Biomass based Briquette	4,000 Kcal/Kg
HSD	11,000 Kcal/Kg

The energy requirements of the ceramic industry are very high, with the amounts of thermal energy used being truly immense. The kilns, above all, use lots of energy to reach high temperatures. The percentage share of thermal and electrical energy is presented below

Figure 44: Percentage share of thermal and electrical energy in ceramic cluster



Various forms of biomass are also used as a source for thermal energy. Various forms of biomass such as briquette, saw dust, wood etc. are also used as a source for thermal energy. The percentage share of energy source is presented below:

Table 38: Percentage share of energy source

	Morbi, Gujarat	
Energy Source	Natural Gas	51%
	Other Fuels – Coal, Lignite, biomass, diesel	49%

Though the ceramic industry does not require any boilers for steam generation but requires gasifiers to meet the heat requirement. Heat is used to fire the kilns. Biomass Gasification is the appropriate technology for the ceramic industry and has huge potential for using Biomass/ Briquette Fired Hot Air Generator Which Supplies Hot Air for Kiln Firing, Dryer and Spray Dryer Firing.

7.1.3.8. Leather and Footwear Industry

Fuel Consumption and Price Economics

India is the second-largest producer, consumer of footwear and exporter of leather garments, the third-largest saddlery and harness, and the fourth largest leather goods exporter worldwide. The leather and footwear sector contributes about 2 per cent to India's overall Gross Domestic Product (GDP) and employs approximately 4.42 Mn workers making the sector one of the top employment generators in the country. India's footwear market is estimated to reach $ 15.5 Billion (Bn) by 2022, from $ 10.6 Bn in 2019. It is expected to grow at 11 per cent over the next five years. The industry is known for its high export earnings and is amongst the prime foreign exchange-earners. According to the Council for Leather Exports (CLE), the export of footwear, leather, and leather goods from India was $ 3.68 Bn during 2020-21.

The leather sector in India occupies a very important place on account of the substantial export earnings, employment opportunities and numerous applications in the downstream sectors of the consumer products industry. The industry has a diversified product base and most of them are SMEs. The industry structure is predominantly unorganized and decentralized. The products include semi-finished and finished leather, footwear, garments, gloves, saddles, harnesses and other leather goods.

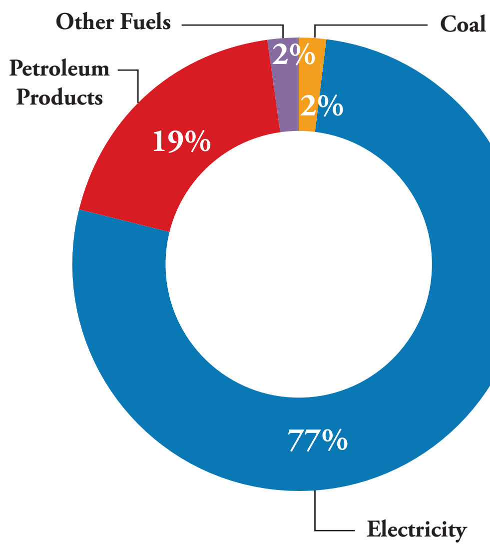
As the leather sector in India comprises of units making different leather products at different stages of the industry's value chain, the production units can be broadly classified into the following categories:

- **tanneries** –which process raw hides/skins to produce semi-finished and finished leather
- **consumer goods production units** – which produce leather products like safety and fashion footwear and as well as its components, saddles and harnesses, garments, gloves and other goods using finished leather
- **integrated units** – which process raw hides/skin and produce downstream consumer goods as mentioned above

As per the ASI data, it suggests that Indian leather market has been fragmented with about 4767 units engaged in various manufacturing. The industry is concentrated in three states viz. Tamil Nadu, West Bengal and Uttar Pradesh. Of the total number of tanneries in India, Tamil Nadu accounts for 52%, West Bengal 23% and U.P 12%.

The industry is highly energy intensive requiring electrical and thermal energy for its various processes. The growth of industry is tied to the rising energy consumption demand, wherein both heat and electricity are required for running internal processes.

Figure 45: Source-wise distribution of energy consumption in the Leather Sector

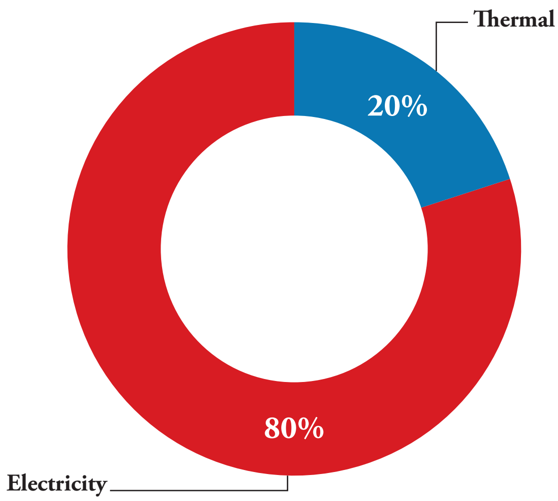


In terms of current fuel usage, the industry primarily relies on coal, gas, diesel oil, electricity for meeting energy requirements. Heat treatment processes like post tanning, finishing and drying are the common processes prevalent in the industry, consuming most of the energy required in the industry.

A fairly significant portion of the energy requirement is met through fossil fuels. However, electricity is the major source of fuel driving most of the processes in the industry.

The cost analysis reveals that industry is currently paying a price of ~Rs 3 million per factory unit for conventional fuel usage annually. And majority of this is spent against electrical energy as presented below:

Figure 46: Share of energy usage in Leather industry



GCV Values of Fuel Consumption

The industry represents one of the highest energy intensive industries, with most of the operations performed below 100 °C temperature. GCV value of fuel usage in industry is ~3000-5000 Kcal/kg, while for biomass it is around 3500-4000 Kcal/kg. Which makes it quite usable in the industry for the process heat.

Internal Industrial Process Mapping and Deployments

The key internal processes involved in the industry have been presented below:

The leather industry comprises of two major production cycles which characterize the adoption of different chemical and physical processes. The processing of raw hide / skins into semi -finished and finished leather called "tanning" forms the first cycle and the production of consumer leather products from the finished leather forms the second cycle.

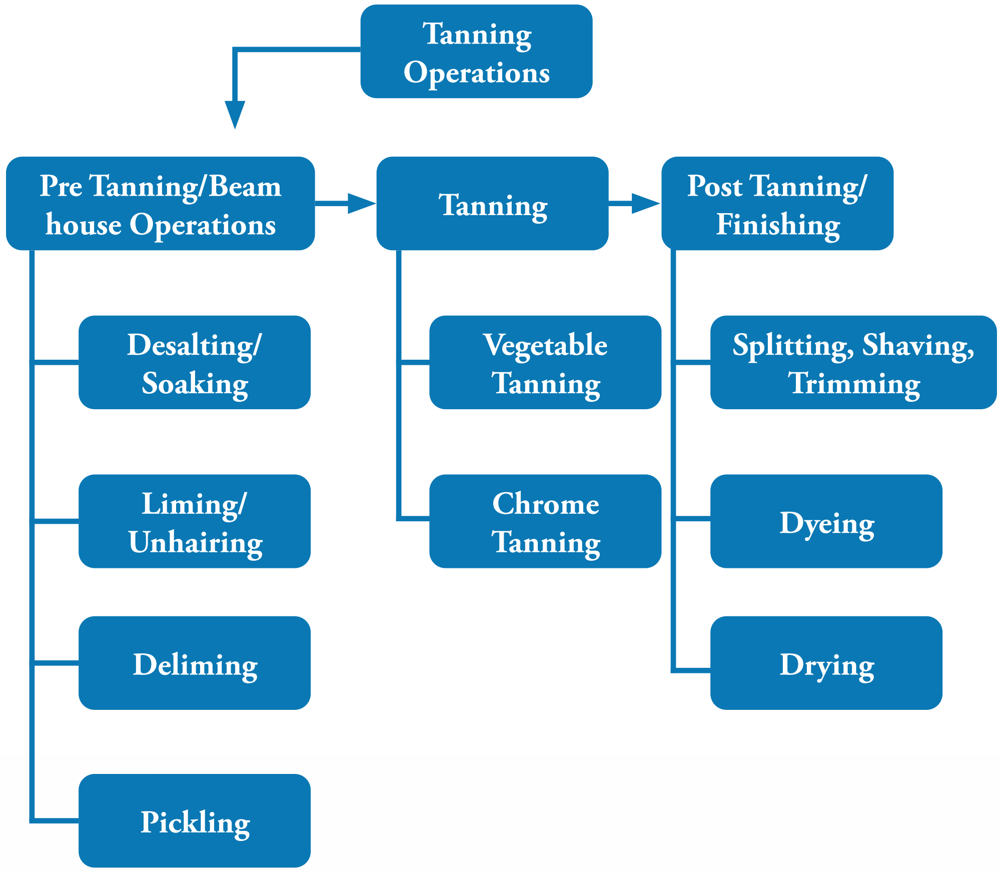
The following major operations come under the tanning process:

- beam house (pre-tanning) operations
- tanning operations
- post tanning and finishing operations

The manufacturing of consumer leather products include the following major operations:

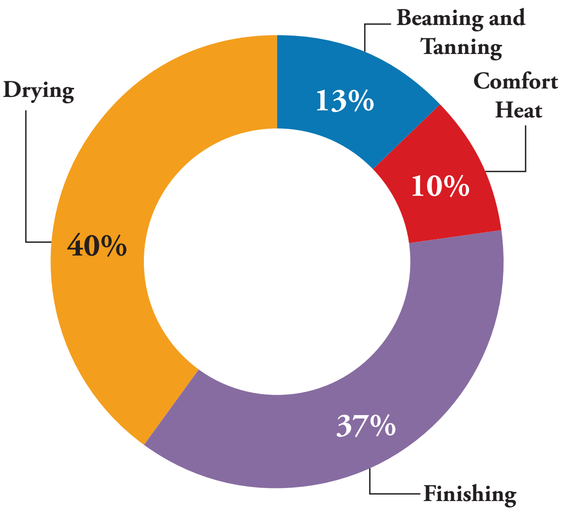
- marking, cutting and dressing finished leather
- sewing and stitching

Figure 47: Process flow in Leather Industry



The tanning operations account for most of the heat energy consumed in the leather industry 'Wet-blue' is the intermediate stage of processing where the hide is converted from its raw state into a suitable material which will not putrefy or be attacked by bacteria. This process consists of a series of chemical and physical processes, and it requires high volumes of water at critical working temperatures, thus creating a huge demand for hot water supply and storage systems normally at temperatures in the range of 60–80 °C. This indicates a potential for biomass applications which have been proven to be very efficient in the temperature ranges mentioned above. Apart from these operations there is also a demand for drying applications which are critical for producing good quality leather.

Figure 48: Process-wise energy consumption profile in Leather Industry



Assessing Potential for Biomass-cofiring for Green Heat/Steam Generation

Evaluating the feasibility of biomass co-firing, the economic aspect does appear promising for the leather and footwear industry due to the existing high fuel costs. Nevertheless, several factors, including the total heat requirements, internal processes, gross calorific value (GCV) prerequisites, and historical trends, suggest significant potential for implementation.

The GCV of their current fuels ranges from 3000 to 6000 Kcal/kg, and the GCV of biomass-based fuel at 3500-4000 Kcal/kg.

Considering the collective impact of these factors, it becomes evident that the leather and footwear industry has significant potential for adopting biomass co-firing practices. This conclusion is further substantiated by consultations with select boiler experts and industry specialists, who classify the industry as a sector with medium potential for biomass integration.

7.1.3.9. Rubber Industry

Fuel Consumption and Price Economics

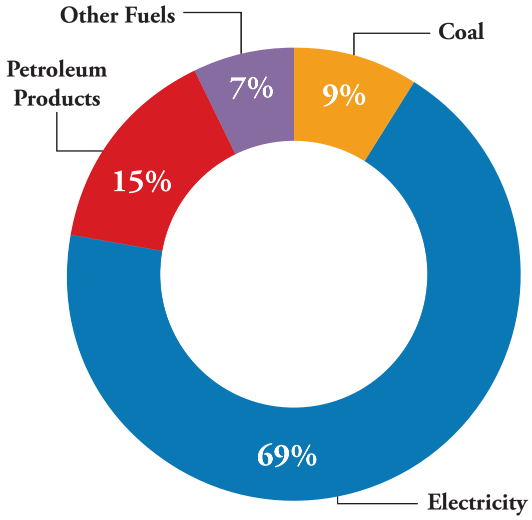
Rubber industry consumes both of the electrical and heat energy. The fuel used for generating heat are gasoline, kerosene, diesel, LPG, heavy oil, natural gas, coal, saw dust, firewood, and rice husk. The type of fuel and technology used are depended on class of industry. The up-stream production, which most work concern the para wood plantation and collecting of latex, consumes small amount of energy. Next step is the transformation of the latex into several forms, for example concentrated latex, rubber sheet, rubber block, and crepe. This step consumes more energy but still small amount. The last step is the real industrial work, in which the natural rubber is changed to finishing products. The three most energy consumption are tire, dipping product, and compressed rubber block. In the tire manufacturing heat from steam is used to heat the mold and calendar and the electricity is supplied to the driving motors. For the rubber block production, most of electrical energy is consumed by the motors while diesel is used to generate heat for the drying oven.

Table 39: Proportion of energy consumption in rubber industry

The proportion of energy consumption (%)		
	Electrical	Heat
Rubber sheet	16.08	83.92
Rubber bar	58.12	41.88
Concentrated latex	86.55	7.49
Tire products	56.87	43.54
Dipping products	29.50	70.50
Extruding products	45.48	54.52
Forming products	66.35	33.35
Miscellaneous products	80.39	19.61

ASI data reported presence of ~3500 industries in the rubber sector manufacturing various products. The ASI data reports the consumption of fuels as presented below:

Figure 49: Overall cost of fuel consumption for the rubber industry



Electricity is the major contributor of around 69% in the industry followed by petroleum products (15%) and then coal (9%). The cost analysis reveals that industry is currently paying a price of Rs 11 million per factory unit for conventional fuel usage annually, which is the quite on the higher side across all industry sectors, owing to the need of high-grade coal for fuel sourcing.

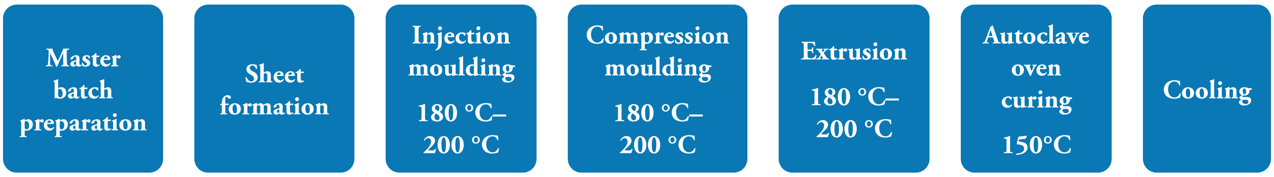
GCV Values of Fuel Consumption

The rubber industry represents one of the energy intensive industries, with most of the operations performed below 200 ˚C temperature. GCV value of fuel usage is around 11000 Kcal/kg as HSD is used in boilers for steam requirement. Various internal process in the manufacturing of rubber require temperature ranging from 150 ˚C – 200 ˚C. The industry also uses LDO in substantial amount with GCV of 10000 Kcal/kg.

Internal Industrial Process Mapping and Deployments

The major steps involved in manufacture of rubber products are mixing of raw materials using mixers/kneaders and preforming before manufacture of the final products through process like injection moulding, extrusion, manual forming and so on. Certain products require curing in ovens to about 150 °C–160 °C. A process how diagram is given in the figure. The major process steps are briefed below:

Figure 50: Internal process mapping for rubber manufacturing



Assessing Potential for Biomass-cofiring for Green Heat/Steam Generation

The cost of conventional fuel usage is the amongst highest across all the industries, the remaining factors - comparable GCV of fuel usage to that of biomass, internal process requiring low temperature of below 200 °C, and already existing deployments- all point to a strong business case for utilization of biomass in such industries.

Considering the combined impact of all the above parameters, it can be ascertained that industry does have high potential for biomass based cofiring operations. The result is further backed up by consultations with select boiler players and sector experts, that label the industry as high potential sector for biomass deployment.

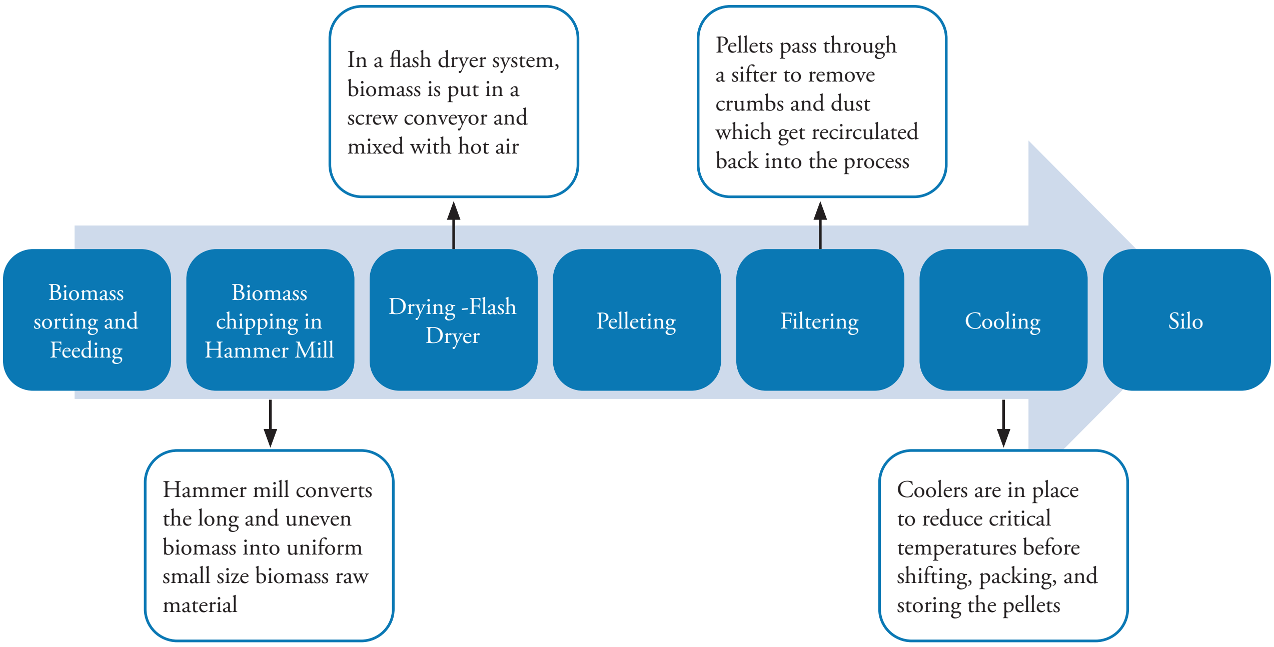
7.2 Assessment of Technical Requirements for Converting Biomass Into a Suitable form (Pellet or Briquette) for Industrial Steam Applications

Modern bioenergy is being recognized as a significantly valuable low-carbon resource by policymakers across the planet to meet climate policy targets. In India likewise, there is an unmistakable acknowledgment of the huge potential of bioenergy in electricity generation as well as in other applications. India produces a large quantity of agricultural and forestry residues/waste, as mentioned in this section below, a major part of which is used for domestic, commercial, and industrial activities, viz., fodder for cattle, domestic fuel for cooking, construction material for rural housing, industrial fuel for boilers, manufacturing cardboard, and other similar applications. However, the traditional use of biomass has many drawbacks as an energy feedstock mostly because of the low bulk density of traditional biomass feedstocks.

To improve the characteristics of traditional biomass feedstocks for combustion, raw agricultural and forestry residues increasingly being upgraded to augment their bulk density through palletisation. Literature review presents that the pelleting process increases the specific density of biomass to more than 1000 kg per cubic meter .

The pellet sector is one of the fastest growing sectors in India. Apart from increasing volumetric calorific value of raw biomass, palletisation also increases the efficiency of thermochemical conversion due to consistent moisture level . The process of pellet manufacturing prominent in India is presented below:

Figure 51: Process of pellet manufacturing prominent in India



The process of palletization starts with collection of raw biomass from fields through direct purchase from farmers or through aggregators. The raw biomass collected is usually kept in open for sun drying and reducing the moisture content from the raw biomass. Once the moisture content is reduced, the biomass is inspected by labor to remove unwanted materials such as stones, metals, etc. which may affect the equipment and pellet quality. As a next step, some raw materials which may be large in size such as pine wood, saw dust, etc. are chipped through a chipping machine to break the biomass particle size. Once the raw biomass size is reduced, a dryer is used to bring down the moisture level to acceptable range such as 10-15%. This moisture range is required to ensure the biomass pellet produced is bind together without the need of any external binder. In case the moisture level in a biomass is lower than this range, water is added to bring the moisture level up. Post drying of biomass, the biomass is further hammered down to small particle size say 3-6 millimetres using hammer mill. The small particles of raw biomass are then run through the pellet mill which bind the raw biomass together and produce pellets of desired size through a die. The temperature of pellet thus produced may be as high as 80-100°C and is thus cooled through a cooler to bring down the temperature to room temperature. In case immediate packaging of pellets is not required, cooler may be avoided, and the pellets may be naturally cooled at room temperature. As the last step in pellet manufacturing, the pellet is packaged in bags for storage and shipment for usage.

Pellet mill dies are usually made from several different types of metal. Dies must be resistant to abrasion, strong enough to handle the forces of pellet production and corrosion resistant without negatively affecting productivity. The materials most often used are carbon steel alloy, stainless steel alloy and high chrome alloy.

Currently biomass pellet manufacturing in India stands at **2.38 Million MT**. State-wise pellet production capacity is provided in the table below[35].

Table 40: State-wise pellet production capacity (MT)

State	Annual Pellet Production Capacity (MT)	Number of Pellet Manufacturers	Number of Briquette Manufacturers
Gujarat	606,000	31	118
Rajasthan	294,600	26	75
Haryana	134,400	13	41
Tamil Nadu	132,000	12	64
Andhra Pradesh	70,000	5	65
Maharashtra	2,40,000	26	167
West Bengal	1,30,000	11	45
Chhattisgarh	43,200	4	14
Bihar	31,800	2	23
Telangana	75,000	8	36
Punjab	1,68,000	11	32
Uttar Pradesh	1,45,200	18	43
Karnataka	186,000	10	97
Other states	130,200	42	207
Total	**2,386,400**	**219**	**1,027**

The next section provides the state level inputs around biomass palletisation collected through site visits and stakeholder consultations.

7.2.1. State Analysis

Gujarat

Two-thirds of the population in Gujarat is engaged in agricultural activities from which they earn their living. Agriculture is the main source of employment in rural areas. The total geographical area of Gujarat is 19,602,400 hectares, of which crops take up 10,630,700 hectares[36].

Overall, Gujarat is the dominant producer of cotton and groundnuts in India. Other major crops produced in the state are rice, wheat, bajra, sugarcane, and pigeon pea. As far as oilseed crops are concerned, castor, groundnut, and mustard are the important crops of the state. The state currently has over 30 biomass pellet players with the combined pellet production capacity of ~50,500 MT / month including saw dust and pine wood and ~34,500 MT / month capacity for agro-based pellets.

The state is producing 42.9 MMT of crop annually of which the crop residue is 69.7 MMT and the biomass surplus available, which is not being used elsewhere, is 25.4 MMT.

35 Calculated based on stakeholder consultations and literature review.

36 https://www.gercin.org/wp-content/uploads/2019/09/teri-report.pdf

Figure 52: Crop production, residue and biomass surplus in Gujarat

Crop production 42.9 MMT → **Crop residue** 69.7 MMT → **Biomass surplus** 25.4 MMT

Cumulatively, these pellet manufacturers are utilizing 455,400 MT of agro-based residue annually for pellet production in the state.

Figure 53: Snapshot of field visit in Gujarat

Pellet and Briquette Manufacturers

- **Global Biomass Pellets:** Manufacturing capacity- 1000 MT/month; biomass pellets based on groundnut shells and mustard husk
- **Neja Bio Pellets:** Manufacturing capacity- 1000 MT/ month; biomass pellets based on groundnut shells and mustard husk
- **Bholenath Industries:** Manufacturing capacity: 2500 MT/month; biomass pellets based on saw dust and pine wood
- **Eco Energy Industries:** Manufacturing capacity: 2500 MT/month; biomass pellets based on saw dust and pine wood
- **Patidhar Fuel Product:** Briquette Manufacturing capacity 3000 MT/ month
- **Forest Green Energy:** Briquette Manufacturing capacity 1500 MT/ month

Equipment Manufacturers

- Servoday, Jamnagar: Manufacturing capacity - 20 machines of up to 8 TPH capacity/month; die imported from Germany; rest of the R&D in-house; lead time - 3 months
- Global Agrotech Engineering: Manufacturing capacity - 6 machines of up to 2.5 TPH capacity/ month; complete R&D in-house; lead time - 45 days
- Radhe Engineering (manufacturing hybrid machines) Manufacturing capacity - 6 machines of up to 2.5 TPH capacity/month; complete R&D in-house; lead time - 30 days

Typically, the pellet manufacturers have a production capacity ranging between 1000-2000 MT / month. The agro-based pellet producers are concentrated in Rajkot and Ahmedabad whereas the Kachchh region has a dominance of saw dust and pinewood-based pellet manufacturers. Through the consultations, it is understood that the typical off takers of the biomass pellets in Gujarat include industries such as chemical, pharmaceuticals, food processing, dairy and cement. Some of the key companies being served by the pellet manufacturers include Amul, Unilever, Patanjali, Zydus, etc. Pellets are being sold to the industries at a price ranging between INR 10,000 – 14,000 / MT and this price is ex-factory and does not include transportation cost which is to be borne by the buyer / customer. Further, it is understood from consultations that pellet manufacturers in Gujarat are supplying the pellets even to a distance up to 600 km. Further, the industrial customers are providing 50% upfront payment and 50% payment within one week's timeline.

Figure 54: Biomass pellets produced by Global Biomass Pellets in Rajkot, Gujarat

Case of Bholenath Industries in Gandhidham, Gujarat

Bholenath Industries is located in Gandhidham in Gujarat and is actively producing saw dust and pine wood pellets since 2012. The company has a pellet production capacity of 5000 MT / month; however, is currently producing 4 TPH of pellets (2400 MT / month) which are being supplied to industries such as **food processing, chemical and pharmaceuticals.** The chemical properties of the pellets being produced are provided below:

- Pellet dimensions (diameter) – 8-10 mm
- GCV – 3900 - 4000 kCal / kg
- Moisture content – 8-10%
- Ash content – 2-4%

The industry supply pellets with dimensions no more than 35 mm, GCV ranging between 2800 – 4000 kCal / kg for non-torrefied pellets and moisture not more than 14%. Already the company is supplying to industrial units located at around 1,000 km.

Typically, the pellet dimensions being offered by the pellet manufacturers range between 6-10 mm with 8 mm being highly in demand. Some of the pellet manufacturers are also using binding material in their pellets. These binding materials include saw dust, press mud, etc. Largely, it is reported that the GCV of the pellets ranges between 3600 – 4100 kCal / kg with GCV of mustard husk and groundnut shell pellets being around 3600 – 4000 kCal / kg and that of saw dust and pine wood pellets ranging around 3900 – 4100 kCal / kg. As far as ash content is concerned, it is the lowest in sawdust and pine wood pellets, ranging between 1-2%, followed by groundnut shell (4-5%) and highest in mustard husk, ranging between 8-10%.

In terms of the raw material cost, it is understood the prices have been increasing year-on-year. Currently, seasonal rate of groundnut shell is between INR 4000 – 4500 / MT, mustard husk is INR 2500 - 3000 / MT and saw dust is INR 4000 – 5000 / MT.

Summary of key inputs received from the physical and video / telephonic consultations is provided below:

Table 41: Biomass Pellet profiling in Gujarat based on inputs shared by stakeholders

Parameter	Output
Cost of raw biomass procured	• Ground nutshell - INR 8000 – 9000 / MT (off-season) and INR 4000 – 4500 / MT (during season) • Mustard husk and coriander husk – INR 2500 - 3000 / MT (seasonal) • Saw dust – INR 4000 – 5000 / MT
Selling price of pellet (ex-factory)	INR 10,000 – 14,000 / MT
Typical Production capacity	0.5-2 TPH
Pellet dimension	6 – 10 mm
GCV of pellet produced	3600 – 4100 kCal/kg
Moisture of the pellet produced	6-10%
Ash content	1-10%
Wastage in conversion	1-2%
Binding material	Either water (15-20%) or materials like saw dust (up to 40%)
Pellet production cost	INR 2000 – 2500 / MT
Major Pellet off-takers*	Industries: some key players include – Jindal, Amul, Unilever, Patanjali, Zydus

Parameter	**Output**
Make of the pellet machine	• Radhe Engineering, Rajkot • Global Agrotech Engineering, Rajkot • Satyajit Machineries, Rajkot • Servoday, Jamnagar • New Lehra, Ludhiana • CPM, USA • Buehler Group, Germany
Cost of civil construction of the facility	INR 1 – 1.5 crore for 2 TPH capacity plant
Land Requirement for placing the pellet mill	500 – 800 sq. mtr. for machinery up to 2 TPH capacity
Storage facility for raw material and pellets	~500 sq. mtr. for storing 1000 - 1500 MT raw material
Requirement of labour to run the plant	4-6 labourers: 1-2 for biomass feeding; 1-2 operators; 2 for packaging

Key Risks Associated with Pellet Manufacturing in Gujarat

Volatile pricing of biomass: Biomass being an unorganized market in Gujarat is susceptible to price rise, depending upon the demand in the market. Biomass aggregators have reported price rise to the extent of two to three times for crops such as groundnut shell, mustard husk, etc. in last few years due to sudden increase in demand. Such volatility in price of biomass affects the cost of pellet thus produced and could be unaffordable for suppliers who are price sensitive.

Alternative usages of biomass pellets: Gujarat has a heavy industrial concentration and most of these industries are either planning or are already going green with their industrial processes. As such, they have a proclivity to replace use of coal as an input in the industrial process with biomass pellets. These include industries such as iron and steel, textile, pharmaceuticals, salt manufacturing, etc. These industries tend to sign long-term contracts with the biomass pellet manufacturers and are offering competitive prices for procurement of pellets.

Payment mechanism: The payment mechanism adopted by industries is usually advance payment against the delivery of pellets, which helps the pellet manufacturers to maintain a steady cash flow. While in some case, a streamlined process is followed under which payment against delivery is usually done between 30-45 days. Advance payment by industries creates a bias for pellet manufacturers where they prefer to receive payment beforehand as opposed to waiting for it.

Biomass Pellet Production Potential in Gujarat

At present, Gujarat has a biomass surplus of 25.47 MMT that can be converted to biomass pellets.

The crop production in Gujarat is the highest in Banas Kantha and Bharuch standing at over 3.8 MMT each. Provided below is the data on district-wise crop production in Gujarat mapped to the number of biomass aggregators / suppliers in these districts. These biomass aggregators / suppliers, 42 in number, are the suppliers of biomass to the pellet manufacturers in the state. Based on the analysis, the districts with the highest potential of biomass pellet production include Banas Kantha, Bharuch, Rajkot and Amreli. These districts have the highest crop production and concentration of biomass aggregators / suppliers which, in essence, are the biomass suppliers to the pellet manufacturers.

Table 42: District wise crop production in Gujarat

District	Crop Production in FY20 (Tonnes)	Number of biomass aggregators / suppliers
Ahmedabad	1,071,829	2
Amreli	2,318,714	2
Anand	1,214,790	1
Aravalli	1,162,329	1
Banas Kantha	3,856,828	4
Bharuch	3,820,262	3
Bhavnagar	1,947,366	3
Dahod	575,883	2
Kachchh	713,076	3
Navsari	1,141,854	2
Patan	503,388	1
Vadodara	952,921	1
Valsad	608,183	6
Devbhumi Dwarka	820,823	1
Gir Somnath	1,060,267	2
Mehsana	1,015,929	2
Narmada	1,294,344	2
Panchmahal	386,939	3
Rajkot	2,836,049	1

Setting up of pellet manufacturing units or expanding capacity for existing units will make sense in the areas / district where biomass residue is available within 50-60 km radius[37]. As such, the districts mentioned in the table above hold the highest potential for pellet manufacturing considering the concentration of biomass aggregators / suppliers in these districts and the high crop production.

Maharashtra

Agriculture is the main stay of Maharashtra with over 50% of the state population engaged in farming. Average share of Crop sector is 63.7 per cent in Agriculture & allied activities sector of the state. Average share of horticulture in total crop production is about 28.4 per cent[38]. Over the last few years, Maharashtra has significantly diversified its production base from coarse cereals to high value crops like sugarcane, cotton, soyabean, maize, fruits, vegetables, and flowers. Other major crops produced in the state are soyabean, gram, rice, wheat, jowar, bajra, etc. As far as oilseed crops are concerned, groundnut and sesame are the important crops of the state. The state currently has nearly 26 biomass pellet manufacturers with the combined pellet production capacity of ~20,000 MT /month with raw materials varying from agro waste like ground nut, coffee husk, soya, bagasse, tur, saw dust and pine wood. Cumulatively, these pellet manufacturers are utilizing 300,000 MT of agro-based residue annually for pellet production in the state (Considering 25% wastage in conversion of raw materials to pellets)

37 Based on discussions with pellet manufacturers and equipment manufacturers.
38 Economic survey of Maharashtra 2021-22

Figure 55: Crop production, residue and biomass surplus in Maharashtra

Crop production 115.9 MMT → **Crop residue** 84.11 MMT → **Biomass surplus** 25.11 MMT

The state of Maharashtra has significant number of small pellet players, but only 3-4 players with production capacities exceeding 1000 MT/month.

Figure 56: Biomass shredder installed by Unity Green in Maharashtra

Number of briquette players operating in the state, with a figure estimated to be more than 150. One of the critical drivers for early development in the state was the policy incentive provided by Maharashtra Energy Development Agency (MEDA) in the form of 20% cost of CAPEX, capped at INR 4 Lakh since FY 2007, in addition to fiscal support under state industrial policy. Moreover, the state has one of the highest surplus crop productions across the country available for conversion into pellet form, and hence in a way is shielded from issues related to raw material deficit and associated increased prices. Comparatively, this has resulted in lower ex-factory price for briquette/pellet production for manufacturers in the state.

Figure 57: Snapshot of field visit in Maharashtra

Pellet manufacturers

- **Katariya Group:** Manufacturing capacity- 150-200T/day; biomass pellets; already supplying to NTPC
- **Rajaram Biomass:** Manufacturing capacity: 50T/day; biomass pellets
- **APM Packaging:** Manufacturing capacity: 1.5T/day; biomass pellets
- **Kreg Ventures:** Manufacturing capacity: 2T/day; pine wood pellets and biomass pellets
- **Mithras Green:** Manufacturing capacity: 15-20 T/day, by Oct'22 100 T/day, by Nov'22 150 T/day (MSW), ready to enter into biomass pellet manufacturing
- **Gangotree Energy Projects Pvt Ltd:** Manufacturing capacity: 2.5T/day; MSW pellet (plans to expand into agro-biomass pellets)
- **Unity Green Solutions:** Manufacturing capacity: 1.5T/day; MSW pellets (plans to expand into agro-biomass pellets)

Equipment Manufacturers

- **Gangotree Energy Projects Pvt Ltd:** Manufacturing capacity 50 kgs/hr to 250 kgs/hr; exporter to Thailand

Associations and SNA

- Biofuel Circle
- Association of Briquette Manufacturers
- Briquette Bazaar
- Maharashtra Energy Development Agency (MEDA)

In terms of raw material usage- groundnut shell, cotton stalk, saw dust and soyabean are most popular choices. Sugarcane bagasse and cane trash, though used in some quantities by players has significantly higher moisture content (as high as 35%). In addition to the normal agri-based residues, the manufacturers have also innovatively tried to materialize 'Refuse Derived Fuel' (RDF) technology by utilizing municipal solid waste (MSW) to produce pellets at competitive prices (~INR 7/kg). In terms of end consumers served, biomass pellets are being supplied for multiple applications-deployment in cook stoves against LPG, steam generation for process heat in industries, and power generation. Food processing industries forms the most common industry where a significant demand has been witnessed, wherein players are purchasing even at rates at upwards of INR 12-13/kg.

The state has notable pellet manufacturers, operating in the districts of Pune, Sangli, and Nagpur, and numerous industry association/think tanks, including MEDA, that have been actively working with these players.

The 3 biggest players operating in the state-Katariya Group, Rajaram Bioenergy and Amruta Biofuels, have a combined capacity of 9500 ton/month and cover ~40% of the state's pellet manufacturing production. All these players have the specification- GCV (>3800 Kcal/kg, in monsoons however the GCV may fall owing to high moisture content), moisture (less than 10%), and ash content (less than 8%). With respect to preference to machinery and equipment procured, the reliance is mostly on procurement from European (Andritz, Denmark), and German equipment suppliers, with few machines sourced locally from suppliers.

The key inputs received from the discussion:

Table 43: Key inputs received from field level surveys from Maharashtra

Parameter	Output
Cost of raw biomass procured	• Sugarcane Trash, Bagasse, Coffee Husk-INR 3000/MT • Soya, Tur, Cotton Stock-INR 5000/MT
Selling price of pellet (ex-factory)	INR 10,000 – 12,000 / MT
Typical Production capacity	50-150 Tonnes/day (big players)
Pellet dimension	8-10 mm
GCV of pellet produced	3800 – 4100 kCal/kg
Moisture of the pellet produced	8-10%
Ash content	6-8%
Wastage in conversion	1-4%
Binding material	Coffee husk, Bagasse
Cost of pellet production	INR 2500/Tonne
Typical Costing	1. Labour cost: INR 50-100/tonne 2. Electricity cost: INR 800-1000/tonne 3. Maintenance: INR 200-500/tonne 4. Packaging cost: INR 250-300/tonne 5. Storage costs: INR 400-500/tonne
Major Pellet off-takers*	Industries; some key players include – Haldiram, HUL, Kellogs, Thermax, including NTPC
Make of the pellet machine	• Andritz, Denmark • Buehler Group, Germany • India
Cost of civil construction of the facility	INR 2– 3 Crores for 2-3 TPH capacity plant
Land Requirement for placing the pellet mill	400 - 500 sq. mtr. for machinery up to 2 TPH capacity
Storage facility for raw material and pellets	~500 sq. mtr. for storing 1000 - 1500 MT raw material
Requirement of labour to run the plant	4-6 labourers: 1-2 for biomass feeding; 1-2 operators; 2 for packaging

In terms of future plans for growth, these players are very much interested in expanding their existing capacities, including entering from briquette/MSW to pellet manufacturing business. Some of the key visionary insights shared by these players include:

- Increasing current manufacturing production by procuring additional equipment, if PO is awarded by large industry or any other substantial off taker; Few players such as Rajaram Bioenergy have plans to double their existing capacity to 100 ton/day in next 6 months
- Few MSW based players (such as Mithras Green) are ready to enter into agro-based pellet production
- Large players (like Katariya Group) are very much keen to explore torrefaction to produce commercially viable torrefied pellets
- Number of briquette manufacturers part of Association of Briquette Manufacturers (ABM) can be converted into pellet players through deployment of combo machines, if rate of procurement is feasible and support on equipment is provided

Key Risks Associated with Pellet Manufacturing in Maharashtra

Inconsistent demand: There is limited or inconsistent demand for biomass pellets in the state, since the briquettes are available at cheaper rate compared to pellets. Also, the manufacturers face the risk of stable and long- term demand of biomass pellets and are satisfied supplying briquettes to the industry considering multiple uses of briquettes compared to pellets. This inconsistency in demand of biomass pellets in the industry might lead to limited availability of biomass pellets.

Biomass Pellet Production Potential in Maharashtra

At present, Maharashtra has a biomass surplus of 25.11 MMT that can be converted to biomass pellets. The state mainly grows crops like maze, sugarcane, cotton, and rice with contribution from other crops. The leading districts with crop production concentration include Pune (12 MMT), Kolhapur (11.9 MMT), Satara (9.58 MMT), Ahmednagar (5.89 MMT) and Nanded (2.95 MMT) of the 115.9 MMT of crop produced. The availability of biomass aggregators / suppliers reflect the ease of aggregation of biomass from various farmers for pellet manufacturing, given their wide network and connect with farmers. Biomass aggregators / suppliers act as potential linkage between the biomass pellet manufacturers and farmers, and act as aggregator to ensure availability of biomass for pellet manufacturing. The presence of biomass aggregators / suppliers in each of these districts is reflected below, which can help pellet manufacturers aggregate biomass for pellet manufacturing.

Table 44: Mapping crop production with biomass aggregators in Maharashtra

District	Crop Production in FY20 (Metric Tonnes)	Number of biomass aggregators / suppliers
Ahmednagar	5,891,269	6
Akola	530,168	4
Amravati	599,665	8
Bhandara	606,982	2
Buldhana	1,107,648	7
Chandrapur	467,456	3
Dhule	491,186	1
Gadchiroli	346,551	5
Parbhani / Hingoli	1,118,511	3
Jalgaon	1,407,139	4
Jalna	2,330,811	1
Kolhapur	11,903,297	5
Latur	2,943,097	5
Nanded	2,954,459	6
Pune	12,033,569	5
Satara	9,575,233	2
Washim	501,886	6
Yavatmal	1,234,423	9

While the above present the presence of biomass aggregators / suppliers in leading districts of Maharashtra, however, it would be important for pellet manufacturers to consider procurement of biomass from a range within 100 kms, beyond which the transportation cost would be high, which may make biomass procurement unviable.

Punjab

Punjab is one of the key agrarian states in the northern part of India. The state's contribution to the country's crop production has been considerable, especially for crops such as rice and wheat. The total cultivable area of the state is 4.2 million hectares, which constitutes only 3% of the net area sown in the country. However, with this small area, Punjab ranks 7th as gross producer of wheat in the world, and it generates third largest marketable surplus after Canada and Australia, which is about one tenth of the global trade in wheat. In case of rice, its market surplus is 2nd only to Thailand at the global level. Agriculture is still the dominant source of livelihood for the people of the state. More than 50% of the rural population is still dependent upon agriculture for its livelihood and employment. However, over the years, agriculture yield has stagnated in the state while cost of cultivation has increased significantly. Instead of crop diversification, the wheat and rice cropping pattern is spreading across the state which in turn has impacted agriculture yield significantly.[39] The state has produced about 46 MMT of crops during the year 2021-22[40]. These include crops such as rice, wheat, bajra, maize, etc. Further, the crop production was analyzed to arrive at the residue available through these crops based on the crop specific residue ratio, which has computed at 67.2MMT. Subsequently, the residue obtained was subject to surplus factors, specific to each crop, to arrive at biomass surplus available for utilization, estimated at 13.7 MMT.

Figure 58: Crop production, residue and biomass surplus in Punjab

Crop production 46.3 MMT → **Crop residue** 67.2 MMT → **Biomass surplus** 13.7MMT

While the secondary assessment was undertaken to arrive at the availability of biomass which can potentially be utilized for pellet production, as a next step, the team carried out meetings with stakeholders in the state to understand the current and future market of pellets in India. In this regard, the team carried out consultations with pellet manufacturers, which has reflected that **the current pellet manufacturing capacity in the state is estimated at 14,000 MT/month of non-torrefied pellets, and another 300MT/month of torrefied pellets.** These are primarily based on paddy straw, mustard straw, sugarcane, etc. The state has large concentration of briquette manufacturers. Cumulatively, the pellet manufacturers are utilizing **235,200 MT** of agro-based residue annually for pellet production in the state.

Figure 59: Snapshot of field visits in Punjab

Pellet and Briquette Manufacturers

- **A2P Energy Solution Private Limited:** Manufacturing capacity of 1,200 MT/month of non-torrefied pellets and 300MT/month of torrefied pellets; based on paddy straw.
- **Ecostan India Private Limited:** Manufacturing capacity of 3,600MT/month of non-torrefied pellets, mainly based on paddy straw with some seasonal additional of sugarcane, mustard, etc.

Equipment Manufacturers

- **Nishant Bioenergy Private Limited:** Manufacturing capacity of 250 Kgs per hour to 2 Tons per hour for non-torrefied and 20 TPD and 40 TPD for torrefied ones; and an estimated lead time of 03 months.
- **Ecostan India Private Limited:** Manufacturing capacity of 1/2/3/5 Tons per hour for non-torrefied pellet machines. The usual lead time is 03 months, while a machine per day can be manufactured.
- **New Lehra Industries:** Manufacturing capacity of 700/1300/1800 Kgs per hour machines. The usual lead time is 02-03 months, with 05 machines per month that can be manufactured.

39 https://finance.punjab.gov.in/punjab-at-a-glance, accessed on June 30, 2022

40 https://agri.punjab.gov.in/sites/default/files/Agricultural%20Statistics.pdf, accessed on June 30, 2022

The pellet production capacity of manufacturers range from 2 Tons per hour to 6 Tons per hour; translating to 1,200 MT/month to 3,600 MT/month. Punjab being home to number of industrial belts in areas such as Ludhiana, Jalandhar, Amritsar, Sangrur, etc., the demand for briquette is considerably higher. Further, the state has rice and wheat as the key crops, thus paddy straw is the widely used biomass for manufacturing of pellets. The discussions have revealed that the key consumers of pellets include food processing, foundry, iron and steel, pharmaceuticals, etc. The discussions have also reflected the preference towards briquettes by industries owing to lower cost compared to pellets and ease of usage in process industries. Some of the key inputs provided by stakeholders are summarized below –

Table 45: Biomass profiling in Punjab based on inputs shared by stakeholders

Parameter	Output
Cost of raw biomass procured	• Paddy straw – INR 1,800 – 2,600/MT (during season) and INR 3,000 – 5,000/MT (off-season) • Saw dust – INR 4,000 – 8,000 / MT
Selling price of pellet (ex-factory)	INR 9,000 - INR 11,000 / MT
Typical Production capacity	0.5-2 TPH
Pellet dimension	6 – 14 mm
GCV of pellet produced	3,200 – 3,600 kCal/kg for non-torrefied, and 3,700-3,800 kCal/Kg for torrefied.
Moisture of the pellet produced	About 10%
Ash content	5-10%
Wastage in conversion	1-2%
Binding material	Inbuilt moisture (15-20%)
Major Pellet off-takers	Industries such as food processing, foundry, iron and steel, pharmaceuticals
Make of the pellet machine	• New Lehra, Ludhiana • Ecostan India Private Limited • Nishant Bioenergy Private Limited
Cost of civil construction of the facility	INR 50 – 75 Lacs for 1 TPH capacity plant
Land Requirement for placing the pellet mill	500 – 800 sq. mtr. for machinery up to 2 TPH capacity
Storage facility for raw material and pellets	~500 sq. mtr. for storing 1000 - 1500 MT raw material
Requirement of labour to run the plant	4-6 labourers: 1-2 for biomass cleaning and feeding; 1-2 operators for machine; 2 for packaging

Key Insights from Punjab

- Punjab is one of the key agrarian states in India, however the key crop produced include paddy straw.
- Paddy straw is one of the most challenging crops for pellet production since the crop has high moisture, ash and silica content. These characteristics make pellet a difficult crop to manufacture pellets.
- In case paddy straw is used for pellet, it is expected that the preventative maintenance schedules could be more frequent, thus reducing the plant performance.
- The GCV of pellet produced through paddy straw is in the range of 3,200-3,300 kCal/Kg, whereas other crops such as mustard straw, groundnut shell can provide pellets with GCV of around 3,800-4,200 kCal/Kg.
- Paddy straw is also widely used for other usages such as fuel in biomass power plants, for CBG production, etc.
- Such other usages of paddy straw and availability of the same only during two months in a year inflate the cost of this biomass during rest of the months in a year.
- Pellet manufacturers use other crops such as mustard straw, groundnut shell, saw dust, sugarcane thrash, etc. for pellet manufacturing.
- Biomass in form of briquette is widely used in Punjab for industries such as food processing, dairy, textile, chemicals, foundry, iron and steel, etc.
- These industries are not very price sensitive, compared to power plants, and thus can offer inflated prices of briquettes as well to an extent.
- Punjab has two of the leading pellet equipment manufacturing companies – Ecostan India Private Limited and New Lehra Industries which manufacture combo machines which can produce briquette and pellet with a change of die. The two can produce 1 machine per day and 5 machines per month respectively.
- Besides, A2P Energy Solutions and Nishant Bioenergy Private Limited have developed in-house torrefaction technology and have realized higher GCV of pellets.
- Torrefaction is a costly process, and, at present, pyrolysis is being adopted which is not environmentally sustainable and releases volatile matter. Carbonization is not being adopted at present due to the high cost of process / equipment associated with it.

Key Risks Associated with Pellet Manufacturing in Punjab

Paddy straw available in abundance: Paddy straw is one of the key biomass residue available in the state of Punjab. However, paddy straw is one of the most challenging crops to be used for pellet production. This is due to the fact that paddy straw contains one of the highest silica content which results in high ash content upon combustion, and thus increased frequency of boiler shutdown maintenance. Presence of silica in the biomass also reduces the mix of other volatile matter and thus reduces the GCV to the extent of 3,200-3,300 kCal/Kg for pellets thus produced. Besides, paddy straw also carries high moisture which needs to be dried considerably to be able to produce pellets. Hence, the pellets thus produced from paddy straw are not ideal for coal fired power plants and thus require blending with other crops to make them fit for co-firing. Further, the biomass users rely on other crops as well such as mustard husk, groundnut shell, etc. which are bought from other states, resulting in increased transportation cost, compared to state grown crops.

Volatile pricing of biomass: Biomass being an unorganized market in Punjab is susceptible to price rise, depending upon the demand in the market. Biomass aggregators have reported price rise to the extent of two to three times for several crops in last few years due to sudden increase in demand. Such volatility in price of biomass affects the cost of pellet thus produced and could be unaffordable for suppliers who are price sensitive.

Alternate usages of biomass: There are a number of industries in Punjab which utilize biomass for their processes. These include biomass power plants which use raw biomass, and there are industries like iron and steel, textile, dairy, pharmaceuticals, etc. which utilize biomass briquettes in their processes. These consumers have steady and long-term demand for biomass, which is often fulfilled by briquette and pellet manufacturers in the state. Besides, due to high demand for briquettes, there is a large concentration of briquette manufacturers who seem comfortable with their arrangement and plans to continue with supply of briquettes.

Price of biomass offered by other users: The other industries consuming biomass, except for biomass power plants, are not very price sensitive and thus have a cushion to absorb slight fluctuations in the price of briquette/pellet. This helps manufacturers in continuing briquette and pellet production for supply to such industries.

Payment mechanism: The payment mechanism adopted by industries is usually upfront, advance or paid within a week's time of delivery of briquette/pellet, which helps the manufacturers maintain a steady cash flow. Timely payments help such manufacturers in procuring raw biomass for future briquette and pellet manufacturing and thus maintain continuous supply of briquette and pellets.

Biomass Pellet Production Potential in Punjab

Punjab has an estimated biomass surplus of 13.72 MMT that can be used for manufacturing pellets. The state mainly grows crops like rice and wheat, with contribution from other crops. The leading districts with crop production concentration include Sangrur (3.31 MMT), Gurdaspur (3.06 MMT), Hoshiarpur (2.96MMT), Ludhiana (2.72 MMT), and Bathinda (2.57 MMT) of the 46 MMT of crop produced. The availability of biomass aggregators / suppliers reflect the ease of aggregation of biomass from various farmers for pellet manufacturing, given their wide network and connect with farmers. The biomass collectors / suppliers act as potential linkage between the biomass pellet manufacturers and farmers, and act as aggregator to ensure availability of biomass for pellet manufacturing. The presence of biomass aggregators / suppliers in each of these districts is reflected below, which can help pellet manufacturers aggregate biomass for pellet manufacturing.

Table 46: District wise crop production in Punjab

District	Crop Production in FY21 (Metric Tonnes)	Number of biomass aggregators/suppliers
Amritsar	1,987,200	2
Gurdaspur	3,062,000	2
Hoshiarpur	2,955,300	2
Jalandhar	2,495,600	3
Kapurthala	1,339,900	2
Ludhiana	2,716,500	4
Patiala	2,185,500	4
Rupnagar	689,300	2
Sangrur	3,305,500	2
SAS Nagar	458,300	2
Tarn Taran	1,605,400	4
Fatehgarh Sahib	991,300	5
Bathinda	2,570,800	3
Fazilka	2,324,300	3

While the above present the presence of biomass aggregators / suppliers in leading districts of Punjab, however, it would be important for pellet manufacturers to consider procurement of biomass from a range of 50-60 kms, beyond which the transportation cost would be high, which may make biomass procurement unviable. Besides, Punjab mainly grows paddy straw which has high moisture and silica within, which makes it complex to manufacture quality pellets. It has been observed from the discussions with stakeholders that the GCV offered by such pellets is in the range of 3,200-3,300 kCal/Kg, which is lower than those offered by other crops such as mustard, ground nutshell, etc. As paddy straw contains high silica, the continuous usage of pure paddy may not be favourable for power plants in long run. Thus, it would be important for pellet manufacturers to also look at districts within the range of 50-60 kms of neighbouring states such as Rajasthan, Haryana to source other crops which may improve the quality of pellets.

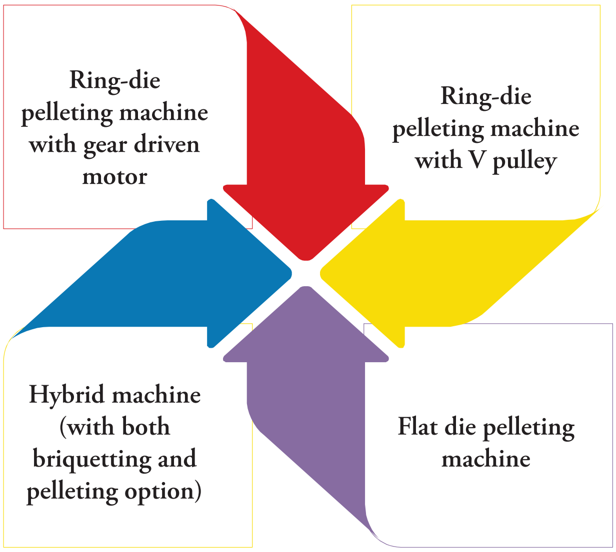
7.2.2. Biomass Pellet Equipment Manufacturing Assessment

The Indian market for biomass pellets has been growing rapidly in the last 6-7 years. Off late, biomass pellets are being utilized by power plants for generating electricity, especially after GoI's mandate of co-firing in thermal power plants and building heat in industries. As such, the demand for machinery for pellet manufacturing has also been on a rise in the country. Currently, two varieties are being offered in India – small-scale and large-scale machines and the pellet machine manufacturers are concentrated in Gujarat and Punjab. Other than the Indian make, the pellet machines are also being imported from Europe, China and USA. Typically, a pellet mill consists of grinder, hammer mill, flash dryer, dust separator, pellet machine, sieving system and a cooling system. The requirement of these individual equipment depends on the raw material being used to produce a pellet. Traditionally, the biomass utilization has been in form of raw biomass or in form of briquette, while pellet formed a fraction of this utilization. However, with recent mandate notified by the Ministry of Power on coal based thermal power plants to co-fire a portion of biomass pellets for power generation, the pellet demand India has witnessed considerably high traction. Besides, some of the industries have also stared deploying pellets owing to its intrinsic benefits such as small size, ease of combustion, etc.

The process of pellet manufacturing has been detailed in earlier sections. While the general principle of pellet manufacturing remains similar, the variance is witnessed in the type of die used and motion given to produce pellets.

The pellet manufacturing in India is mainly carried out through following techniques –

Figure 60: Type of machinery for pellet and briquette manufacturing



The pellet manufacturing process involves die of suitable size to produce pellets. However, the process of providing motion and transfer of energy to die differentiates from one process to another, as explained below -

Ring-die Pelleting Machine with Gear Driven Motion

The ring-die machines which are aligned with gear are placed vertically and the biomass fed is distributed over the inner surface of a rotating, perforated die ahead of each roll, which compress the feed mass and compress it into the die holes to form pellets. The motion is provided by a gear which compresses the raw biomass from the top and makes the same pass through the die to produce pellets.

These machines are produced by Servoday, Nugreen Energy in India.

Ring-die Pelleting Machine with V Pulley

In this case, the ring die is placed vertically, and the motion given to drive material through the pellet mill is usually through a pulley which is aligned in a V-shape. This type of arrangement provides a reciprocating motion, and the biomass passes through the mill to produce pellets.

These machines are produced by Global Agrotech Engineering, Satyajit Renewable Engineering, B.K Engineers, SMS Hydrotech, JS Pelleting Technologies, Global Namdhari Engineers.

Flat Die Pelleting Machine

Generally, there are two types of flat die pellet mills in the market, the rotating die type and the rotating roller type. The former one has a stationary roller with the rotating die while the latter has a stationary die with a rotating roller. Adopting vertical principle, the raw materials drops down by its own weight into the pelletizing chamber where they are compressed between the rollers and die to form pellets by going through the die holes.

These machines are produced by Raghavendra Industries, Nishant Bioenergy Private Limited.

Hybrid Machine (with both Briquetting and Pelleting Option)

Traditionally, the usage of biomass has been in the form of briquette for process industries. However, with increase in demand for pellets, some of the equipment manufacturers have redesigned their machines to allow both pellets and briquettes to be manufactured using the same machine. In such cases, the mechanism remains the same, except for change of die. In case of pellets, die with a diameter of up to 25 millimetres is used, whereas in case of briquettes, die with a diameter of 60 millimetres or above is deployed. Usually, flat dies are used in hybrid machines. The motion of the machine is a reciprocating in nature, wherein the force exerted on the raw biomass pushes it through the die to make it pellets. Besides, the output from such machines is reduced to 60% when produced pellet, compared to originally produced briquettes.

These machines are produced by Radhe Engineering, New Lehra Industries, EcoStan India.

The following table compares the flat die with the ring die used for pellet manufacturing –

Table 47: Comparison of flat die with the ring die used for pellet manufacturing

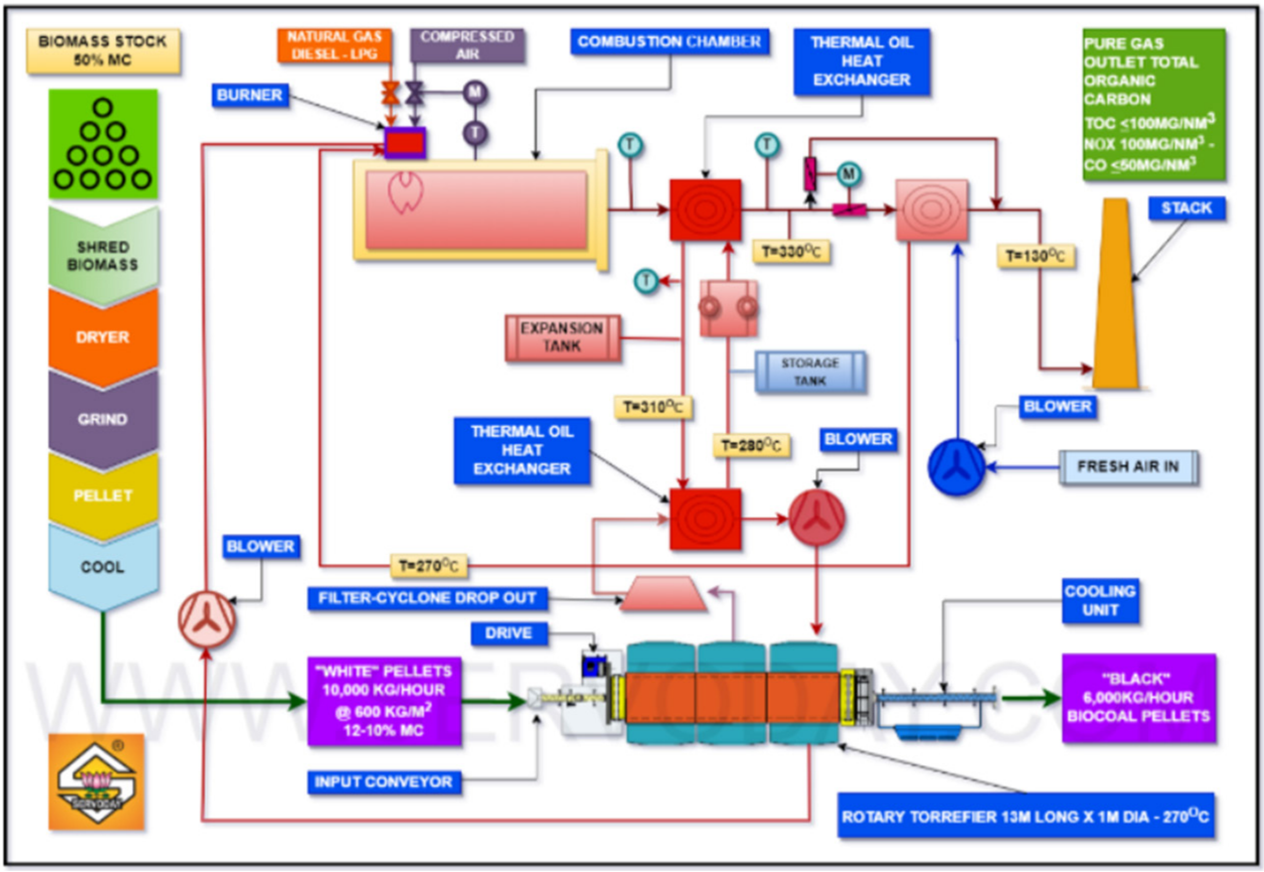
Flat die	Ring die
Advantages	
• Easy to clean • Quick access to chamber • Ease of visibility of pellets produced • Wider tolerance	• Lower cost of roller and die and other consumables • Extra friction resulting in more heat and better quality of the pellets
Disadvantages	
• Possible uneven roller and die wearing • Slipping action of rollers	• Extra friction resulting in more energy consumption • Large size and weight • Difficult access to rollers and die • High cost

Table 48: Key inputs of consultations with equipment manufacturers across states

Pellet equipment Manufacturer	Type of Machine	Capacities offered	Cost of Machine	Pellet size (diameter)	Area required for equipment	Power consumption (HP)	Cost of Torrefaction	Warranty (years)	O&M Cost (per MT)	Lead time (months)	Production Capacity no. of machines per month)
Global Agrotech Engineering, Gujarat	Ring die (v pully)	0.5 – 2.4 TPH	INR 45 Lakhs / 1 TPH	6-10 mm	500 – 800 sq. mt.	50-80	-	1	INR 1100 – 1200	1.5	4-5
Radhe Engineering	Combo	0.6 – 1.5 TPH	INR 30 Lakhs / 1 TPH	8 mm		48 – 93	-	1	INR 1200 – 1800 / MT	1	5-6
Satyajit Engineering	Combo and ring die	1.5 – 3 TPH	INR 55 Lakhs / 2 TPH	8-20 mm	700 – 1200 sq. mt.	90 – 120	-	1	Combo - INR 1200 – 1500 Ring die – INR 2000 – 2500	2	Combo – 4 Ring die – 2
Servoday Group	Ring-die with gear driven motor	1 – 12 TPH	INR 2.1 Crores / 1 TPH capacity	6-8 mm	500 – 1000 sq. mt.	170 – 420	INR 38 Crores for 8 TPH machine	1	INR 1700 – 2000	3 – 5	2-3
Gangotree Energy Projects Pvt Ltd, Maharashtra	Rotary flat die	0.05-0.25 TPH	INR 30 lacs + GST for 250 kg/hr	6-25 mm	600 sq. ft per ton	100-130	-	1	INR 1000	Not found	1-2
Nishant Bioenergy Pvt Ltd, Punjab	Flat die	0.25-2TPH	INR 25-75 Lacs+ GST	8 to 12 mm	1500 sq mt per ton	130	INR 2,500/ Ton	1	INR 450-800	3	4-5
Ecostan India Private Limited, Punjab	Combo and ring die	1/2/3/5 TPH	INR 50 Lacs – INR 1.5 Cr + GST	8 to 20 mm	2000 sq ft per ton	120	-	1	INR 2,000	3	15
New Lehra Industries, Punjab	Combo and ring die	0.7/1.3/1.8 TPH	INR 30 – 70 Lacs + GST	8 to 20 mm	2000 sq ft per ton	65 – 130	-	1	INR 2,000	3	5-10
Raghavendra Industries	Flat Die	0.25-1 TPH	INR 10-15 Lakhs	6-15 mm	300-400 sq. mt.	50		1	INR 1500	1-1.4	4-5
Sree Engineering Works	Flat Die	0.15-1.5 TPH	INR 5.4 Lakhs/1.5 TPH (only pellet m/c)	8-20 mm	300-500 sq. mt.	20-75		1	INR 1200-1500	1	4-5

Typically, labour required to run these machines ranges between 3-4 people which includes 2-3 labourers for feedstock feeding and 1 operator. In terms of the production cost, typically, for combo machine, the pellet production cost ranges between INR 1500 – 2000 / MT and for ring die machine, the pellet production cost ranges between INR 2500 – 3000 / MT. The production cost is also reflection of the raw material used in the machinery and the location of the pellet manufacturer. For example, in Gujarat the production cost is lower as compared to Rajasthan where paddy is used a raw material which has higher quantity of silica which, in turn, increases the wear and tear of the die. In Rajasthan, the die replacement shall be required every 35-40 hours. However, in Gujarat, since groundnut shell and mustard husk are majorly used as raw materials, which are drier in nature and have low silica content, the die can operate up to 200 – 300 hours. Here the operational cost of the machinery would be lower. These machines also require regular greasing. For some of them lubricant needs to be stored in the oil tank and automatic greasing keeps taking place and for some, such as Global Agrotech Engineering, manual greasing needs to be undertaken every 24-48 hours. For automatic greasing, oil tank needs to be filled in once in every month (80 -100 litre oil tank).

Furthermore, out of the four equipment manufacturers in Gujarat, only Servoday offers torrefaction through torrefaction reactor. Servoday offers torrefaction using dry superheated steam as the heating medium to replace the traditional air/oxygen methods of drying. This dramatically improves the efficiency of the drying process whilst at the same time using a safe, invisible dry gas being used at atmospheric pressure. The process followed by Servoday is depicted below:



7.3 Economic and Financial Analysis of the Feasibility of Using Biomass for Industrial Steam Applications

With the recent hikes in fuel prices, industries are switching to cheaper options of fuels. At the same time, industries are also opting for clean and renewable fuels from the sustainability and environment protection perspective. Biomass in recent time has become one such option for the industries. Using biomass for green heat/ steam generation for industrial steam applications is a feasible and increasingly popular option for sustainable energy generation. Biomass in various forms such as wood chips, agricultural residues, pellets and briquettes and dedicated energy crops that can be burned or processed to produce steam for industrial processes. While evaluating the feasibility of using biomass for industrial steam applications, below are some considerations:

- **Fuel Availability**: The feasibility of using biomass depends on the availability of suitable biomass feedstocks in the region where the industrial facility is located. It's essential to assess the local biomass supply chain and ensure a consistent and reliable source of feedstock.
- **Energy Content:** Different biomass feedstocks have varying energy content, which affects the efficiency and cost-effectiveness of steam generation. Higher energy content feedstocks, such as briquettes or certain agricultural residues, are typically preferred by the industry.
- **Equipment Compatibility:** Converting an industrial facility to use biomass for steam production may require modifications to existing boilers or the installation of new equipment specifically designed for biomass combustion. The compatibility of existing infrastructure should be evaluated.
- **Emissions and Environmental Regulations**: Using biomass for steam generation can be environmentally friendly if managed correctly. However, it's essential to comply with emissions regulations and implement pollution control technologies to minimize environmental impacts.
- **Energy Efficiency**: Biomass boilers and combustion systems can be efficient, but the design and operation of the system must be optimized to ensure maximum energy efficiency.
- **Fuel Storage and Handling**: Biomass fuels often require special storage and handling considerations, as they can be bulky and have unique characteristics. Proper storage and handling are essential to prevent spoilage and ensure a continuous fuel supply.
- **Cost Considerations**: The initial investment in biomass infrastructure and ongoing operating costs should be compared to the potential cost savings or benefits associated with using biomass, such as reduced fuel costs or access to incentives or subsidies for renewable energy.
- **Sustainability and Carbon Footprint**: Biomass is considered a renewable energy source when managed sustainably. Assessing the sustainability of the chosen feedstock and considering its impact on the carbon footprint is crucial for long-term feasibility.

With the recent development of technologies and availability industries are opting for retrofitting and using biomass in the existing boilers whereas biomass-based steam boilers or multifuel based boilers are preferred by the industries.

7.3.1 Technical Requirement for Modifications in the Existing Boiler for Using Biomass

As per the interaction with various industries, it was found out that if industry is looking to set up a new biomass-based boiler, the high upfront cost of such boilers pose a challenge. Although biomass boilers are economical to operate due to their fuel, the boiler itself costs around 10 times more than a more conventional gas-fired boiler. Another challenge faced by the industries is arranging a space for biomass fuel storage. It is important to store the fuel in a dry place to maintain its quality. This involves a considerable investment by the industries. Another challenge is the cost of retrofitting of feeding mechanism in the conventional fuel-based boilers. It also requires frequent maintenance and cleaning of ash. The maintenance required varies depending on whether the process plant uses a manual or automatic biomass boiler. Manual biomass boilers require cleaning of ash every week, whereas automated boilers offer self-cleaning.

While looking at MSMEs, which typically deploys small boilers with capacity ranging from 3 – 10 TPH and the boiler technology deployed typically does not allow another type of fuel to be used in the boiler. Also, the combustion system of the boiler being small in the size also prohibits the blending of fuel.

Though the discussion with few industries suggested that blending of fuel or biomass is possible in the existing set up by retrofitting i.e., conversion of existing technology. Retrofitting is done to the below set up to use biomass in the existing boiler:

- Fuel feeding system
- Combustion system
- Pollution control system based on local regulations and compliances

Fuel feeding systems in boilers are critical components that deliver the fuel (solid, liquid, or gaseous) to the combustion chamber, ensuring efficient and controlled combustion. The choice of a specific fuel feeding system depends on the type of fuel, boiler design, and application. As per the consultations it was found out that the below feeding systems are suitable to handle solid fuels such as biomass pellets and briquettes:

- **Manual Feeding:** In small-scale or simple boilers, fuel can be manually loaded into the combustion chamber. This is common for some solid fuel boilers and is suitable for biomass-based fuels.
- **Mechanical Stoker:** Mechanical stokers are devices that automatically feed solid fuels like coal or biomass into the combustion chamber. There are different types of mechanical stokers, including chain grate stokers, vibrating grate stokers, and underfeed stokers.
- **Screw Feeder:** Screw feeders are used to transport and feed solid biomass fuels, such as wood chips, sawdust, or pellets, into the combustion chamber. They are commonly used in small to medium-sized biomass boilers.
- **Pneumatic Conveying:** In some cases, particularly with fine powdery fuels like coal or biomass pellets, pneumatic conveying systems are used. These systems use air pressure to transport fuel from a storage silo to the combustion chamber.
- **Dual-Fuel Systems:** Some boilers are equipped with dual-fuel systems that can switch between different types of fuels. This provides flexibility in choosing the most cost-effective or available fuel source.
- **Reciprocating grate fuel feeding system** is a type of fuel feeding mechanism commonly used in biomass boilers, waste-to-energy facilities, and some solid fuel-fired boilers. It's designed to feed solid biomass or other fuels into the combustion chamber for efficient combustion

The consultations with the industries suggested that the fuel feeding systems such as dual fuel system, reciprocating grate and manual feed systems are being preferred for the boiler.

Another aspect is the changes required in the combustion system to burn the biomass-based fuels. The combustion system in boilers for biomass plays a critical role in efficiently converting the energy stored in biomass materials into heat for various applications. Biomass combustion systems can vary in complexity and design depending on the type of biomass fuel, boiler technology, and specific requirements. Based on discussions, key aspects of the combustion system in biomass boilers:

- **Biomass Fuel Preparation:** Biomass fuels come in various forms, including wood chips, sawdust, wood pellets, agricultural residues, and more. The fuel must be properly prepared to meet the boiler's specifications. This may involve shredding, drying, or pelletizing to achieve the desired moisture content and size.
- **Fuel Storage and Handling:** Biomass fuel needs appropriate storage and handling systems to ensure a continuous and reliable fuel supply to the boiler. This can involve silos, conveyors, augers, or other equipment.
- **Primary and Secondary Air Supply**: Combustion requires the controlled supply of air to support the burning process. Typically, there are primary and secondary air supply systems. The primary air is used for fuel combustion, while secondary air is used to complete the combustion process and reduce emissions.
- **Grate or Bed Systems**: In many biomass boilers, a grate or bed system is used to support and burn the fuel. The fuel is spread evenly on the grate, and combustion occurs as the fuel moves through the combustion zone. Grates can be fixed, vibrating, or reciprocating, depending on the boiler design.
- **Gasification:** Some advanced biomass boilers use gasification technology to convert solid biomass into a combustible gas. The gas is then burned in the combustion chamber. Gasification can improve combustion efficiency and reduce emissions.
- **Control Systems:** Biomass boilers often incorporate advanced control systems to optimize combustion. These systems may include sensors to monitor temperature, oxygen levels, and emissions, as well as automated adjustments to maintain optimal combustion conditions.
- **Emissions Control:** Emissions control technologies, such as electrostatic precipitators or baghouses, are often used to reduce the release of particulate matter and other pollutants into the atmosphere. Flue gas cleaning systems can help meet environmental regulations.
- **Ash Handling:** Biomass combustion results in ash generation, which needs to be removed and handled. Ash can be a valuable resource for certain applications, such as fertilizer or construction materials.

- **Maintenance and Cleaning:** Regular maintenance is essential to ensure the combustion system's efficient operation. This includes cleaning the combustion chamber, inspecting and repairing components, and managing ash removal.

Consultations with few select MSMEs revealed that the boiler being small in size does not permit the blending and their boiler design and combustion system is specifically designed to handle one particular type of fuel. Whereas the biomass combustion requires a chamber design to be larger in size to handle same amount of fuel.

Suitable form of Biomass Used in the Boiler

The suitability of the biomass depends on the type of boiler and its combustion technology. Based on the consultations it was revealed that the common forms in which biomass is suitable for use in boilers include:

- **Wood Chips:** Wood chips are small pieces of wood that result from the chipping or grinding of logs, branches, or wood waste. They are suitable for use in many types of boilers, including large industrial and small residential boilers. Wood chips are often used in biomass boilers due to their consistent size and moisture content.
- **Pellets:** are a highly processed and standardized form of biomass. They are cylindrical in shape and typically have a moisture content below 10%. Pellets are commonly used, offering high energy density and efficient combustion.
- **Sawdust:** Sawdust is a byproduct of wood processing and is often used as a biomass fuel. It is suitable for boilers with appropriate combustion technology, such as fluidized bed or cyclone boilers. Sawdust can be used alone or mixed with other biomass fuels.
- **Agricultural Residues:** Crop residues like corn stover, rice husks, and wheat straw can be used in boilers after suitable preparation and processing. These residues are typically used in boilers designed for biomass with solid fuel combustion systems.
- **Wood Logs:** In some traditional and residential boilers, whole wood logs can be used. These boilers are often designed for relatively small-scale applications.
- **Biomass briquettes** are a type of compressed biomass fuel that are used as an alternative to traditional fossil fuels like coal, oil, and natural gas. These briquettes are produced by compacting various biomass materials into a uniform shape and size, typically resembling small cylinders, logs, or other geometric shapes. The process of making biomass briquettes involves using pressure and sometimes binders to hold the biomass particles together.

It's essential to ensure that the chosen biomass form is compatible with the boiler's combustion system and that fuel quality and moisture content meet the boiler's specifications. Proper storage, handling, and processing of biomass fuel are also critical to ensure efficient and clean combustion in the boiler.

7.3.2. Biomass Type and form Best Suited for a Particular Type of Boiler and Blending Percentage:

Based on the consultations and secondary research it was found out that biomass in a particular form are being used in the boilers for better efficiency. The table below shows the biomass type and form for each select industry category and the percentage blending that can be done with retrofitting for use of biomass:

Industry category	Biomass Used	Percentage blending with retrofit
Industry category	Biomass Used	Percentage blending with retrofit
Textile	Wood, Upla, Pellets and briquettes	Up to 20%
Food Processing	Wood chips and briquettes	Up to 20%
Pharma	Pellets and briquettes	Up to 20%
Paper and Pulp	Wood chips, wood logs, sawdust, rice husk and agro waste	Up to 100%
Chemical	Briquettes	Up to 20%
Dairy	Agri residue, wood chips, pellets	Up to 20%
Ceramic	Saw Dust, Briquette	Steam Boilers are not used. Biomass gasification is the appropriate technology
Leather and Footwear Industry	Pellets and briquettes	Up to 20%
Rubber	Wood chips, Pellets and briquettes	Up to 20%
Aluminium Die Casting	Pellets and briquettes	Steam Boilers are not used. Biomass gasification is the appropriate technology

The above results are completely based on the consultations and are indicative the actual results are to be verified through site visits and pilots.

7.3.3. Cost Assessment for Biomass Utilisation in Existing Process

Biomass cofiring in industries refers to the replacement of a portion of conventional fossil fuel (wood, coal, furnace oil etc.) usage with biomass for steam/heat generation for industrial applications. In most cases, this takes place by mixing of biomass with conventional fuel before burning in the boilers.

The moisture content is different for each biomass and also depends on the form of feeding (raw biomass / briquettes/ pellets). Based on stakeholder discussions, cofiring with coal or wood chips aids the combustion of biomass in the boilers by tackling the issues of varying moisture content.

In additions to the savings in terms of reduced carbon emissions from biomass cofiring, there are potential savings by way of replacement of costlier coal by cheaper biomass.

The discussions with stakeholders comprising of boiler manufacturers, pellet manufacturers and industry highlighted the fact that a case-to-case assessment is required to determine whether reconfiguring of boiler is required for biomass cofiring or not. The same shall be determined by site assessments by specialized boiler manufacturers. In some cases, a one-time reconfiguring or retrofitting cost maybe required to be incurred by the industry player, the cost of which shall depend on the following factors:

i. technology on which the boiler is based like manual fired boilers, bubbling bed boilers, fluidized bed boilers, etc.

ii. configuration of fuel feeding mechanism in place like manual feeding, travelling grate, etc.

iii. type of biomass raw material and its form that is proposed to be utilized for cofiring. For example, in some cases where a fluidized bed boiler based on coal is to be reconfigured to use rice husk, no modification or retrofitting will be required in the feeding mechanism.

iv. existing surface area of boilers and for effective steam generation from biomass fuel, in some cases, increase in boiler/ furnace surface area may be required

v. introduction of any new system (if any) like grates, steam pipes, etc.

The discussions with stakeholders like boiler manufacture and equipment supplier revealed the cost as presented below:

Table 49: Cost of Boiler and retrofit technology

Boiler Capacity Range	Tentative Cost	Cost for Retrofitting
3-10 TPH	INR 50 Lakhs to INR 3 Crores The cost may go upto 6 Crores deploying advanced technology with control and monitoring systems	Another 50 Lakhs to 1 Crores* **Depending local environmental regulations and compliance*

The above cost are for the boilers where the fuel feeding system is suited for single type of solid fuel.

The cost associated with multifuel or dual fuel feeding system is presented below:

Table 50: Cost of Multi Fuel Boiler and retrofit technology

Boiler Capacity Range	Tentative Cost	Cost for Retrofitting
3-10 TPH	INR 75 Lakhs to INR 3.5 Crores *The cost may go up to 7 Crores deploying advanced technology with control and monitoring systems*	Another 50 Lakhs to 1 Crores* **Depending local environmental regulations and compliance*

The costs mentioned above is not a challenge for the industries but the major bottleneck is sourcing of fuels like biomass whose availability is largely seasonal and another major cost is the operational cost which industry has to manage on day-to-day basis.

Another concerns for MSMEs are the storage of the fuels specially biomass fuels which needs a proper storage facility to maintain its moisture content.

We conducted a cost benefit analysis for switching to biomass based fuels, the table below presents a comparative assessment:

Table 51: Cost Benefit Analysis for using Biomass

Sr. No.	Description		Typical fuels			
			Briquette	**Natural Gas**	**Furnace Oil**	**Indonesian Coal**
	Average Steam Load	kg/hr.	10000	10000	10000	10000
	Steam to Fuel Ratio	kg/kg or kg/sm3	5.3	14.5	13	6.8
	Fuel Consumption	kg/hr. or sm3/hr.	1887	690	769	1471
	Fuel Cost	Rs/kg Rs/sm3	8	66	60	16.5
A	**Cost of Fuel per Hour**	**Rs.**	**15094**	**45517**	**46154**	**24265**
	Average Annual working hours considered	**Hrs.**	**8000**	**8000**	**8000**	**8000**
	Annual Fuel cost	Rs. In Lacs	1208	3641	3692	1941
B	**Power Consumption**	**kw/hr.**	**100**	**35**	**40**	**40**
	Cost of power considered	Rs/kw	7.0	7.0	7.0	7.0
	Annual power consumption cost	Rs in lacs	56.00	19.60	22.40	22.40
C	**Ash Generated**	**kg/hr.**	**151**	**0**	**0**	**0**
	Cost of ash disposal	Rs/kg	0.8	0.8	0.8	0.8
	Annual Cost of ash disposal	Rs. In lacs	10	0.00	0.00	0.00
D	**IBR Operator required**	**No.**	**4**	**4**	**4**	**4**
	Annual cost of IBR operator	Rs. In Lacs	16.80	16.80	16.80	16.80
E	**Labors for Fuel and ash handling plus Fitter & Electrician**	**No.**	**8**	**0**	**0**	**0**
	Annual cost of labors	Rs. In Lacs	19.20	0.00	0.00	0.00
F	**Cost of spares and Maintenance per annum**	Rs. In Lacs	**15**	**2**	**2**	**2**
G	**Water Cost (25 % make up Water considered)**	Rs. In Lacs	**17**	**17**	**17**	**17**
H	**Total Operational Cost per Annum**	**Rs (Lacs)/annum**	**1341**	**3696**	**3750**	**1999**
	Steam Cost In each case	**Rs/kg**	**1.68**	**4.62**	**4.69**	**2.50**
	Saving if replaced with Biomass fuels Rs (Lacs)			**2356**	**2409**	**658**
	Typical Capex Rs (Lacs)		**1000-1200**			
	CO_2 Savings (tons/year)			**15500**	**17500**	**23000**

The cost benefit shows that the using biomass based fuels can help the industries save INR 2356 Lakhs for Natural Gas, INR 2409 Lakhs for Furnace Oil and INR 658 Lakhs for Coal. The analysis also presents the steam cost from biomass which is 1.68 Rs/kg which is almost two times lower than the steam cost from other fuel sources. Thus, the analysis presents a strong case for shifting towards biomass and replace conventional fuels for steam generation.

7.3.4. Biomass storage options for industries

As compared to conventional fuel like coal, biomass is voluminous and due to lower calorific value, is required in larger quantities than coal to produce the same amount of heat or energy. Its handling and storage require more spend on manpower and logistics by any company. Further, the procurement process also needs to factor in the short time frame from harvest to sowing to procure biomass from the agricultural fields. There is a short time period of 20-25 days between rice harvesting and sowing of wheat during which biomass has to be lifted from the fields for industrial usage. The stakeholder discussions revealed that ~1,000 tons of rice straw can be stored in 1 acres of land.

Due to lack of specialized large scale supply chains to manage the procurement process considering the nascent stage of adoption in the country, industries rely on following procurement modes to meet their demand:

i. Procurement of the complete annual quantity of biomass usage post harvesting and storing it at their plant site or warehouses.

ii. Procurement of biomass through multiple biomass aggregators or pellet manufacturers in batches of required quantity throughout the year.

The major expenses in the transport, handling and storage of biomass from field to plant are transportation, land lease rentals for storage, wastage in transportation, protection items like tarpaulin sheets and manpower expenses. Storing biomass in raw form for long periods of time away from the plant is more expensive and cumbersome. The biomass aggregators, therefore, prefer to convert raw biomass to pellets when long term storage is required. Transportation of raw biomass through tractor trolleys instead of pellets/briquettes results in ~5% losses during transport. The delivered cost of biomass in form of pellets is ~10% costlier than delivery in raw form.

If we consider an average time of 9 months before which new harvest is ready for biomass generation, procurement from biomass aggregators or pellet manufacturers once every 3 months would be subject to increase in transport cost due to fuel price escalation. We can consider the annual escalation of 10.5% in diesel prices in Delhi over last 5 years as representation to reflect ~2.6% increase in fuel price every 3 months i.e., ~8% escalation over 9 months. The impact of industrialization has been witnessed in the increase in labour wages in India which has doubled since 1993-94. The wages at plant level, therefore, would be two times the wages to be paid by various aggregators. The plant may prefer to hire half the number of workers, working continuously through the year, as that employed by aggregators (seasonal/informal workers) in order to keep the manpower expenses same in both cases.

The storage of biomass at plant site or at field/aggregators level, assuming raw biomass procurement, has been analysed below.

Evaluation parameter	Biomass storage near to plant v/s near to field	Impact
Land requirement for storage	Equal in both cases	At parity
Land lease rentals	Equal in both cases assuming aggregators are located in same region as the plant. However, the industry located in industrial area may be subject to higher lease rentals as compared to field or land leased by aggregators in rural and internal areas.	At parity for land leased in same region
Spend on protection items like tarpaulin, fire control, etc. Transportation cost handle biomass	Equal in both cases	At parity
Transportation cost	One time procurement in case of storage at plant v/s procurement based on requirement in case of storage at field (say once every 3 months i.e., thrice in 9 months)	Savings in transportation cost by 8% in case of storage at plant
Manpower requirement to handle biomass	Manpower at plant maybe half of the manpower employed at field/ aggregators level (formal labour in case of storage at plant and informal/seasonal labour at field/aggregators level)	At parity in terms of expenses
Wastage	Transport of biomass results in 5% wastage in case of storage at plant. It is convenient to procure pellets in case of storage at field/aggregators level that, however, results in increase in procurement cost by ~10%.	At parity for same form of biomass (raw form) procurement

It is seen from the above parameter analysis that for an industry, storage of biomass at plant site is more economically feasible and ensures better control over the fluctuating variables like losses associated with regular procurement around the year.

7.4 Financial Incentives or Subsidies Available for Biomass-based Industrial Steam Applications

7.4.1. Financial Incentives from MNRE

At present, MNRE provides Financial incentives or subsidies for Renewable Energy for Urban, Industrial and Commercial Applications, as furnished below:—

"Financial assistance available under the Programme on Energy from Urban, Industrial and Agricultural Wastes/Residues for setting up Waste to Energy plant is as follows:—

- Bio-gas generation: Rs. 1.0 crore per 12000cum/day;
- Bio-CNG generation (including setting of Biogas plant): Rs. 4.0 crore per 4800Kg/day;
- Power generation based on Bio-gas (including setting of Bio-gas plant): Rs. 3.0 crore per MW.
- **Biomass Gasifier:**
- **Rs. 2,500 per KWe with duel fuel engines for electrical application**
- **Rs. 15,000 per KWe with 100% gas engines for electrical application**
- **Rs. 2 lakhs per 300 KWth for thermal applications."**

MSMEs like ceramics, Aluminium Die Casting, Leather and Footwear, Tea Processing industry (Analysed in previous sections above) where Gasifiers are deployed using Natural gas for heat requirement can be shifted to Biomass gasifiers and may benefit from the scheme.

Apart from the above Fiscal Incentives provided by the Ministry is furnished below:—

- Concessional Customs Duty and GST at rate of 5% for initial setting up of grid connected projects for power generation or production of Bio-CNG from wastes.
- Preferential Tariff announced by the CERC/SERC."

"The Government of India, through various schemes extends financial support for introducing appropriate solid waste management systems and for setting up processing and disposal facilities. These include the following:—

- Viability Gap Funding Swacch Bharat Mission of MoHUA.
- Loan from IREDA.
- Grants from MNRE for Supporting W to E Projects.

At present, all the schemes are supportive power generation and biomass gasifiers, and there is a need of financial incentives and subsidies which help in promotion of biomass uptake in industries.

7.4.2. Credit Linked Capital Subsidy Scheme

Credit Linked Capital Subsidy Scheme or CLCSS for technology upgradation was launched in October 2000 by the Government of India. The said scheme is directed towards MSMEs to help them improve their technology for optimising revenue generation. However, to become a beneficiary of this scheme, individuals need to meet specific eligibility criteria, among other requirements.

CLCSS was introduced by the Ministry of Micro, Small and Medium Enterprises to boost production of small-scale industries by providing them access to subsidised capital. Under this scheme, eligible enterprises can enjoy a capital subsidy of 15% on loan availed from a financial institution.

The primary objectives of this scheme can be described as the intention to upgrade the plant and machinery of enterprises with state-of-art technology, irrespective of expansion. Besides existing MSMEs, new enterprises which have set up as per CLCSS guidelines can qualify as beneficiaries of this scheme.

- **Businesses can receive up to 15% subsidy on their investment in specific machinery under this scheme. It must be noted that the subsidy comes with an upper limit of Rs.1 crore.**
- Available to those enterprises which have put their money in machinery by availing a term loan from the approved list of financial institutions.
- Industries that are transitioning from small to medium scale by availing loan under CLCSS are also entitled to benefit from this subsidy scheme.
- According to the revised CLSS scheme, an extra 10% subsidy is extended to entrepreneurs who belong to the SC/ST category and hail from the selected districts of the North-East or other hilly terrains.

Industries or MSMEs where Gasifiers are being deployed can benefit by the scheme by shifting to biomass-based gasifiers as the technology is being covered under the scheme. This is presented below:

Industry category	Technology	Advantages
Textile	Biomass Gasifier based water boiler.	Operated by natural fuel, advantageous in comparison to the diesel fired boiler. Environment friendly and easy to operate. Small investment and economic.
Food Processing like namkeen making, meat processing	Biomass Gasifier based Furnace	Replacement of 56 litre/hour diesel with local biomass. Eco-friendly Cost effective
Rubber processing	Biomass Gasifier based drying furnace.	Saving of conventional fuel (diesel/electricity) Reduction of wood consumption up to 50% Environment friendly technology Easy to operate and maintain

As per the analysis of various industry and policies of states and local bodies, its is observed that the there is a need for policies and financial incentives which supports the biomass uptake for steam applications apart from the gasifiers.

7.5 Analysis of the potential revenue streams associated with the use of biomass for industrial steam applications

The use of biomass for industrial steam applications can offer various potential revenue streams, both through cost savings and income generation. The specific revenue opportunities can vary depending on factors such as the scale of the industrial operation, the type of biomass feedstock, and the local regulatory and market conditions. Here's an analysis of potential revenue streams associated with biomass for industrial steam applications:

- **Fuel Cost Savings:** One of the most significant cost-saving benefits of using biomass for steam generation is the reduced fuel cost compared to fossil fuels. Biomass feedstock is often cheaper and can be locally sourced, reducing transportation costs. The difference in fuel costs can directly contribute to the company's bottom line.
- **Renewable Energy Credits (RECs):** The use of biomass as a renewable energy source can generate renewable energy credits. These credits can be sold or traded to utilities or other entities that are required to meet renewable energy targets, providing an additional source of income.
- **Carbon Credits and Offset Programs**: Using biomass can lead to a reduction in greenhouse gas emissions compared to fossil fuels. This reduction may qualify the company for carbon credits or participation in carbon offset programs. These credits can be monetized or used to offset emissions from other operations.
- **Government Incentives and Subsidies**: Many governments offer incentives and subsidies for the adoption of renewable energy sources, including biomass. These can include tax credits, grants, and low-interest loans, providing financial support for the installation and operation of biomass-based steam systems.
- **Excess Heat/ Steam Sales:** If the industrial process generates more steam than needed for internal use, excess heat can be sold to neighbouring businesses or district heating systems, creating a revenue stream.
- **Export of Biomass Products:** Some industrial facilities may produce value-added biomass products, such as wood pellets or biochar, as by-products of the steam generation process. These products can be sold on the market.
- **Maintenance and Service Contracts:** For companies providing biomass-based steam solutions, offering maintenance and service contracts to industrial clients can be a source of recurring revenue.
- **Energy Performance Contracts:** In energy performance contracting arrangements, third-party providers may install and operate biomass steam systems, guaranteeing energy cost savings. The client pays based on the actual savings achieved.

7.6 Summary of the findings

7.6.1. Summary of MSME cluster analysis

The table below summarizes the 11 MSME clusters that were studied in detail where biomass in various forms can be used to produce green heat/ steam in their operations.

S. No.	Industry	Thermal	Electrical	Grade of heat	Boiler Usage	Type of Boiler	Fuel Used	GCV of fuel Used	GCV of Biomass	Type of Biomass used
1	Textile	35%	65%	Low to medium grade	Yes	Steam	Electricity- 71% Coal- 14% Petroleum- 10% Biomass- 3-5%	~4000 Kcal/kg	3000-4500 Kcal/kg	Wood, Upla, Pellets and briquettes
2	Food Processing	50%	50%	Low grade	Yes	Steam / Thermic Fluid	Electricity- 62% Coal- 7% Petroleum- 15% Biomass- 5-10%	<3000 Kcal/kg		Wood chips and briquettes
3	Pharmaceutical	37%	63%	Low to medium grade	Yes	Steam	Electricity- 69% Coal- 5% Petroleum- 17% Biomass- 5-10%	4000-4000 Kcal/kg		Pellets and briquettes
4	Paper	85%	15%	Medium grade	Yes	Steam	Electricity- 49% Coal- 27% Biomass- ~20%	3000-3500 Kcal/kg		Wood chips, wood logs, sawdust, rice husk and agro waste
5	Chemicals	85%	15%	Low to medium grade	Yes	Steam / Thermic Fluid	Electricity- 29% Coal- 12% Petroleum- 7% Other including biomass- 52%	10000 Kcal/kg		Briquettes
6	Dairy	40%	60%	Low to medium grade	Yes	Steam	Electricity- 52% Coal- 4% Petroleum- 25% Other including biomass- 20%	3300-4000 kcal/kg		Agri residue, wood chips, pellets
7	Ceramics	98%	2%	High grade	No	Gasifiers	Electricity- 27% Coal- 30% Petroleum- 6% Other including biomass- 37%	6000 kcal/kg		Saw Dust, Briquette
8	Leather & Footwear	13%	87%	Medium to high grade	Yes	Thermic Fluid	Electricity- 77% Coal- 2% Petroleum- 19% Other including biomass- 2%	3000-5000 Kcal/kg		Pellets and briquettes
9	Rubber	14%	86%	Medium grade	Yes	Steam	Electricity- 69% Coal-9% Petroleum- 15% Other including biomass- 7%	>10000 Kcal/kg		Wood chips, Pellets and briquettes
10	Aluminium Die Casting			Medium to high grade	No	Gasifier	Coal: 14% Electricity- 7% Wood- 59% Furnace Oil- 20%	6000 kcal/kg		Pellets and briquettes
11	Tea Processing			Low to medium grade	No	Gasifier	Electricity- 14% Coal-60%% Petroleum- 15% Other including PNG, biomass- 7%	10000 Kcal/kg		

Low grade heat: < 100 °C; Medium grade heat: > 100 °C; High grade heat: >400 °C

7.6.1. Summary of technical and financial requirement for boiler retrofitting for biomass utilisation

The below tables summarises the technical requirement for boiler modifications so as to use biomass for green heat/ steam production and also the financial implications for such retrofitting or modifications:

Typical size of boilers used in MSMEs	Technical requirement for modifications in the existing boiler	Tentative Cost of Boilers	Cost for Retrofitting
3-10 TPH	• **Fuel feeding system:** Manual Feeding, Mechanical Stroker, Screw Feeder, Pneumatic Conveying, Dual-feeding and Reciprocating grate fuel feeding system • **Combustion system** • **Pollution control system based on local regulations and compliances**	• **Boiler with single fuel handling technology** INR 50 Lakhs to INR 3 Crores per TPH The cost may go up to 6 Crores deploying advanced technology with control and monitoring systems. • **Boiler with multi fuel handling technology** INR 75 Lakhs to INR 3.5 Crores The cost may go up to 7 Crores deploying advanced technology with control and monitoring systems.	Another 50 Lakhs to 1 Crores* per TPH *Depending local environmental regulations and compliance

8 Observations and Recommendations

From various secondary research conducted and consultations with select industries and assessment of 10 MSME industries, various observations are listed below:

- Industries like textile, food processing, chemical, pharmaceutical, rubber, dairy and paper are using steam boilers for their steam requirement
- Industries like footwear, leather, ceramics, aluminium die casting are using gasifiers for their thermal energy requirement
- From assessing these industries, it was observed that, almost all of them are using biomass in some form as an alternate fuel for thermal energy requirement
- Few industries like textile, food processing, chemical, pharmaceutical, rubber dairy and paper have started shifting to biomass-based boilers and are using biomass as high as 76% (Jamshedpur Chemical Cluster) of their total fuel consumption in their operation
- Industries like footwear, leather, ceramics and aluminium die casting have shirted to biomass-based gasifiers
- Tea industries have also shifted to biomass-based gasifiers and have replaced LPG or PNG or diesel with biomass for producer gas
- Few industries like textile, food processing including breweries, pharmaceutical and rubber have opted for biomass-based boilers on Build Own Operate Transfer (BOOT) model and have signed 10-year steam supply agreement.
- Majority of the MSME clusters have boilers in the range of 3-12 TPH
- Blending in existing boilers are not possible due to technological restrictions
- Blending up to 20% is possible with retrofitting on fuel feeding system and combustion system
- Industries are switching to multifuel based boilers and in case of industries are using biomass, fuel feeding system like manual fired or reciprocating grate are preferred
- Operational cost and fuel cost are major challenge for MSMEs as these together constitute more than 80% of the cost
- While using biomass, sourcing of fuel, fluctuating price, and storage are some of the issues
- MSMEs have fair understating of shifting to alternate and cleaner fuel options and have understood the value of greening their operations
- Supportive policies at central level and state level for generation and co-firing but absence for steam generation
- Financial aid for Biomass based gasifiers from MNRE and Capital subsidy from MSME but absence for biomass-based boilers

Recommendations to promote biomass usage in industries

Promotion of biomass usage in industries shall lead to reduction in dependence on polluting fuels like coal which shall in turn result in lowering of carbon intensity of the economy. Due to scale of production, biomass availability can be ensured at lower costs for industries along with benefits like additional income source for farmers, job creation across biomass value chain and self-sufficiency.

The key recommendations that may support uptake of biomass by industries are listed below.

- **Biomass Deployment Obligation:**

Based on the consultations it was suggested that by retrofitting the biomass cofiring or blending can be done up to 20%. A mandate on cofiring target needs to be defined for a period of minimum 5 years.

An initial mandate of 5% can be proposed similar in lines with biomass usage % stipulated by MoP for thermal plants and then can be increased further.

A sample blending target is presented below:

Year 1	Year 2	Year 3	Year 4	Year 4
5%	5%	7%	10%	15%

- **Biomass Exchange and Trading Platform:**

To mitigate the effects of stubble burning and establish a streamlined price mechanism for dry biomass procurement (including agri-waste, animal dung and poultry litter), there is a pressing need to set up a trading platform/marketplace for raw and processed biomass trading. The main aim of intervention is the collection and mobilisation of raw material to the plant/industry, which could be facilitated by a biomass trading platform. On the supply side, developing a platform to collect and process biomass will help generate additional employment opportunities in rural areas and increase the source of income for biomass suppliers. On the demand side, a trading platform will ensure regular and consistent biomass supply for processing in industries and power plants. In the absence of a formal trading exchange, it is necessary to ensure high levels of transparency and clear regulatory frameworks to reduce uncertainty for economic agents and build trust between them. This can incentivise the development of the bioenergy sector in the country.

- **Innovative models like Community Boilers:**

MSMEs have space constraints and storage is a challenge. In order to support adoption of biomass by maximum number of industries, the concept of 'community boilers' can be explored wherein large boilers can be installed in a common space, the output of which can be fed to multiple units. However, this shall require coordination with state local authorities and agencies as the common land lies in their jurisdiction. Licenses, approvals and metering of such operation for the individual units is also a concern. The ministry should issue guidelines and rules for developing innovative models like community boilers so that industry has a wide range of option to adopt biomass.

- **Industrial policy to promote usage of biomass:**

The adoption of biomass by industries is presently being indirectly driven by policies to reduce pollution from conventional fuels and fines/penalties imposed on farmers for stubble burning.

Further, there are policies related to use of biomass for power generation. It is essential for states to bring about specific industrial policies to promote biomass usage which shall result in regulatory guidance for adoption.

- **Price Benchmarking for pellets and briquettes:**

It was observed that there is wide variation in price of pellets and briquettes due to which sometimes industry fail to procure, as a result neither manufacturer are able to sell their pellets and industry is not able to buy in large quantity.

- **Ensuring sustainability of Supply chain:**

The supply chains of conventional fuels like coal and petroleum products have been established and streamlined over the years giving assurance to industry players regarding the availability of fuel for their production requirements. On the other hand, biomass procurement is a nascent and fragment sector and prone to supply shocks due to lack of well-established supply chains. There is requirement from industry players to be insulated from supply shocks to explore switching to biomass.

- **Financial incentives or subsidy for steam application in similar line with Biomass gasifiers for thermal applications from MNRE**
- **Credit Linked Capital Subsidy by MSME:**

In line with existing scheme by MSME, wherein financial aid is being provided for switching to biomass gasifiers for select industries (Textile, Food processing, Rubber).

Other industries with specific technology can be included in the existing list which uses steam for internal operations and incentives being provided for switching to biomass for steam requirement.

- **Public platform for data on biomass availability and suppliers across geographies:**

The data related to availability of biomass across geographies, especially at the district/block level, is not easily available and requires case by-case research. This affects the planning of such projects. Hence, most stakeholders conduct their own analysis to assess the availability of biomass. Subsequently, availability of surplus biomass for bioenergy production may or may not be accurate, time efficient and cost-effective.

It is recommended to have a dedicated platform which has readily available data on biomass availability and suppliers across geographies.

- **Standardising steam supply agreements**

During the consultations and secondary research, it was found out that the industries are switching to new business models wherein the boiler manufacturers are setting up the complete facility in Build Own Operate Transfer (BOOT) model.

The industries are signing 10-year long term steam supply agreement and paying as per the steam being used in their operations.

Currently, there is no proper and set guidelines for MSMEs and only large-scale industries are opting for it. It is recommended to have standard guidelines for industries which enables MSMEs as well and promotes uptake of biomass for steam generation.

- **Awareness creation and knowledge sharing:**

There is a short period of time for farmers to prepare their field for the next sowing season due to which they resort to measures like stubble burning. Nearly 39 MMTPA of paddy straw is burned across north Indian states of Punjab, Haryana, Rajasthan and Uttar Pradesh. The farmers are unaware of the economic value of biomass lying in their fields due to which a substantial amount is destroyed, and its energy value lost.

Knowledge sharing sessions at state level can be organized by MSME to share the best practices with the stakeholders. The reluctance of industry players to adopt biomass can be tackled through roping in industry associations and imparting them knowledge about biomass value chain as such associations are in regular communication with their members for addressing concerns and acting as policy advocacy groups. In addition, sharing of successful deployment stories in the form of case studies, highlighting-key learnings, use cases and benefits accrued at SNA's website can also help promote further uptake.

9 Prioritizing and Shortlisting MSME Cluster for a Workshop

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Based on the assessment of industries, the SME sectors selected are presented in the table below. These are textile, food processing, footwear, paper, bricks, chemicals, pharma, ceramics, rubber, garment and leather, and Al die casting. These are also selected based on availability of biomass in the selected region.

Six locations have been selected for further analysis and assessment. These locations are Ludhiana and Jalandhar, and its respective SMEs are presented in the table. Ahmedabad and Surat in the state of Gujarat have been prioritized for further study. Similarly, Aurangabad and Pune have been finalized in the state of Maharashtra.

Major industry associations in the regions are also identified and same has been highlighted in the table below.

Table 52: Prioritizing and shortlisting MSME cluster for first workshop

Region / Location	SME Sectors	Major Industry Association
Ludhiana – Jalandhar	• Textile, • Food Processing, • Footwear, • Paper, • Bricks	CICU – Ludhiana FIEO – Jalandhar
Ahmedabad	• Chemicals, • Textile, • Pharma, • Ceramics	Vatva Industry Association
Darjeeling	• Food Processing- Tea industry	Industrial Association for Tea Growers*
Surat	• Textile	South Gujarat Textile Processors Association
Pune	• Textile, • Food Processing, • Rubber, • Aluminium Die Casting	The Maratha Chamber of Commerce Industries and Agriculture
Aurangabad	• Textile, • Paper, • Garment and Leather	CIMA

The workshop shall be organized in the selected MSME cluster for capturing the views and suggestions of the industry associations and players.

Annexure 1: Reports and Documents Reviewed

Reports and Articles by BEE

- Report by Bureau of Energy Efficiency (BEE) on Energy Efficiency in Small and Medium Enterprises (SMEs) sector (https://beeindia.gov.in/sites/default/files/Annexure%201.pdf)
- UNLOCKING NATIONAL ENERGY EFFICIENCY POTENTIAL (UNNATEE) (https://beeindia.gov.in/sites/default/files/press releases/UNNATEE%20Report.pdf)
- Reports and articles from Simplified Digital Hands-on Information on Energy Efficiency in MSMEs for promotion of Energy Efficiency and Renewable Energy (https://sidhiee.beeindia.gov.in/)
- Energy mapping study, 2021
- Articles and newsletters from SAMEEKSHA (http://www.sameeeksha.org/)

Other Reports and Articles

- Status Quo and Outlook 2022: Indian Ceramics Industry (https://www.indian-ceramics.com/wp-content/uploads/2018/10/Ceramics Industry Report.pdf) MSME Energy Efficiency (https://www.oecd.org/environment/cc/cefim/india/roadmap/CEFI-Roadmap-MSME-Energy-Efficiency-Workshop-Summary.pdf) Pharmaceutical Industry overview
- (https://www.investindia.gov.in/sector/pharmaceuticals#:~:text=India%20also%20has%20the%20highest,in%20the%20global%20API%20Industry)
- India's Plastic Industry by IBEF

Annual Survey of Industries (ASI), 2019-20 and MOSPI Energy Statistics 2022

Annexure 2 - Framework for Biomass Purchase Obligation

The measurement of actual biomass utilization in co-firing process across the shortlisted industrial sector entails development of a comprehensive framework that addresses specific nuances relating to capture, reporting, validation, monitoring and overall information flow across key stakeholders involved.

The framework needs to be dynamic and flexible in nature as new industries might need to be integrated on Y-o-Y basis. Also, the reporting requirement including targets and mandates might need to be amended from time to time.

Hence the framework needs to be evolving one.

To design the framework for biomass deployment obligation the following 4-step approach has been proposed.

Review and mapping	Preliminary framework development	Selection of best possible implementation strategy	Finalization and roll out
Detailed review of well established regulatory mandates in the sector and mapping key success factors in terms of overall implementation and adoption	Defining key building blocks of biomass co-firing /adoption framework and process flow	Exploring alternatives approaches for successful implementation for biomass uptake	Finalization of the framework and ground roll out

Implementation strategy

- **Shortlisting of consumers/ clusters** – Establishing feasible criteria/ approaches to identify industrial clusters consumers for proposed mandate
- **Target Setting** – Developing industry specific cofiring targets and trajectory over the next phase
- **Data formats and reporting** – Identify key data inputs to be captured and developing a standardised reference key data format for the specific industry clusters
- **Monitoring and Verification framework** – Developing M&V framework involving design of institutional framework, data reporting guidelines, energy auditing, and data storage
- **Penalty and Incentivisation framework** – Developing a framework for under and over achievement of stipulated mandate.

NOTES

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