Final Report

To Study and Evaluate Price of Fuel to be used in Biomass and Bagasse Based Power Plants in Maharashtra

Supported by / Prepared for
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Abbreviations

ACC	:	Air cooled condenser
AFBC	:	Atmospheric Fluidized Bed Combustion
CACP	:	Commission for Agricultural Costs and Prices
CAI	:	Cogen Association of India
FRP	:	Fair and Remuneration Price
H&T	:	Harvesting and Transportation
KERC	:	Karnataka Electricity Regulatory Commission
MEDA	:	Maharashtra Energy Development Agency
MERC	:	Maharashtra Electricity Regulatory Commission
MNRE	:	Ministry of New and Renewable Energy
MSCSFFL	:	Maharashtra State Cooperative Sugar Factories Federation Limited
MSEDCL	:	Maharashtra State Electricity Distribution Co. Ltd.
RE	:	Renewable Energy
SAP	:	State Advisory Prices
SERC	:	State Electricity Regulatory Commission
TCD	:	Tons of Cane per Day
TNERC	:	Tamil Nadu Electricity Regulatory Commission
UPERC	:	Uttar Pradesh Electricity Regulatory Commission
UPRUVNL	:	Uttar Pradesh Rajya Vidyut Utpadan Nigam Limited
UPPCL	:	Uttar Pradesh Power Cooperation Limited
WCC	:	Water cooled condenser

Message

The Indian sugar industry is a key driver of rural development, supporting India's economic growth. The industry is inherently inclusive supporting over 50 million farmers and their families, along with workers and entrepreneurs of almost 500 mills, apart from a host of wholesalers and distributors spread across the country. The industry is at a cross roads today, where it can leverage opportunities created by global shifts in sugar trade as well as the emergence of sugarcane as a source of renewable energy, through ethanol and cogeneration.

Maharashtra Electricity Regulatory Commission (MERC), an apex regulatory body for electricity in the State has given an opportunity to TERI to evaluate the fuel price used in biomass and bagasse based power plants in Maharashtra. TERI had extensive discussions with stakeholders across the value chain – farmers, millers, traders and policy makers. These were supported with data collection from various sources, a comprehensive consumer study and expert views from national sugar research agencies. This report is the culmination of all these efforts and insights.

Acknowledgement

The Energy and Resources Institute (TERI), New Delhi wish to express sincere gratitude to the MERC for entrusting TERI and giving the opportunity to work on the project of fuel price analysis of Biomass and Bagasse based captive power plants in Maharashtra.

We appreciate the co-operation and support extended to our team members during the entire tenure of field study and structuring the report thereof.

TERI wants to thank all those who contributed to this study. We thank Hon'ble Chairperson, Hon'ble Members, Secretary and all concerned officials of MERC for providing timely support and guidance during the study. Thanks are also due to the Directors and Officials of various bagasse and biomass power plants who participated in the study by providing the information for their respective units. We appreciate the cooperation from Nodal officer MEDA for his guidance during the study. We would like to extend our thank to other important stakeholders such as Commissioner Sugar and Director General, VSI, Pune for providing us valuable inputs and support. We would like to thank our Co-consultants M/s. PPS Energy Solutions Pvt Ltd., Pune for providing us local support in conducting primary survey during pandemic situation of COVID-19.

Also we want to express our gratitude towards all factory management for extending their support in sharing the primary data and relevant information to our team.

The Energy and Resources Institute, New Delhi.

Executive Summary

MERC appointed TERI as a Consultancy Firm/ Agency /Institution for Study and evaluation of the price of fuel to be used in Biomass and Bagasse based power plant in Maharashtra. Due to pandemic situation of COVID-19, TERI engaged Pune based reputed consulting firm "PPS Energy Solutions Pvt Ltd." for acquiring primary data from various biomass and bagasse based power plants, enlisting the field observations. MNRE, has launched biomass power & cogeneration program. Biomass and bagasse are considered as very important energy sources due to multiple benefits such as renewable energy promotion, widely available, carbon neutral and has the potential to drive the rural economy by creating jobs. The cogeneration is considered to be the most viable option, in order to eliminate the waste heat in the plant and it also meets the electrical power requirement of the Sugar industry. The cost of fuel is very important constituent of power cost. Hence, MERC has initiated the scientific evaluation of the cost of Bagasse and Biomass.

In order to evaluate the fuel pricing, expert team visited selected plants and acquired the primary data. Also various farmers from the command area have been interviewed for understanding the parameters contributing to fuel pricings. Experts interviewed the transporters to understand the transportation costs and various parameters affecting the fuel pricing. Primary field survey of 33 numbers Bagasse based Power plants and 7 numbers Biomass based Power Plants was carried out. Primary surveys of 5 farmers and 2 transporters from each plant command area were conducted. Out of 33 Number of Bagasse based power plants 6 were closed.

The secondary data is acquired by structured interactions with stakeholders like Sugar commissionerate, Cogeneration Association of India, Vasantdada Sugar Institute (VSI) and MEDA. Also various reports available on sugar cane and sugar production in public domain such as, CAI, NITI AYOG, VSI Report, Regulations, Market rates, etc. are consulted and referred.

Notable Observations:

<u>Bagasse based Power plants</u>

- Cost of sugarcane paid to the farmers is given as per FRP decided by the Government after deducting H&T (Harvesting and Transporting) Cost from the FRP.
- The H&T cost is different for different sugar plants. The sugar factories have H&T cost in range of INR 500 to 750 per Ton.
- The bagasse is directly fed into the boiler, only two cogeneration units Malegaon SSKL and Ashok SSKL units had mechanical dryers.
- Sugar cane is weighed at the input point and finished sugar at output points. As there is no separate weighing mechanism for the bagasse, the bagasse weight is derived from weights of sugar cane and finished sugar.

<u>Biomass based Power Plants</u>

- Mostly rice husk is used as a fuel for biomass based power plants

- The cost of fuel is not fixed in case of biomass based plant. The cost of biomass depends upon seasonal availability, price of fuel mix and GCV of fuel mix.

Fuel Pricing

The fuel pricing is very important parameter in defining the energy tariff. The fuel contribution evaluation is need of the day and this study emphasis on fuel price evaluation for both biomass and bagasse for captive power plants.

Biomass pricing

The major fuel used by biomass plants such as M/s. Manas Agro Industries & Infrastructure Ltd., Chandrapur and Nagpur are rice husk, soybean and fossil fuel.

The average purchase price gathered from the different biomass plants shows that the base price ranges from 1796 to 3431 Rs/Ton. The loading and unloading cost ranges from 5% to 7% of fuel cost, whereas the storage cost varies from 7% to 9.5%. Transportation cost is not fixed as it depends on the distance from where the fuel is purchased. GST is applicable as per the GST law. Based on weighted average analysis carried out, the estimated cost of biomass based on weighted average is Rs. 3238 per ton at corresponding weighted average GCV of 3307 kcal/kg.

Bagasse pricing

Six different approaches have been considered for estimating the price of bagasse. These approaches are as follows:

Approach 1: Coal Equivalent method

Approach 2: Alternate fuel GCV equivalent method

Approach 3: Based on market value of bagasse

Approach 4: Split off cost method

Approach 5: Preferential tariff based calculation

Approach 6: Production cost method (KERC and UPERC approach)

Each approach has its own distinctions and holistic view is needed for adoption of a particular approach. TERI in study proposed to adopt weighted average of cost derived from above mentioned six (6) approaches, which comes out to be Rs. 1836 per MT

During exercise of bagasse price discovery, following is evident:

- The average GCV of the used bagasse is 2200 kCal/kg and the average SHR is 3721kcal/kWh of the surveyed plants.
- The bagasse to steam ratio ranges from 2.10 to 2.40 as observed during the survey. Since bagasse is a valuable and cheap source of captive energy to a sugar mill, sugar mills need to install state-of-the-art dryers to ensure that they extract maximum energy from bagasse.

- Dryers are used only in two sugar mills which have shown better bagasse to steam ratio.
- The average production of the bagasse is in the range of 27% to 28% w.r.t crushed capacity of the cane for 2019-20 year.

Chapter 1: Introduction

1.1. Background

Maharashtra Electricity Regulatory Commission (MERC), as stipulated in the Electricity Act 2003, is required to determine tariff for bagasse & Non fossil fuel based co-generation plants in the State and promote co-generation and generation of electricity from renewable sources. As per mandate, the Commission notified the Maharashtra Electricity Regulatory Commission (Terms and Conditions for Determination of Renewable Energy Tariff) Regulations, 2019 dated 30 December 2019. The said Regulations shall be applicable for determination of tariff in cases covered under these Regulations with effect from 1 April 2020. Review Period under these Regulations is of five (5) financial years (FY), from FY 2020-21 up to the end of FY 2024-25[1].

The Regulation 8, 46 and 56 of the MERC (Terms and Conditions for Determination of Renewable Energy Tariff) Regulations, 2019 deals with the Variable Charges/Fuel Prices of Biomass and Bagasse based projects respectively. The Commission specified that Fuel Prices for Biomass and Bagasse will be determined through an independent study to be conducted by the Commission. The relevant excerpts from Regulations 46 and 56 are reproduced below:

"

46. Fuel Price

The biomass fuel price for the first year of the Project shall be determined based on the prevailing prices of the fuel mix for each Project and based on an independent study by the Commission, and shall thereafter be linked to the indexation mechanism specified in Regulation 47:

Provided that the aspects such as disposal cost, opportunity cost in terms of alternative uses of the fuel, and Gross Calorific Value shall be considered, while determining the fuel price.

56. Fuel Price

The price of bagasse for the first year of the Project shall be determined based on the prevailing price of bagasse as assessed through an independent study by the Commission, and shall thereafter be linked to the indexation mechanism specified in Regulation 57:

Provided that the aspects such as disposal cost, opportunity cost in terms of alternative uses of the fuel, and Gross Calorific Value shall be considered, while determining the fuel price:

Provided further that for use of biomass other than bagasse, the biomass prices as specified under Regulation 46 shall be applicable."

[1] MERC Case No. 77 of 2020 (Dated: 2 April, 2020)

In view of above, MERC desired to appoint a Consultancy Firm/ Agency /Institution for Study and evaluate price of fuel to be used in Biomass and Bagasse based power plant in Maharashtra.

In this regard MERC has issued several Orders determining Generic Tariffs for biomass/bagasse based power generation. However, as per Regulation 7.1 of 'RE Tariff Regulations, 2019', the Commission has specified that it shall not be determining the Generic Tariff and will only adopt the tariff discovered through transparent competitive bidding. Scope of determination of Generic Tariff is limited to determination of variable charge for Biomass and non-fossil fuel-based Co-generation Projects having valid EPAs under earlier generic tariff orders. However, Generic Tariff determination of Variable Charges shall not apply for Biomass and non-fossil fuel-based Co-generation projects, whose tariff has been determined through the competitive bidding process and adopted by the Commission.

For biomass-based power project: The biomass fuel price for the first year of the project shall be determined based on the prevailing prices of the fuel mix for each project and based on an independent study by the Commission, and shall thereafter be linked to the indexation mechanism specified in Regulation 47. For Non-fossil Fuel-based Co-Generation project: The price of bagasse for the first year of the Project shall be determined based on the prevailing price of bagasse as assessed through an independent study by the Commission, and shall thereafter be linked to the indexation mechanism specified in Regulation 57.

Provisional variable charges of biomass and non-fossil fuel-based Co-generation projects for FY 2020-21 and FY 2021-22 are Rs. 5.55/kWh and Rs. 4.38/kWh respectively. Based on proposed independent study and the subsequent public process, the Commission will determine the final variable charges which would be adjusted in subsequent bills or through supplementary bill.

MERC appointed TERI to conduct a primary and secondary survey based study to evaluate price of fuel to be used in Biomass and Bagasse based Power Plants in Maharashtra. TERI's study would be helpful in determining the fuel prices and availability of biomass/bagasse for power generation in Maharashtra.

In December 2019, the Maharashtra State Electricity Distribution Co. Ltd. (MSEDCL) invited a tender for procurement of power from bagasse based Co-generation Projects, whose EPAs with MSEDCL have expired, through Competitive Bidding Process. MSEDCL fixed the ceiling tariff of Rs 3.56/kWh for the bidding process. Both MSCSFFL and CAI filed their Petitions, seeking increase in the ceiling tariff of Rs 3.56/kWh to at least to Rs 5/kWh. Variable cost should be common to all (new & old plants) and only the fixed cost should be placed for bidding. The reason stated by them was as follows:

- There is acute shortage of sugar cane during the crushing season 2019-20 and the crushing season is expected to last only for 100-120 days, against the normal crushing season of 150-160 days. Such situations intermittently arise with a periodic frequency of 3-4 years.

- Sugar factories will not be in a position to continue to pay the FRP to the sugarcane farmers. The availability of bagasse has reduced substantially and the bagasse prices in the market have increased beyond Rs 3,500/tonne.

  In response to the aforementioned Petitions filed by MSCSFFL and CAI, the Commission passed the Common Order dated in Case Nos. 26 and 27 of 2020 which has been summarized below:

- Variable Cost as fixed by the Commission for 2019-20 & 2020-21 is Rs. 4.38/kWh and Fixed Cost is Rs. 0.66/kWh, hence, total tariff is Rs. 5.04/kWh. However, the Tariff rate for the new plants for 20 years period derived through competitive bidding is Rs.4.75/kWh. Hence to ensure that the tariff of old plants whose EPA expired after 13 years does not exceed the tariff for New Plants, it was decided that the PPA will be signed at Rs 4.75/kWh.
- The commission stated that, as per its first Order on 'Purchase of power from Bagasse based Co-generation projects' on 16 August 2002, benefit of generic tariff were to be available only for 13 years of EPA and post expiry of such period; tariff would be subjected to market operations. Thus, there was never an assurance of purchase of power post expiry of 13 years of EPA. However, considering useful life of 20 years, post expiry of 13-year EPA, additional EPA up to 7 years can be signed.
- The Commission approved competitive bidding for deciding tariff post expiry of EPA. Thus, the Commission continued its stand of Tariff Discovery through Competitive Bidding Process under Section 63 of the EA, 2003.
- Further, for the existing projects, the Commission shall determine only the variable cost through independent study of fuel cost by appointed consultant (TERI). In case the variable cost determined through the on-going study decreases below Rs. 4.38/kWh, then total tariff would decrease by that extent. Otherwise, total tariff would be fixed to Rs. 4.75/kWh to maintain parity with tariff determined through competitive bidding.

1.2. Scope of work and Study Objectives

The main scope of this study aims at detailed analysis of the data to evaluate the potential availability of the Biomass and Bagasse fuel along with its pricing. This study involves visits to the command area (100 km radius) of the sampled Biomass and Bagasse based power plants in Maharashtra. While analysing the landing price of the fuel, the various costs like transportation and stacking of fuel etc. are considered. The electronic analysis of information/data is also significant. It has also included the detailed estimation of biomass and bagasse that is available for the power production on a long-term sustainable basis, price escalation factor and gross calorific value (GCV) of the fuel.

While working out price of the fuel, due weightage is given to the seasonal availability, residual value of biomass/bagasse and its alternate possible use. The objectives of work under the project consist of:

1. Visiting the selected biomass/bagasse based power plants along with their command areas within the 100 km radius to investigate the availability of biomass and bagasse in Maharashtra.
2. Identifying the price of fuel after labour cost, collection cost, processing, transportation and fuel stacking cost, etc.
3. Quantification of biomass/bagasse left after its other various usages such as animal fodder, household usage, composting, commercial and industrial usage.
4. Detailed estimation of biomass/bagasse available for the production of power on a long-term sustainable basis, price escalation factor, and Gross Calorific Value of the fuel.
5. Comparing the trend of fuel availability for the previous 3 years.
6. Estimating the Calorific Value of Biomass & Bagasse fuel based on its ash and moisture contents.
7. Comparing the results of Maharashtra with other top five states having highest number of biomass and bagasse based power plants each.
8. Estimating the Crop-to-Residue Ratios (CRR) and validating the usage of existing literature.
9. Analysis and report preparation.

1.3. Proposed methodology

The methodology adopted during the course of project is depicted in the form of a flow diagram as shown below. The methodology illustrates the key activities proposed under the project.

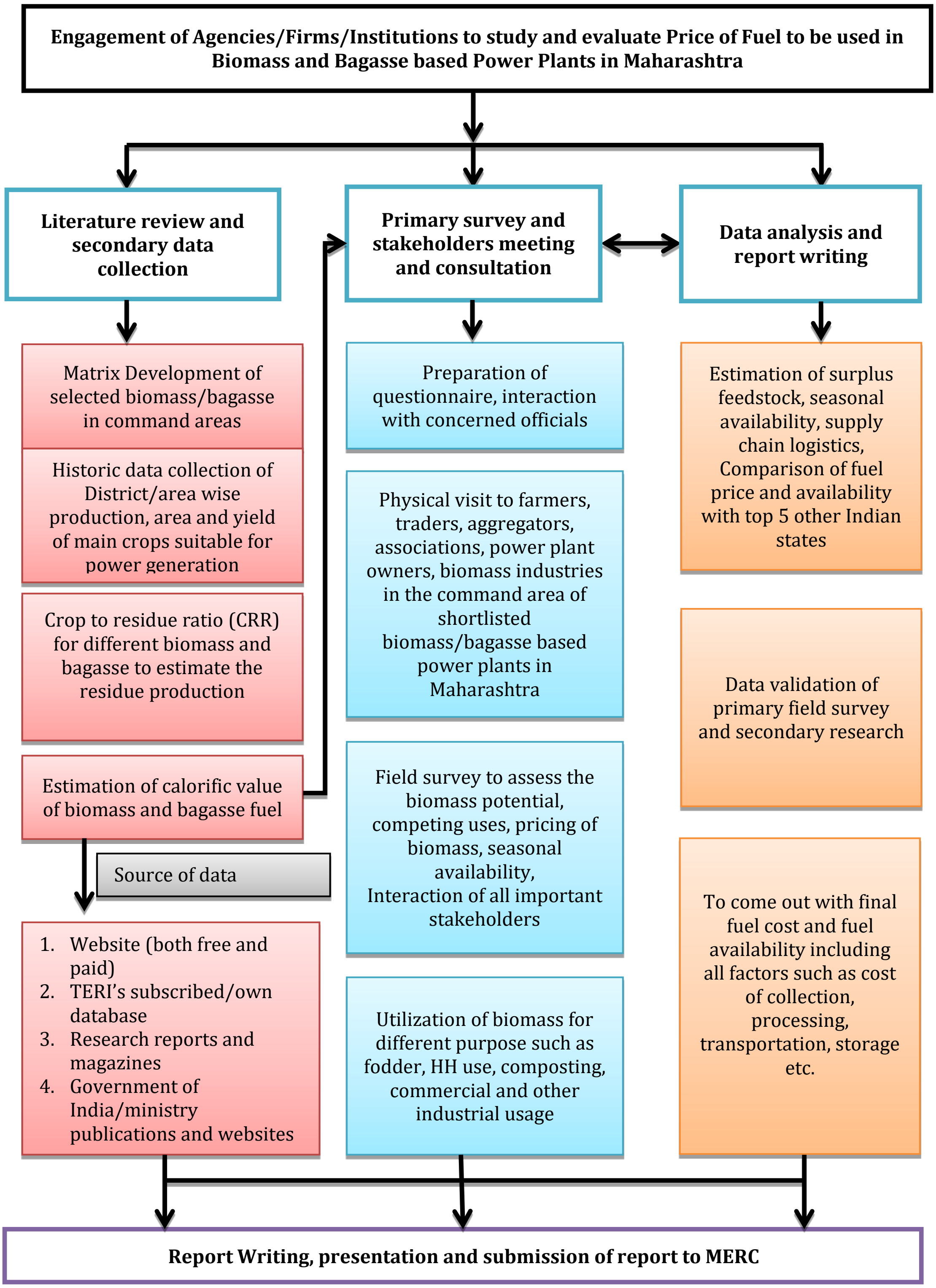


Figure 1.1: Proposed methodology to conduct the study

1.4. Scope covered in this report

This report majorly covers literature review, data collection (secondary as well as primary research), data analysis and data compilation on district wise, year wise availability of fuel to be used for power generation in biomass/bagasse based power plants in Maharashtra. During this study, TERI team obtained the secondary data related to crop pattern, agricultural yield, land use pattern, agro residue potential, season-wise crop production data, collection and compilation of information/data in respect of location(s) for various types and quantity of biomass and bagasse availability based on various agro products. Review of Central Government/State Government policies for various programs promoting biomass/bagasse power projects in the state has also be done during baseline research. For the purpose of primary survey, the biomass and bagasse cogen plants of Maharashtra were visited to get the data/information required to complete the study.

The secondary research includes assessment of data from the Ministry of Agriculture/Agriculture Department (State as well as Centre) for district wise annual and seasonal crop production. The Crop-to-Residue Ratios (CRR) for different biomass fuels and for bagasse has been taken from authentic reported documents. Various other sources have also been referred to get detailed information as a part of secondary research such as:

a. Websites (both free as well as paid websites).

b. TERI's subscribed/own database.

c. Research reports and magazines.

d. Government of India Publications.

1.5. Methodology adopted to determine biomass and bagasse availability

After obtaining the district wise year wise Area, Production and Yield (APY) data of major crops generated in Maharashtra, analysis has been carried out separately for each feed-stock as mentioned below:

- A matrix is developed based on area, production and yield under agricultural feed-stocks.
- Crop Residue Ratio (CRR) for each feed-stock is determined in order to estimate the residue/biomass generation from each crop.

Calculation for biomass generated:
Amount of biomass generated is calculated crop-wise by applying the CRR of a particular crop with yield. The CRR may be defined as the ratio of total residue generated (in kg) in various forms, such as husk, stalk, straw, shell, bagasse, leaves, etc. from a crop (in kg). Generally, crop to residue ratio is calculated with the formula given below. CRR values of different biomass produced from identified crops are given in Table 1.1.

The data is compiled and analysed to calculate the biomass in each district for the usage in power plant. The biomass generation from different identified biomass is given as follows:

$$\textbf{Total crop residue (tons)} = \textbf{Total crop production (tons)} \times \textbf{CRR of particular crop}$$

Table 1. 1: Agriculture residue production from different crops and their CRR values

Name of crop	Biomass	CRR (kg/kg of crop)
Cotton	Husk	1.1
	Stalk	3.8 (tons/hectare)
	Boll shell	1.1
Groundnut	Shell	0.3
	Stalk	2
Wheat	Stalk	1.5
	Pod	0.3
	Cobs	0.33
Sugarcane	Bagasse	0.33
	Top leaves	0.05
Maize	Cob	0.3
	Stalk	2
Paddy	Husk	0.2
	Stalk	1.5
	Straw	1.5

Source: Combustion Gasification and Propulsion Laboratory (CGPL), IISc, Bangalore INDIA

Chapter 2: Biomass/Bagasse Power Generation Mapping & Policy Overview- Maharashtra Scenario

2.1. Introduction

Biomass and bagasse have always been a great energy source for the country. Its full availability, renewability, carbon-neutral property makes it favourable fuel and contributes to the nations GDP by providing notable employment in the rural areas and fulfilling energy demand. In India, biomass is widely available because of its agriculture potential throughout the country. More than 70% of the country's population depends upon on biomass for its energy needs, and about 32% of total energy is derived from biomass[2].

According to estimates of MNRE, India generates about 500 million tonne of Biomass (including forest and agro-residues) annually, out of which 120–150 million tonne per annum is the surplus generated. India carries the power potential of about 26 GW from total biomass it produces. As on 30.7.2020, the cumulative achievement of India in Biomass and bagasse Cogeneration power generation is 679.81 MW and 9200.50 MW, respectively[3]. The states which are leading for biomass power projects are Chhattisgarh, Maharashtra, Punjab, Rajasthan, Haryana, and Karnataka[4].

For efficient utilisation of fuel, various schemes are initiated by the Government of India and State Government to increase energy generation capacity through biomass power generation and bagasse-based cogeneration in sugar mills. As of February 2018, the power generation capacity in Maharashtra through bagasse-based cogeneration and biomass power generation is recorded as 1948.85 MW and 215 MW respectively. It has been observed that the state is pushing it bagasse Cogen projects with an addition in the average capacity of 100 MW in February 2018[5]. Maharashtra has commissioned total 2406 MW capacity of Bagasse based cogeneration and 235 MW is of Biomass-based power generation. With the recent development, according to MSEDCL there are around 2418 MW of contracted and 2289 MW commissioned projects of bagasse cogeneration as on 31.01.2020[6],[7].

Maharashtra is one of the largest producers of sugarcane crop and thus the bagasse fuel in India. Thus, it is required to assess the availability of biomass/bagasse and its surplus amount to provide continuous feed throughout all seasons with predetermined low fluctuation cost for financial stability. This study aims to evaluate

[2] http://www.indiaenergyportal.org/subthemes_link.php?text=biomass&themeid=5
[3] https://mnre.gov.in/the-ministry/physical-progress
[4] https://indien.um.dk/en/innovation/sector-updates/renewable-energy/biomass-energy-in-india/#:~:text=Currently%2C%20about%2032%25%20of%20total,%25%20are%20off%2Dgrid%20plants.
[5] https://www.mahaurja.com/meda/data/other/Power_Generation_from_Renewable_energy.pdf
[6] https://www.mahadiscom.in/consumer/wp-content/uploads/2020/03/Order-322-of-2019.pdf
[7] https://www.mahadiscom.in/wp-content/uploads/2020/02/Bagasse-based-Co-generation-Power-Contracted-as-on-31.01.2020-1.pdf

the price of fuel to be used in biomass and bagasse-based power plants in Maharashtra for appropriate tariff rate determination.

2.2. Bagasse and Biomass energy scenario in Maharashtra

MEDA has been promoting Bagasse co-generation in sugar mills for surplus power generation in Maharashtra. There are almost 202 sugar factories listed in Maharashtra. A total number of Bagasse based projects, which are commissioned and running in the State of Maharashtra are about 131. The Total capacity of these projects is about 2250 MW. As per information available from MSEDCL, there are 7 Biomass based projects in Maharashtra which are in working condition. The total installed capacity of these projects is 65 MW.

2.3. Bagasse Energy generation

Sugarcane is a promising farm source of biomass energy. It can produce mainly two varieties of biomass, sugarcane trash and Bagasse. The residue remains in the field after harvesting is called sugarcane trash while after milling sugarcane; the fibrous leftover residues are called Bagasse. Calorific value especially depends on bagasse water content, the lesser the moisture content, the higher the calorific value. Moisture content depends on the milling process, which can vary from 45% to 52 %. It is estimated that a sugar factory produces nearly 30 tonnes of wet Bagasse from every 100 tonnes of crushed sugarcane[8].

Maharashtra is one of the leading sugarcane producing state in India. In FY year, 2019-20 Maharashtra has generated about 90 million tonne of sugarcane. As per the data available for FY (2019-20) Bagasse based Energy generation capacity is 2520.45 MU[9] .

2.4. Biomass Energy generation

Biomass-based power generation has a vast scope in Maharashtra. Energy generation from biomass depends upon the calorific value and cropping pattern of various potential crop wastes. But due to many obstacles such as fuel quality, dependence upon rainfall and cropping pattern, the established capacity in the state is nearly 10% of the potential. There are a total 182 MW biomass-based power generation units established till 2014, as against the total evaluated potential of 1,887 MW. For FY 2018-19 and 2019-20, the annual energy generation from biomass in Maharashtra is 412 and 445 million units respectively. Till 2020 the total Power generation capacity of Maharashtra through biomass-based cogen power generation are calculated as 16.4 MW[10] .

[8] https://www.bioenergyconsult.com/energy-potential-bagasse/
[9] https://www-indiastat-com-teri.new.knimbus.com/table/power-data/26/monthly-energy-generation/1210465/1318725/data.aspx
[10] https://mnre.gov.in/the-ministry/physical-progress

2.5. Bagasse/biomass Tariff and fuel Cost Variation in Maharashtra

From figure 2.1, it is observed that the cost of bagasse considered in Maharashtra is fluctuating with years and so the tariff rate. With the increase in the bagasse cost, it is observed that there is an increase in the tariff rate. But from FY (2016-17) to FY (2017-18) though the cost of bagasse is constant with the previous year (2273.75 Rs/ton), it is observed that there was a decrease in the tariff rate from 6.6 Rs./unit to 6.52 Rs/unit respectively. For FY 2019-20, the cost of bagasse is 2506.81 Rs/tonne and the tariff rate is 6.98 Rs/unit[11]. Similarly, for FY 2020-21, CERC proposed the 2632 Rs./ton as the bagasse cost while tariff is considered same as previous year (6.98 Rs/unit) for Maharashtra. However, these rates are not finalized and applied by MERC. Figure 2.2 shows that tariff rate determined for biomass-based power generation unit has decrease from 7.9 Rs/kWh for FY (2015-16) to 7.83 Rs/kWh for FY (2019-18) despite an increase in Biomass cost from 3987 Rs/tonne to 4295.57 Rs/ton respectively[12],[13]. Levelised Tariff cost consists of two factors (fixed cost and variable cost). Variable cost depends on fuel price and fixed cost is depending on factors such as interest on capital and loan, O&M Cost etc. However, variable cost increases as per fuel cost while fixed cost decreases. Therefore, total tariff cost is not increasing in line with fuel cost.

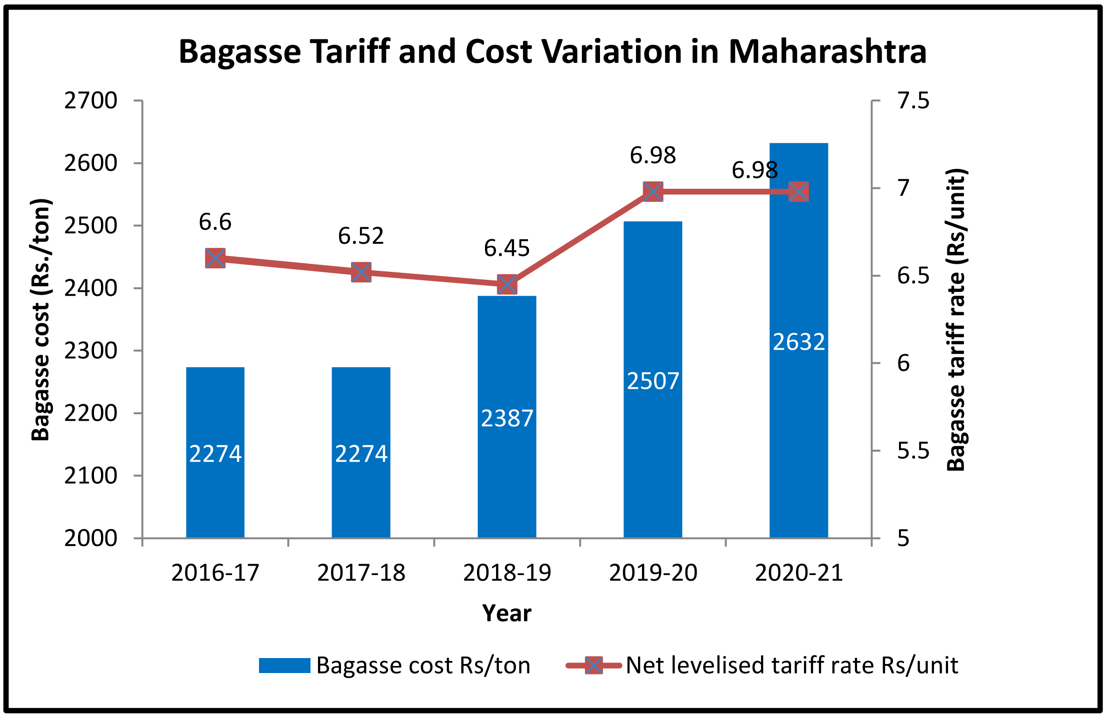


Figure 2.1: Bagasse Tariff and Cost Variation in Maharashtra

[11] http://www.cercind.gov.in/2019/orders/Draft%20RE%20Tariff%20Order%20for%20FY%202019-20.pdf
[12] http://www.tnerc.gov.in/orders/Tariff%20Order%202009/2018/BaggasseT.O-4of2018.pdf
[13] https://www.mahadiscom.in/wp-content/uploads/2019/05/30.04.2019-Order-52-of-2019.pdf

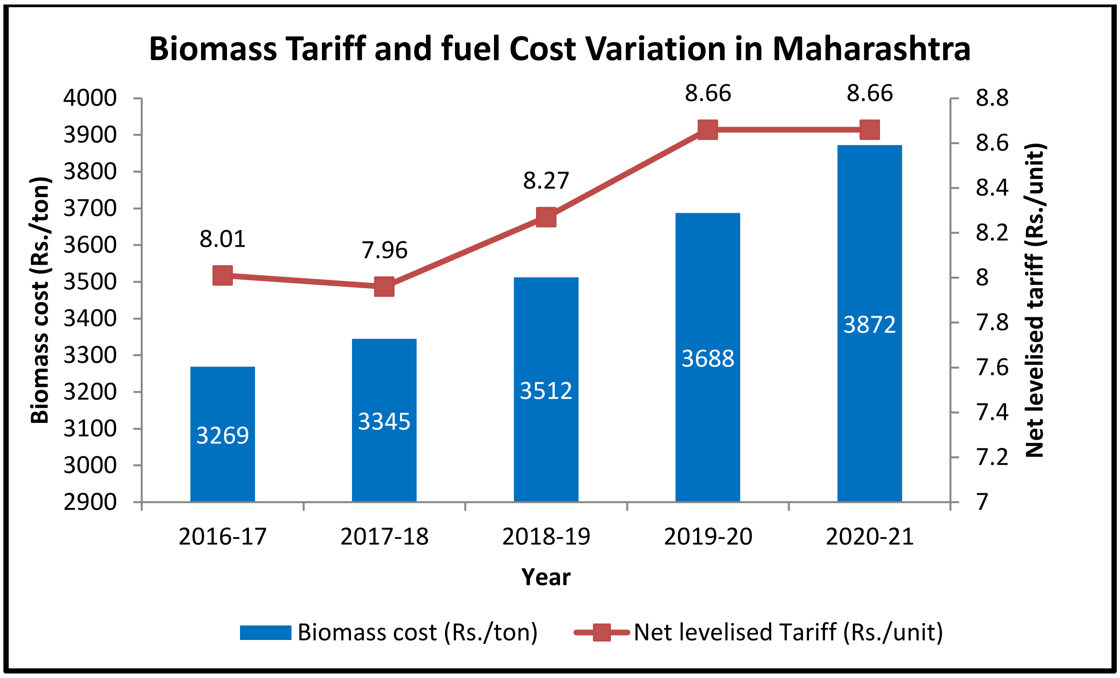


Figure 2.2: Biomass Tariff and Cost Variation in Maharashtra

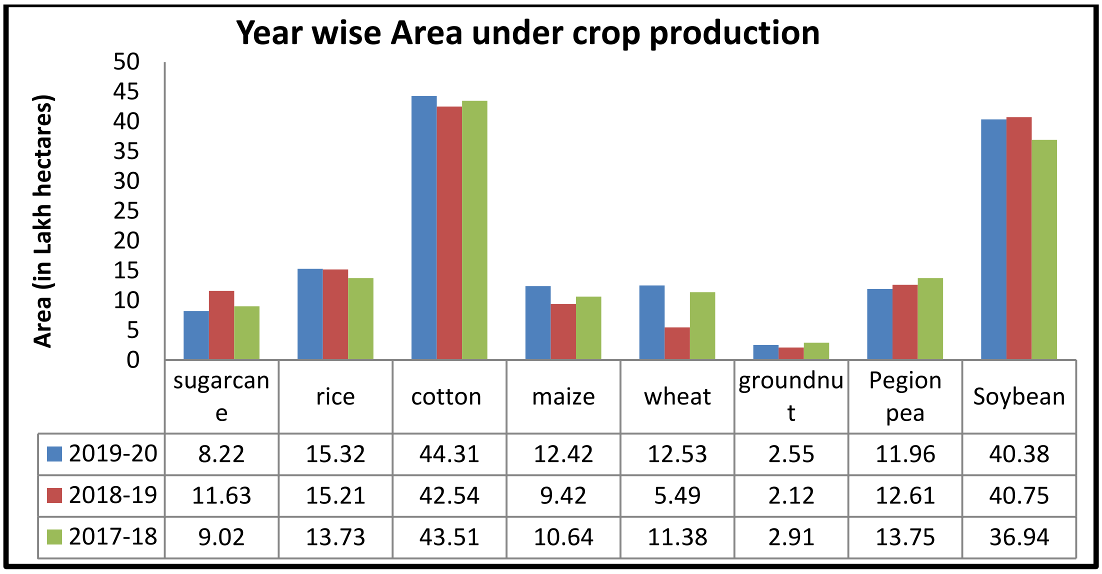
2.6. Agricultural scenario and crop production in Maharashtra

The total geographical area of Maharashtra is 30.7 million hectares, of which net area under agriculture is 17.7 million hectares i.e. 57.65 % of the total geographical area. The rainfall variations from 500 to 3000 mm have been recorded with an average of 1000 mm distributed over 60-70 days[14]. Maharashtra is the leading producer of sugarcane, rice, maize and cotton in India. Other major crops produced in the state are bajra, jowar, ragi, wheat, arhar, gram, moong, urad. Castor seeds, groundnut, Soybean and sunflower are the oilseed crops of the state.

2.7. Cropping pattern

Figure 2.3 shows year wise area under crop production for major crops for year 2017-18, 2018-19 and 2019-20. In the year 2019-20, the area covered by sugarcane, rice, cotton, maize, wheat, groundnut, pigeon pea and soybean are 8.22, 15.32, 44.31, 12.42, 12.53, 2.55, 11.96 and 40.38 lakh hectares respectively. However, area under crop production is highest in case of cotton (46%), but the production is highest in case of sugarcane due to its highest productivity of sugarcane among mentioned crops.

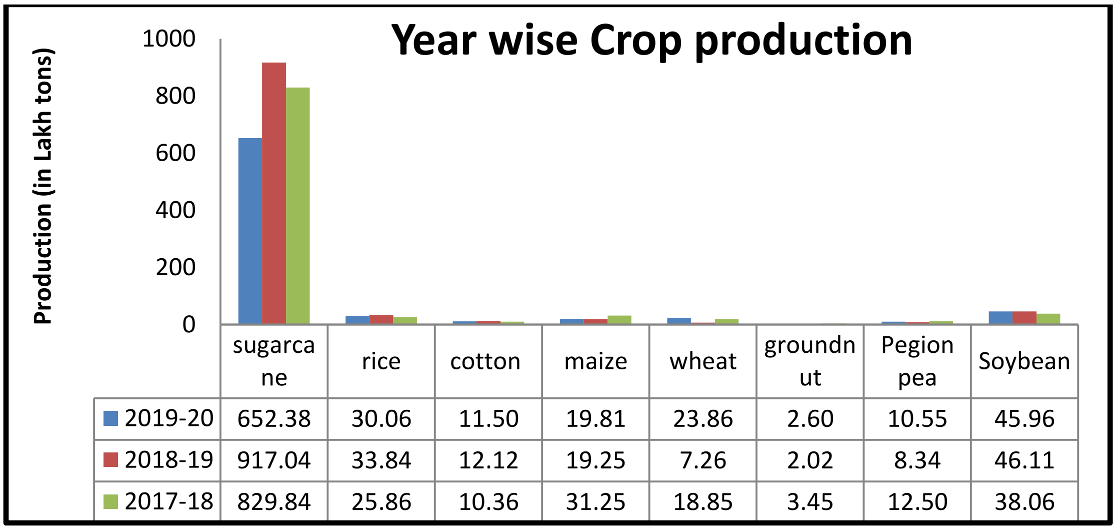
[14]https://farmech.dac.gov.in/FarmerGuide/MH/index1.html#:~:text=The%20state%20has%20an%20area,grape%20and%20cashew%20nut%20etc



	sugarcane	rice	cotton	maize	wheat	groundnut	Pegion pea	Soybean
2019-20	8.22	15.32	44.31	12.42	12.53	2.55	11.96	40.38
2018-19	11.63	15.21	42.54	9.42	5.49	2.12	12.61	40.75
2017-18	9.02	13.73	43.51	10.64	11.38	2.91	13.75	36.94

Figure 2.3: Area under major crop production in Maharashtra[15]

It can be revealed from Figure 2.4 that sugarcane has the highest production amongst the major crops produced in Maharashtra. The production of sugarcane is 65.23 million tonne in 2019-20, while production of sugarcane in 2018-19 and 2017-18 is 91.7 million tonne and 82.98 million tonne respectively. The production of rice, cotton and maize are very less as comparable to sugarcane. However, area under crop production is very high for cotton and soybean but production of sugarcane is highest. This is due to the fact that, yield of sugarcane is around 500 times and 100 times more than that of cotton and soybean respectively. Out of all major crops in Maharashtra, 80% production shares is for sugarcane followed by groundnut and rice with 6% and 4% production share respectively. However, residue generation from these crops may share different proportion depending upon respective CRR number of respective crops.



	sugarcane	rice	cotton	maize	wheat	groundnut	Pegion pea	Soybean
2019-20	652.38	30.06	11.50	19.81	23.86	2.60	10.55	45.96
2018-19	917.04	33.84	12.12	19.25	7.26	2.02	8.34	46.11
2017-18	829.84	25.86	10.36	31.25	18.85	3.45	12.50	38.06

Figure 2.4: Three year production of major crops in Maharashtra

[15] https://www-districtsofindia-com-teri.new.knimbus.com/maharashtra/alldistricts/index.aspx

2.8. Maharashtra state policy[16]

The Government of Maharashtra notified a Policy for New and Renewable (Non-conventional) Energy Sources - 2020. This policy will be applicable till 31st March 2025. Policies of 20-07-2015 and 11-02-2016 will be superseded by this 2020 Policy. A total of 17,360 MW capacity power projects based on new and renewable energy sources are targeted as per this policy.

2.9. Bagasse / Agricultural Waste (biomass) based Co-generation Power Projects:-

1. Excess electricity can be made available in the state from by-products available from sugar factories and agro-industries. This benefits the farmers who depend on such industry. Therefore, it is necessary to give impetus to such projects. According to the report of Vasantdada Sugar Institute, there exists a potential of 1374 MW in the state. In view of this, a target of 1350 MW is being set for co-generation projects based on sugarcane chips / agricultural residues.
2. Under this policy, the electricity generated from such projects can be used by the power distribution companies in the state to meet their renewable energy purchase obligation. For registered projects, MEDA will provide infrastructure clearance.
3. Power will be procured by MSEDCL on Memorandum of Understanding (MoU) basis at the Tariff and the terms and conditions as decided by Commission without any tender process till policy target is met. After fulfilment of targeted capacity, procurement shall be through tenders.

2.10. Centre Policy[17]

The Ministry of New and Renewable Energy (MNRE) has decided to continue the scheme to support promotion of Grid Interactive Biomass Power and Bagasse Cogeneration in Sugar Mills in the country during the 12th Five Year Plan. The objectives of the scheme are as follows:

a) To promote setting up of biomass power projects with minimum steam pressure configuration of 60 bar and above for power generation (grid interfaced on commercial basis).

b) To promote cogeneration projects for surplus power generation from bagasse in private/cooperative/public sector sugar mills with minimum steam pressure configuration of 40 bar and above (Grid interfaced on commercial basis).

[16] https://www.mahaurja.com/meda/data/grid_bagasse/state_policy/Policy%202015_2.pdf

[17] https://www.mahaurja.com/meda/data/grid_bagasse/state_policy/pg2_MNRE%20policy%20Bagasse%20Cogenration%2020-06-2014.pdf

c) To promote bagasse cogeneration projects for surplus power generation in cooperative/public sector sugar mills with minimum stream pressure of 60 bar and above, taken up through BOOT/BOLT model by IPPs/State Govt. Undertakings or State Government Joint Venture Company (Grid interfaced on commercial basis).

Grid connected Biomass Power and Bagasse Cogeneration Projects with the following capacity/parameters will only be eligible under the scheme:

Biomass Power (combustion)	Minimum 60 bar steam pressure Maximum of up to 15% use of fossil fuel of total energy consumption or as per DPR, whichever is less. For only new boilers and turbines (capacity limited to in accordance with the estimated potential in a state)
Bagasse Cogeneration in existing cooperative sugar mill employing boiler modification	Minimum 40 bar steam pressure. PPA as per SERC. Maximum of up to 15% use of fossil fuel of total energy consumption in Kcal or as per DPR, whichever is less, during crushing season. Minimum export of power – 3 MW.
Bagasse Co-generation by Private/cooperative / Public Sector Sugar Mill	Minimum 40 bar steam pressure Maximum of up to 15% use of fossil fuel of total energy consumption in Kcal or as per DPR, whichever is less.
Bagasse Cogeneration through BOOT/BOLT model by IPP's /State Govt. undertaking / State Govt. Joint Venture Company	Minimum 60 bar steam pressure Maximum of up to 15% use of fossil fuel of total energy consumption in Kcal or as per DPR, whichever is less, during crushing season. Minimum export of power – 5 MW
Biomass Power (combustion)	Minimum 60 bar steam pressure Maximum of up to 15% use of fossil fuel of total energy consumption or as per DPR, whichever is less. For only new boilers and turbines (capacity limited to in accordance with the estimated potential in a state)

2.11. Central Financial Assistance (CFA)[18] [19]

To support biomass-based cogeneration in sugar mills and other industries (up to March 2020) Central Financial Assistance (CFA) will be provided at the rate of Rs.25 Lakh / MW for bagasse cogeneration projects on surplus exportable capacity. CFA will be calculated on surplus exportable power as mentioned in Power Purchase Agreement (PPA) / Appraisal Report. The CFA will be back-ended and will be released in one instalment after successful commissioning and commencement of commercial generation and performance testing of the plant. The CFA will be released to the term loan account to reduce the loan component of the promoter. No advance CFA will be released under the scheme. CFA will be provided only for projects which will be installing new boiler and turbines.

CFA for bagasse cogeneration project in cooperative/ public sector sugar mills implemented by IPPs/State Government Undertakings or Special Purpose Vehicle (Urja Ankur Trust) through BOOT/BOLT model

PROJECT TYPE	MINIMUM CONFIGURATION	CAPITAL SUBSIDY
Single cooperative mill through BOOT /BOLT Model	60 bar & above 80 bar & above	Rs.40 Lakh/MW of surplus power Rs.50 Lakh/MW of surplus power (maximum support Rs. 6.0 crore/ sugar mill)

** Power generated in a sugar mill (-) power used for captive purpose i.e. Net power fed to the grid during season in a sugar mill.*

CFA for bagasse cogeneration project in existing cooperative sector sugar mills employing boiler modifications

PROJECT TYPE	MINIMUM CONFIGURATION	CAPITAL SUBSIDY
Existing Cooperative Sugar Mill	40 bar & above 60 bar & above 80 bar & above	Rs.20 Lakh/MW of surplus power Rs.25 Lakh/MW of surplus power Rs.30 Lakh/MW of surplus power*

* Power generated in a sugar mill (-) power used for captive purpose i.e. Net power fed to the grid during season in a sugar mill. CFA will be provided to the sugar mills who have not received CFA earlier from MNRE under any of its scheme.

2.12. Price Policy for Sugarcane & Associated Factors[20]

Price of sugarcane directly/indirectly affects the price of bagasse and hence the tariff cost of bagasse based co-generation plants. Therefore, it is important to understand the price policy of sugarcane.

[18] https://www.mahaurja.com/meda/data/grid_bagasse/state_policy/pg2_MNRE%20policy%20Bagasse%20Cogeneration%2020-06-2014.pdf
[19] https://mnre.gov.in/img/documents/uploads/file_f-1585710569965.pdf
[20] https://dfpd.gov.in/gen_policy.htm & https://cacp.dacnet.nic.in/ViewQuestionare.aspx?Input=2&DocId=1&PageId=41&KeyId=676

2.13. Sugar Cane Pricing Policy

Internationally, cane price ranges from 60%–66% of revenue from sugar and/or by products.

With the amendment of the Sugarcane (Control) Order, 1966 on 22.10.2009 and the concept of Statutory Minimum Price (SMP) of sugarcane was replaced with the 'Fair and Remunerative Price (FRP). The cane price announced by the Central Government is decided on the basis of the recommendations of the Commission for Agricultural Costs and Prices (CACP) after consulting the State Governments and associations of sugar industry. The amended provisions of the Sugarcane (Control) Order, 1966 provides for fixation of FRP of sugarcane having regard to the following factors: -

- Cost of production of sugarcane
- Return to the growers from alternative crops and the general trend of prices of agricultural commodities
- Availability of sugar to consumers at a fair price
- Price at which sugar produced from sugarcane is sold by sugar producers
- Recovery of sugar from sugarcane
- The realization made from sale of by-products viz. molasses, bagasse and press mud or their imputed value
- Reasonable margins for the growers of sugarcane on account of risk and profits.

Under the FRP system, the farmers are not required to wait till the end of the season or for any announcement of the profits by sugar mills or the Government. The new system also assures margins on account of profit and risk to farmers, irrespective of the fact whether sugar mills generate profit or not and is not dependent on the performance of any individual sugar mill.

In order to ensure that higher sugar recoveries are adequately rewarded and considering variations amongst sugar mills, the FRP is linked to a basic recovery rate of sugar, with a premium payable to farmers for higher recoveries of sugar from sugarcane.

Accordingly, FRP for 2021-22 sugar season has been fixed at Rs. 290 per quintal linked to a basic recovery of 10% subject to a premium of Rs. 2.90 per quintal for each 0.1% increase of recovery over and above 10% and reduction in FRP at the same rate for each 0.1% decrease in the recovery rate till 9.5%. With a view to protect interest of farmers the Government has decided that there shall not be any deduction in case where recovery is below 9.5%; such farmers will get Rs. 275.50 per quintal for sugarcane in the current season.

2.14. Payment to Sugarcane Growers

There is a provision in the Sugarcane Control Order (SCO) that payment by the mills should be made to farmers within 14 days from the date of delivery of sugarcane to the mills, failing which mill shall pay interest on the amount due at the rate of 15% per annum for the period of such delay beyond 14 days. Mills take loans from banks to make the cane payments to farmers, which increases their costs. Practice of cane payment in instalments was followed by cooperative sugar mills in Maharashtra and Karnataka prior to FRP regime.

2.15. Incentivizing Efficiency: Benefit Sharing between Farmers and Mills

The sugar recovery of sugarcane depends on crop variety, climatic conditions and technological interventions (crushing efficiency of mills). A comparative analysis of sugar recovery in Uttar Pradesh reveals that recovery rate is significantly high in private mills (10.96 %) compared with cooperative sector (9.73 %). However, there are large intra-regional differences in sugar recovery rates, which can be attributed mainly to technological efficiency of sugar mills as agro-climatic conditions and crop varieties grown in a region will be almost similar. Almost a similar situation was observed in Maharashtra (Table 2.1). Therefore, a mechanism for incentivizing efficient mills along with the farmers on every percentage point increase in recovery may be evolved. This will encourage sugar mills to improve manufacturing efficiency and productivity, which will benefit both farmers and millers. The values in the bracket are in (%) and the values outside the bracket are number of mills.

Table 2. 1: Intra-Regional Variation in Sugar Recovery Rates in Maharashtra[21]

Region	No. of Mills with Recovery ≤10 %		No. of Mills with Recovery >10 %	
	Private	**Co-operative**	**Private**	**Co-operative**
Yavatmal	0	0	1 (11.15)	1 (10.28)
Marathwada (Aurangabad, Beed, Parbhani, Latur, Osmanabad, Hingoli)	8 (8.39)	7 (9.25)	13 (10.61)	13 (10.78)
Vidarbha (Bandhara, Nagpur, Wardha	3(9.81)	0	1 (10.27)	0
Khandesh (Ahmednagar, Nandurbar, Nasik, Jalgaon)	2 (9.65)	6 (8.95)	4 (10.98)	13 (11.12)
Desh (Kohlapur, Pune, Satara, Sangli, Solapur)	4 (9.78)	7 (9.38)	32 (11.34)	51 (11.78)
Maharashtra	**17 (9.41)**	**20 (9.20)**	**51 (10.87)**	**78 (10.99)**

2.16. Cane Area Reservation and Minimum Distance Criteria

Government of India delegated the power of reserving the cane area in July, 1966, as per Sugarcane (Control) Order, 1966, Provision No.6 - power to regulate distribution and movement of sugarcane. The Committee recommended that states should encourage development of market-based long-term contractual arrangements and phase out cane reservation area and bonding over a period of time. Maharashtra is

[21] DFPD

the only state which has no reservation of cane area and farmers are free to sell to any mill.

2.17. Installed Capacity and Capacity Utilization

State-wise annual installed capacity (IC) and utilization capacity (UC) of sugar mills from 2012-13 to 2016-17 are shown in Table 2.2. The table shows that installed capacity of sugar mills has been increasing over the past 5 years. However, capacity utilization has remained erratic during the same period. While it reached a peak of 86.4 % in 2014-15, in 2016-17 it was only 59.8 %. This dip was largely due to a fall in sugarcane production in 2016-17. Uttar Pradesh capacity utilization jumped from 72.3 % in 2015-16 to 92.7 % in 2016-17.

Table 2. 2: State-wise Annual Installed Capacity (lakh tones) and Utilized Capacity (%)[22]

	2012-13		2013-14		2014-15		2015-16		2016-17	
State/Year	**IC**	**UC**	**IC**	**UC**	**IC**	**UC**	**IC**	**UC**	**IC**	**UC**
Uttar Pradesh	95	79.2	95	69.8	95	75.4	95	72.3	94.7	92.7
Maharashtra	98	81.2	101	76.6	106	99.4	110	77.3	112	37.5
Karnataka	40	85.8	41	100.3	42	117.7	43	94.2	44.9	47.8
Tamil Nadu	29	67.5	29	49.6	29	43.9	29	47.7	28.7	36.9
All India	**319**	**79.0**	**323**	**76.0**	**329**	**86.4**	**334**	**75.2**	**338.6**	**59.8**

2.18. Movement in Agricultural Labour Wages and Farm Inputs

Average daily wage rate of Agricultural labour in Maharashtra is shown in Figure 2.5. It is seen from figure that, average daily wage rate of agriculture labour ranges from Rs. 255/day to Rs. 280/day. Daily wage rates are lowest in January while highest in the month of June. However, as compared with other Indian States, the average wage rate is the highest (`432 per day) in Tamil Nadu[23].

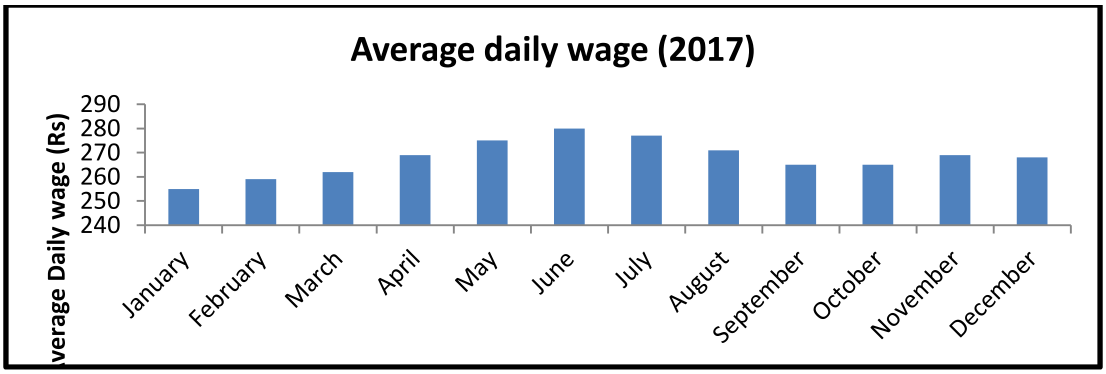


Figure 2.5: Average Daily Wage Rates of Agricultural Labor in Maharashtra

[22] Directorate of Sugar (DFPD)
[23] Labour Bureau, Ministry of Labour & Employment, Government of India

Chapter 3: Biomass/bagasse fuel energy and pricing: A state wise comparison

3.1. Introduction

Maharashtra is one of the largest producers of sugarcane as well as sugar in India. The sugar cane is a cash crop for farmers. Most of the sugar industries are located in rural areas employing rural sections. From figure 3.1, it is observed that for FY (2018-2019), Uttar Pradesh has immerged as highest sugarcane producing state with a capacity of 180 million tonnes while Maharashtra holds the second-highest position with the capacity of 90 million tonnes. The estimated sugarcane production of FY (2019-2020) for states like Uttar Pradesh, Karnataka, Bihar, Tamil Nadu and Gujarat have shown minor reduction from the previous year. It was surprising to observe that sugarcane production in Maharashtra have shown a significant reduction of approximately 36% for FY (2019-2020). A report presented by CRISIL has estimated that there will decline in the production of sugarcane due to extreme weather condition in Maharashtra[24].

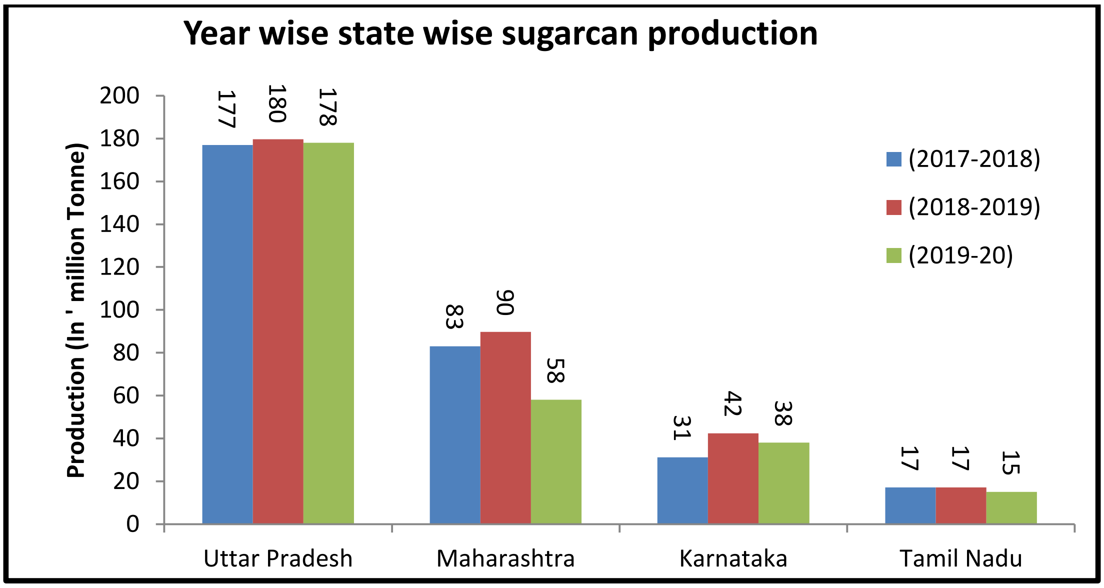


Figure 3.1: Top Sugarcane Producing States

3.2. Cane crushing trend

As Uttar Pradesh, Maharashtra, Karnataka and Tamil Nadu are the major sugarcane producing states of India. Every year, 65-75% of total sugarcane in India is crushed collectively by Uttar Pradesh, Maharashtra, Karnataka and Tamil Nadu. Hence, year wise cane crushing data of these 4 states has been considered for analysis. Figure 3.2

[24] https://www.crisil.com/content/dam/crisil/our-analysis/views-and-commentaries/impact-note/2019/september/crisil-research-impact-note-sugar-exports-seen-up-20percent-prices-8percent.pdf

shows state wise year wise trend of cane crushing for years 2017-18, 2018-19 and 2019-20. It is observed that, every year Uttar Pradesh crushes highest quantity of sugarcane among all states. However, quantity of cane crushing depends on climatic conditions and hence is not same every year. Cane crushing was highest during FY 2017-18 among past 3 years in UP and Maharashtra. Out of total sugarcane production in Uttar Pradesh, 57-62 % cane is crushed for sugar production while in case of Maharashtra; 95% of cane is crushed for sugar production. The reason of higher proportion of cane crushing in Maharashtra is due to the fact that, Maharashtra is the only state which has no reservation of cane area and farmers are free to sell to any mill[25]. Another reason for high crushing capacity of Maharashtra is that Maharashtra purchases sugarcane from neighboring states such as Karnataka, Madhya Pradesh and Gujarat.

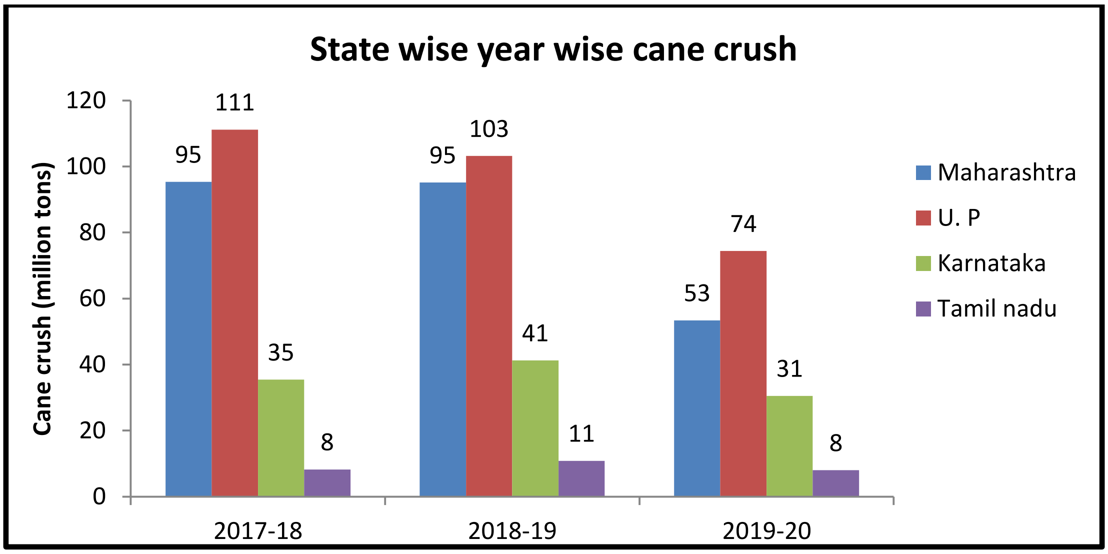


Figure 3.2: State wise year wise trend of cane crushing

3.3. Energy Generation from Bagasse

According to MNRE, the implementation of the biomass power and co-generation power programs is present in India since mid-nineties. With an approximate number of 500 biomass and bagasse co-generation projects all over India, the total installed capacity aggregates to more than 10,170 MW out of which grid-connected counts to major portion and off-grid counts to minor. (MNRE, 2019) (CEA, 2021).

Figure 3.3 shows state wise comparison of energy generation through Bagasse in million units (MU) for year 2018-19 and 2019-20. It can be observed that energy generation from bagasse in Maharashtra reduced significantly from 3988 MU in 2018-19 to 2520 MU in 2019-20. This is due to the fact that, sugarcane production in Maharashtra reduced from 90 million tons in 2018-19 to 58 million tons in 2019-20. Overall, Maharashtra holds 2nd position in terms of energy generation through bagasse-based cogeneration plant while Uttar Pradesh stood first. The state of UP,

[25] https://cacp.dacnet.nic.in/ViewReports.aspx?Input=2&PageId=41&KeyId=676

Maharashtra and Karnataka shares around 94% of total bagasse based energy generation in selected districts and hence are considered for more comparative analysis.

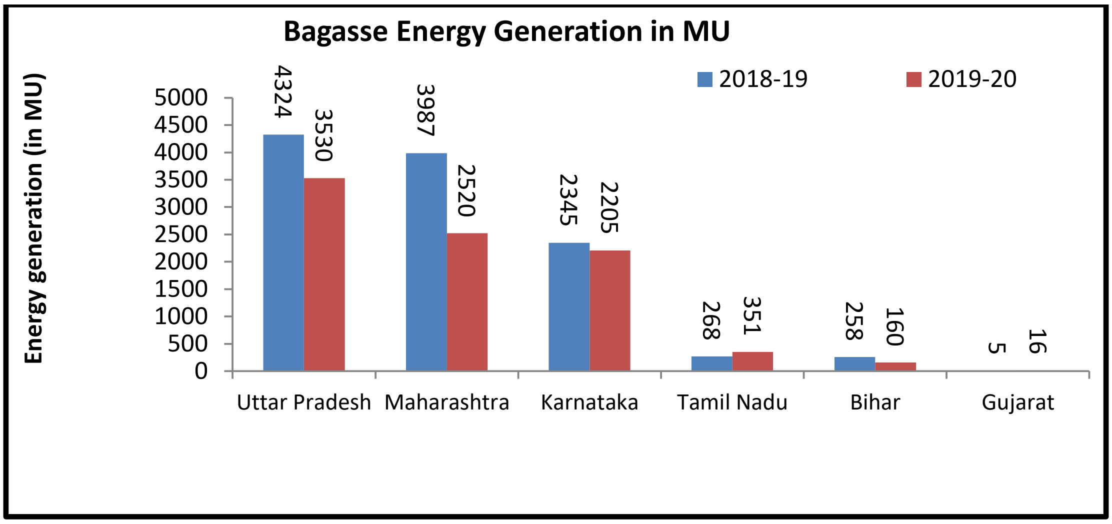


Figure 3.3: Bagasse Energy Generation (2019-20)[26]

3.4. Energy Generation from Biomass

Figure 3.4 shows state wise comparison of energy generation through Biomass in million units (MU) for year 2018-19 and 2019-20. It is observed from figure 3.4 that for FY (2019-20), Chhattisgarh has highest biomass energy generation of 680 MU as compared to other biomass energy potential states. Maharashtra has second highest biomass energy generating capacity of 412 MU for FY (2019-20)[27]. As per general observation, energy generation from biomass is not significant and is typically 8-10 times lesser as compared to energy generation from bagasse. Therefore, bagasse based energy generation is more focussed in this study.

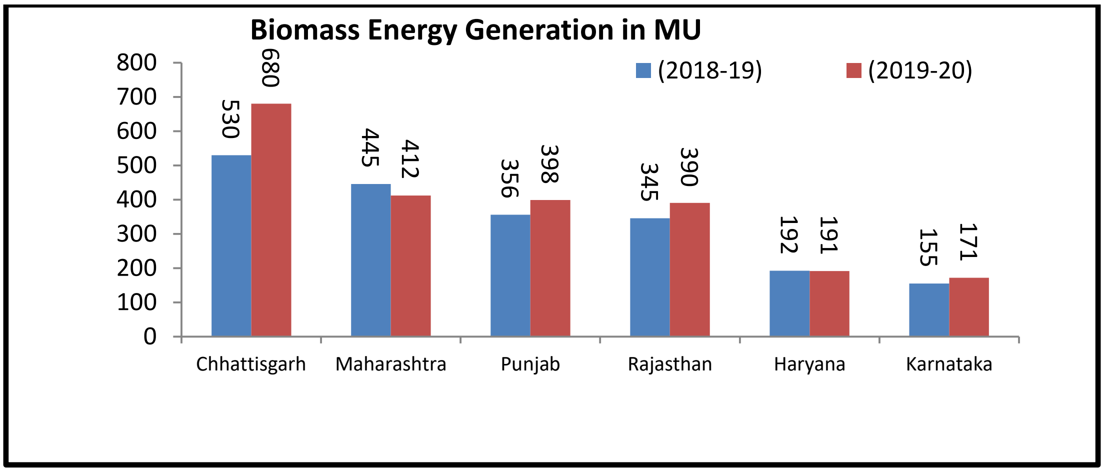


Figure 3.4: Biomass Energy Generation (2019-20)

[26] https://www-indiastat-com-teri.new.knimbus.com/table/power-data/26/monthly-energy-generation/1210465/1318725/data.aspx

[27] https://www-indiastat-com-teri.new.knimbus.com/table/power-data/26/monthly-energy-generation/1210465/1318725/data.aspx

3.5. Sugarcane price details

FRP is fair and remuneration price of sugarcane decided by central government for all Indian states. However, SAP is state advisory price which is decided by individual states over and above FRP. FRP of sugarcane in India for FY 2019-20 was 275 Rs. /Quintal.

Figure 3.5 shows the SAP of leading sugar producing states of India. From figure 3.5, it can be observed that for FY (2019-2020), Haryana has highest SAP of 335 Rs./Quintal followed by Uttar Pradesh with SAP of Rs. 315 per quintal[28]. SAPs of states such as Uttar Pradesh, Punjab and Haryana are usually higher than the Centre's FRP. However, Maharashtra follows the centre's practice of giving FRP[29].

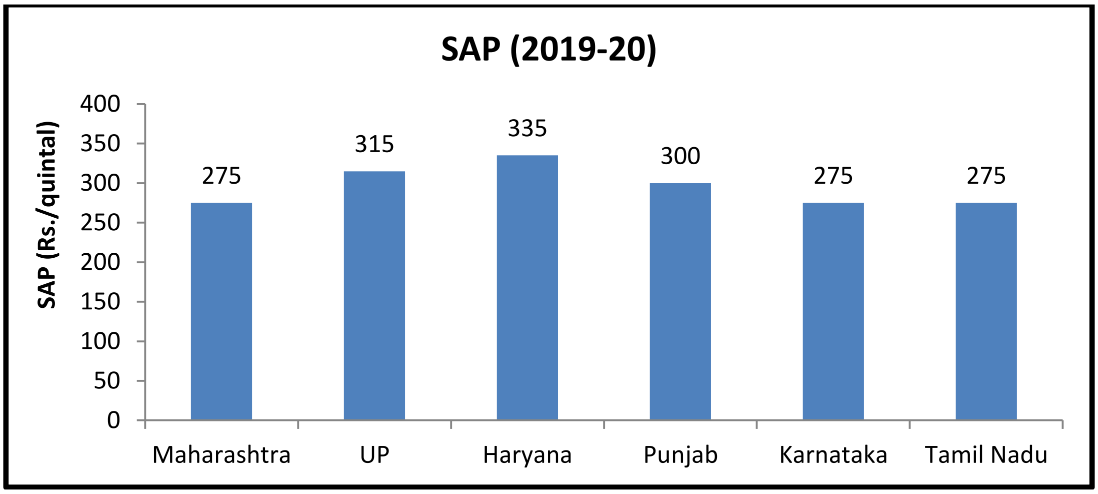


Figure 3.5: Sugarcane Price State Wise Comparison

3.6. Tariff determination approaches: A comparative analysis

A comparative analysis has been made in order to analyse the approaches adopted by CERC including various State Electricity Regulatory Commissions such as UPERC, KERC, TNERC and MERC. The subsequent sections describe parameters considered by KERC and UPERC in order to determine the cost of fuel as well as tariff.

3.7. CERC[30]

This section describes the various factors considered by CERC in order to determine cost of fuel and tariff of biomass and bagasse based power projects for FY 2021.

[28] https://www-indiastat-com-teri.new.knimbus.com/table/industries-data/18/sugar-consumption-and-prices/449609/558822/data.aspx
[29] https://www.financialexpress.com/economy/maharashtra-farmer-leaders-call-for-scrapping-frp-aerial-distance-norm-between-factories/1770691/
[30] http://www.cercind.gov.in/2020/regulation/159_reg.pdf

1. **Capital cost:** CERC determines the cost of biomass power projects for all categories of technology. Table 3.1 shows the capital cost considered by CERC for different category of biomass power projects.

Table 3. 1: Capital cost by CERC

Biomass power projects based on Rankine cycle technology	Capital Cost (Rs. Crore/ MW)
Project [other than rice straw and juliflora (plantation)] with Water Cooled Condenser (WCC)	5.59
Project [other than rice straw and Juliflora (plantation)] with Air Cooled Condenser (ACC)	6.00
For rice straw and juliflora (plantation) based project with WCC	6.11
For rice straw and juliflora (plantation) based project with ACC	6.52
For non-fossil fuel based co-generation projects	4.92

2. **Station Heat rate (SHR):** For projects using travelling grate boilers the value of SHR is 4200 kCal/kWh. For projects using AFBC boilers the value of SHR is 4125 kCal/kWh. The ceiling SHR for new non-fossil fuel-based Co-Generation Projects shall be 3600 kcal/kWh.

3. **Useful life:** useful life of Biomass-based Power Project, Non-Fossil Fuel-based Co Generation with Rankine cycle technology considered by CERC is 25 years

4. **Gross Calorific Value (GCV):** The gross calorific value of biomass fuel, for the purpose of determination of tariff, shall be at 3100 kCal/kg. The GCV for non-fossil fuel based co-generation projects shall be considered as 2250 kcal/kg.

5. **Auxiliary Consumption**

   - For projects using water-cooled condenser: 10%
   - For projects using air-cooled condenser: 12%
   - for non-fossil fuel based co-generation projects: 8.5%

6. **Plant Load Factor:** The minimum PLF for the purpose of determining the fixed charge component of the Tariff. As per CERC, For the purpose of determination of tariff, the Plant Load Factor shall be considered as 80% and 60% for biomass power projects and for non-fossil fuel based co-generation projects respectively.

In order to determine biomass fuel price for respective states, **"Equivalent heat value approach for landed cost of coal for thermal power stations at respective States"** is adopted by CERC. As the approved fuel prices pertain to FY 2008-09 in most States, the biomass prices so derived has been escalated based on fuel price indexation mechanism to derive fuel prices during first year of the Control Period (i.e. for FY 2009-10). In order to calculate fuel cost for subsequent years, escalation factor of 5% is imposed[31], [32].

[31] http://www.cercind.gov.in/2017/draft_reg/Expl.pdf
[32] http://www.cercind.gov.in/2015/orders/SO4.pdf

Formula used to determine biomass/bagasse Fuel Price across States is as follows:

$$P_{(n)} = P_{(n-1)}*\{a*(WPI_{(n)}/WPI_{(n-1)})+b*(1+IRC_{(n-1)})+c*(Pd_{(n)}/Pd_{(n-1)})\}$$

Where,

WPI_n = Wholesale Price Index for n^{th} year

P_n = Price per ton of biomass for n^{th} year

P_{n-1} = Price per ton of biomass for $(n-1)^{th}$ year

IRC = Average Annual Inflation rate for indexed energy charge component

a = Factor representing fuel handling cost

b = Factor representing fuel cost

c = Factor representing transportation cost

Pd = Weighted average price of HSD

3.8. KERC Tariff determining parameters and Considerations[33]

Karnataka Electricity Regulatory Commission (KERC) believes that the slow growth of biomass based power generation projects could be due to the prevailing buyback tariff and the fuel cost which is dynamic. KERC commissioned a study called '**Sustainability of Biomass based Power Generation in Karnataka**' in order to review the situation and suggest improvements so that there could be a healthy mix of biomass generated power in the State under the renewable energy category. Parameters which support directly or indirectly for the tariff determination of Bagasse based Co-Generation Power Projects (BCPP) and Rankine cycle based Biomass power projects with WCC and ACC are discussed below.

3.9. Karnataka Fuel Price Calculation Method

As per the generic tariff order on RE 2018 before KERC (dated 14 May 2018), after considering and discussion with various stakeholder and expert committee, KERC decides to calculate the cost of bagasse on basis of cost at production point. As bagasse is the by-product of sugarcane and is produced in-house with the sugar production. Hence, it does not incur the transportation cost which acquires major chunk in overall cost of bagasse. Finally, as linking the logic of 30% of bagasse production from a particular quantity of sugarcane, the price of bagasse is also considered as 30% of average price of sugarcane in the state i.e. Rs 2817 per tonne in year 2017-18. So, the price value of bagasse is derived as Rs 819 per tonne for 2017-18 and escalated to Rs 865.85 per tonne for year 2018-19 with escalation factor of 5.72%. However, KERC states that, no sugar factory in the State is either selling bagasse or

[33] https://kredlinfo.in/General/KERC%20tariff%20orders/RE%20Tariff%20Order%202018.pdf

purchasing bagasse, therefore KERC decides not to link the bagasse price to a notional market value of sugarcane i.e. FRP.

Then, KERC adopts another method to determine bagasse price as discussed below:

It is considered that the production cost of sugar from sugar cane range from 20% to 30%. Similarly considering 20% production cost for bagasse is Rs 1039.00 per tonne for year 2018-19 is derived. As cited in the KERC tariff order 2018, the price of Bagasse for financial year 2018-19 is Rs. 1039 per tonne. With an annual escalation of 5.72%, the price of bagasse will be Rs. 1098.44 per tonne for FY 2019-20 and Rs. 1161.28 per tonne for FY 2021. For biomass power projects with WCC and ACC the fuel price is Rs.2500 per tonne for all types of biomass.

Major recommendations:

To sustain the operation of biomass power plants in the state and to meet the minimum purchase obligation for procurement of power from renewable sources, these power plants should be categorised as 'must run' plants. The following recommendations have been made to ensure the sustainability of biomass power plants.

1. **Adopt two part tariff (Fixed & Variable cost):** To encourage biomass based power generation plants through competitive bidding Cost-Plus method is followed. As the fuel cost varies from time to time it is advisable to adopt a two part tariff and the fuel cost is considered as a pass through. The variable component of tariff would take care of such a price escalation.
2. **Follow MNRE Guidelines for New upcoming plants:** To avoid the price volatility of fuel due to local demand, it is suggested to follow guidelines of MNRE plants which have a minimum radial distance of 50 Km while setting up new biomass power plants
3. **Fuel shortage mitigation techniques:**
    - Conduct energy audit program for rice mills
    - Adopt policy change to stop export of paddy - APMC
    - Check on new industrial licenses – Use of Biomass
    - Encourage energy plantation scheme

   It is strongly recommended that the tariff is determined once in two years by working out the tariff for the fixed expenses and variable expenses. Implementation of the above recommendations can lead to sustainability of biomass power plants in the state.

3.10. UPERC fuel price determination approach[34]

In the UPERC (Captive and Renewable Energy Generating Plants) Regulations, 2019, it is mentioned that according to the Order dated 11.1.2010 in Petition No. 636/09 &

[34] http://www.uperc.org/App_File/Draft_CRE_Regulations_2019-pdf44201991905PM.pdf

637/09 the Commission changed its approach of determining the price of bagasse from "equivalent heat value of coal considering pit-head coal" to the approach based on "equivalent heat value of coal considering landed price of coal including transportation cost". The transition of approach from considering the 'pit-head coal cost' to 'landed cost of coal including transportation' provided extra advantage to the co-generators in terms of fuel price. This change in approach led to steep y-o-y increase of around 34% in the notional price of bagasse during 2009-10.

The cane production and bagasse production in the State occur within a reasonably small geography not comparable with the large distances of non-pit head power stations from the coal mines. Therefore, the following inconsistencies exist in pricing of bagasse:

- Consideration of landed cost of coal for bagasse is erroneous as it includes transportation cost. The bagasse cogeneration plants are equivalent to pit-head plants as they consume their own bagasse generated out of the sugar crushing process. *Since, Bagasse is produced within the campus during process of sugar manufacturing; hence, no transportation is applicable.*
- Cost of fuel- Cane cost is decided by State Government after due diligence with the agreement of farmers and industries. Bagasse generation is 30% of cane. Hence, Bagasse price should be 30% of canes price.

Some Parameters that affect the tariff determination are as discussed below

1. **Control Period:** For the biomass and Co-generation projects the control period is considered as 5 years
2. **Tariff Competitive Vs Preferential:** The Commission opines that procurement of power from Bagasse based generation and cogeneration plants and Biomass based power from plants commissioned after 1st April 2019 should be through bidding route only. For existing plants of Bagasse and Biomass based generation and cogeneration plants, the Commission has determined Feed in tariff.
3. **Tariff structure of Captive and RE Generation:** For the fixed cost component of existing captive and RE projects the 2- part tariff for their remaining useful life shall be considered. For variable/ fuel cost component for Bagasse and Biomass based power plants, it is linked with coal equivalent basis i.e. weighted average coal price of pit head plants of UPRUVNL for last Quarter of previous FY which shall be applicable for that FY after deducting coal transportation charges and relevant cess and duties thereon.
4. **Decisions taken by UPERC:** Considering the suggestion made by the utility and the price discovered by UPPCL, the Commission has decided to consider 10.66 % rate of interest on loan while rate of interest on working capital is considered as 11.66%
5. **Normative parameters:** For bagasse based power plants, fuel cost and ceiling tariff is considered as Rs. 1000/tonne (only pit head coal cost) and 4.81 Rs./kWh respectively while SHR is considered as 3200 kcal/kWh. In case of biomass based power plants, fuel price is considered as 2585 Rs/tonne while

GCV and SHR has been considered as 3200 kcal/kg and 4200 kcal/kWh respectively.

6. **Electricity (MW/MU) supplied over and above 50% PLF for bagasse based power plants:** The Bagasse based generating plants, to generate more power beyond 50% PLF, the generator shall be paid variable cost, as applicable along with incentive as @ 50 paise per kWh.
7. **Electricity (MW/MU) supplied over and above 80% PLF for Biomass based power plants:** To provide suitable incentive to biomass (rice husk based) based generating plants, to generate more power beyond 50% PLF, the generator shall be paid variable cost, as applicable along with incentive as @ 50 paise per kWh.

UPERC released "Statement of Reason" in response to objections/comments received by stakeholders on CRE, 2019. The commission considered price and GCV of G10 Grade Coal is 1171 Rs./tonne and 3683 kCal/kg respectively. Based on these values, price of bagasse comes out to be 715 Rs./tonne. The commission in final regulation has considered the bagasse price as 1010 Rs/tonne based on revised norms and parameters (coal cost: Rs 2256 per tonne and GCV of coal: 3500 kCal/kg). *However, as per interaction with UPERC official, it is found that, CRE2019 regulations are objected by power plant stakeholders and challenged in Allahabad High court. The decision is still pending. Till then, CRE 2019 will be under consideration.*

3.11. TNERC

The proposed tariff (w.e.f. 01-04-2020) shall be applicable to Bagasse based Co-generation plants and biomass based power plant. According to Order No. 5 & 6 /2020, until a new order is issued, Commission extends the validity of the Order No.3 & 4 of year 2018 for biomass and Bagasse based Cogeneration power plants respectively[35]-[36]. In order to determine tariff, cost-Plus Tariff method is adopted in this order as it is a more practical approach and encourage the setting up of new co-gen plants till the competitive bidding is introduced. However, two part tariff is adopted where the fuel cost varies from time to time and considered as a variable cost component. The tariff components as proposed in the consultative papers for Bagasse based power plants[37] and Biomass based power plant[38] are shown in table 3.2. All biomass plants in Tamil Nadu are Air cooled condenser based technology[39]

A debt-equity ratio of 70:30 is adopted period for bagasse based and biomass based power plants and proposed to maintain the same for the next control[40]. However, the interest rate of 10.31% is considered on loan for biomass based power plant as well as bagasse based power plants. The useful life of the plant is considered 20 years for tariff determination process for both the types of power plants. For bagasse and

[35] http://www.tnerc.gov.in/orders/Tariff%20Order%202009/2020/Ext-Bagasse-6-2020.pdf
[36] http://www.tnerc.gov.in/orders/Tariff%20Order%202009/2020/Ext-Biomass-5-2020.pdf
[37] http://tnerc.gov.in/Concept%20Paper/2020/Bagasse-2020-2021.pdf
[38] http://tnerc.gov.in/Concept%20Paper/2019/Biomass-concult.pdf
[39] http://www.tnerc.gov.in/orders/Tariff%20Order%202009/Bio%20Mass%20Order%2027.04.2009.pdf
[40] http://www.tnerc.gov.in/orders/Tariff%20Order%202009/2018/BiomassT.O.3of2018.pdf

biomass based power plants, TNERC proposes the same value as adopted by CERC for year 2019-20 as Rs.1926.63 and Rs. 3271.51 per ton respectively with an escalation of 5% p.a.

Table 3. 2: Tariff determining factors for bagasse and biomass based power plants (2020-21)

Sr. No.	Tariff Component	Bagasse based power plant	Biomass based power plant
1.	Capital cost (Rs. Crore/MW)[41]	4.925	6.11
2.	PLF (%)	60	80
3.	O & M expenses	3% of Capital Cost with an annual escalation of 5.72% from 2nd year onwards	5% with escalation of 5.72% from 2nd year on 85% of capital cost for machinery
4.	Station Heat Rate (kCal/kWh)	3240	3840
5.	GCV (kCal/kg)	2300	3200
6.	Specific Fuel Consumption (kg/kWh)	1.41	1.20
7.	Fuel Cost (FY 2020-21) (per ton)	Rs. 1926.63	Rs. 3271.51 with 5% escalation from 2nd year onwards
8.	Auxiliary Consumption (%)	8.5	10
9.	Variable Cost (per kWh) 2020-21 2021-22	 Rs.2.97 Rs.3.12	 Rs.4.36 Rs.4.58
10.	Fixed Cost (per kWh) 2020-21 2021-22	 Rs.2.08 Rs.2.10	 Rs. 2.18 Rs. 2.21
11.	Total Cost (per kWh) 2020-21 2021-22	 Rs.5.05 Rs.5.22	 Rs.6.54 Rs.6.79
12.	Use of Fossil fuel	15% of total fuel consumption on annual basis.	

3.12. MERC fuel price determination approach[42]

As per order No. 33 of 2017 (dated 28 April 2017) and order No. 204 of 2018 (dated 18 Aug 2018), bagasse price for Maharashtra for FY 2017-18 and 2018-19 are 2273.75 Rs./ton and 2387.44 Rs./ton respectively.

For the biomass based power projects and Non-fossil fuel-based Co-generation plant a single part tariff with two components i.e. fuel cost components and fixed cost components like Return on Equity, Interest on loan capital, and O & M expenses

[41] http://www.tnerc.gov.in/orders/Tariff%20Order%202009/2018/BaggasseT.O-4of2018.pdf
[42] https://www.mahadiscom.in/wp-content/uploads/2020/01/39.-30.12.2019-RE-Tariff-Regulations-2019-English.pdf

shall be determined. As mentioned in the general principle, the regulations shall be applicable for the period of 5 years. The tariff period for the biomass based power projects and Non-fossil fuel-based Co-generation plant which is equal to their useful life is 25 years for which tariff shall be determined on a levelised basis and it shall commence from the date of commercial operation of Generating station. The fuel price shall be determined based on prices of fuel mix for each project and an independent study by the commission. Table 3.3 shows the parameters to determine the tariff for Biomass based power plant and Non-fossil fuel based Co-generation plant.

Financial Parameters:

1. **Debt-equity ratio:** For determining the generic tariff the debt-equity ratio is considered as 70:30 and if the actual equity deployed exceeds 30% of capital cost it is treated as normative loan.
2. **Depreciation**: The depreciation rate for the first 12 years of the Tariff Period is 5.83% per annum, and the remaining depreciation shall be spread over the remaining useful life of the project from the 13th year onwards.
3. **Return on Equity**: The Equity value is 30% of the capital cost or the actual equity and shall be computed at the base rate of 14%, to be grossed up as per the Minimum Alternate Tax ('MAT') rate applicable as on 1st April of the previous Financial Year.

Table 3. 3: Parameters to determine the tariff for Biomass based power plant and Non-fossil fuel based Co-generation plant.

Sr. No.	Parameter	Biomass based Power Plant	Non-fossil fuel based Co-generation plant
1.	Capital Cost	To be approved in case of project-specific tariff considering the prevalent market conditions for both the types of power generation plants	
2.	Plant Load Factor	• During Stabilization period (not longer than 6 months after commissioning) : 60% • During remaining period of 1st year : 70% • From 2nd year onwards : 80%	On the basis of plant availability 180 days (crushing) + 60 days (off-season) = 240 days operating days : 60%
3.	Auxiliary Power Consumption	10% (Ceiling)	8.5% (Ceiling)
4.	Station Heat Rate	4200 kcal/kWh (Ceiling)	3600 kcal/kWh (Ceiling)
5.	O&M Expenses	5.32% of the Capital Cost for the base year of review period	3.54 % of the Capital Cost for the base year of review period
6.	Use of fossil fuels	Limited to 15% of the total fuel consumption on an annual basis only for existing plants. However, use of fossil fuel is not allowed for new plants. (plants will be considered as new if commissioned w.e.f. FY 2020-21)	

Sr. No.	Parameter	Biomass based Power Plant	Non-fossil fuel based Co-generation plant
7.	Calorific Value	For existing biomass projects: 3611 kcal/kg. (minimum average) For new Biomass projects: 3100 kcal/kg. (minimum average)	2250 kcal/kg (minimum gross)
8.	Fuel price	Fuel price would be determined based on prices of fuel mix for each project and an independent study by the commission which shall be linked to the indexation mechanism considering the aspects such as disposal cost, opportunity cost in terms of alternative uses of the fuel, and GCV. Also depending upon the Biomass fuel prices determined by the Central commission, an independent study by the commission or an escalation of 5% per annum.	
9.	Fuel price Indexation Mechanism	Annexure I	

3.13. Cost of biomass and bagasse (CERC Data)

The cost of fuel plays an essential role in the feasibility and profitability of any power generation projects. In bagasse-based cogeneration plant bagasse is the primary feedstock with the small composition of other fuel. While in Biomass-based power generation plant biomass from agriculture waste is the main feedstock. Both Bagasse and Biomass are not available throughout the year of plant operation. It is generated during the harvesting period of crops and needs to store for non-seasonal service. Hence their price varies during season and off season. The factor determining the cost of these fuels includes production, handling, transportation and processing. To reduce the transportation cost, Onsite shredding of biomass needs to be processed to increase its density when procurement is done from a longer distance.

Figure 3.6 and 3.7 shows the cost of biomass and bagasse proposed by CERC for FY (2021-2022). From figure 3.6, it is observed that, Maharashtra has highest biomass cost of 4065 Rs/ton compared to other top biomass potential states followed by Haryana with proposed biomass cost of 3975.3 Rs/ton. Similarly, figure 3.7 shows that, the CERC proposed highest bagasse cost of 2804 Rs/ton in Haryana compared to other top bagasse potential states followed by Maharashtra with proposed bagasse cost of 2763 Rs/tonne.

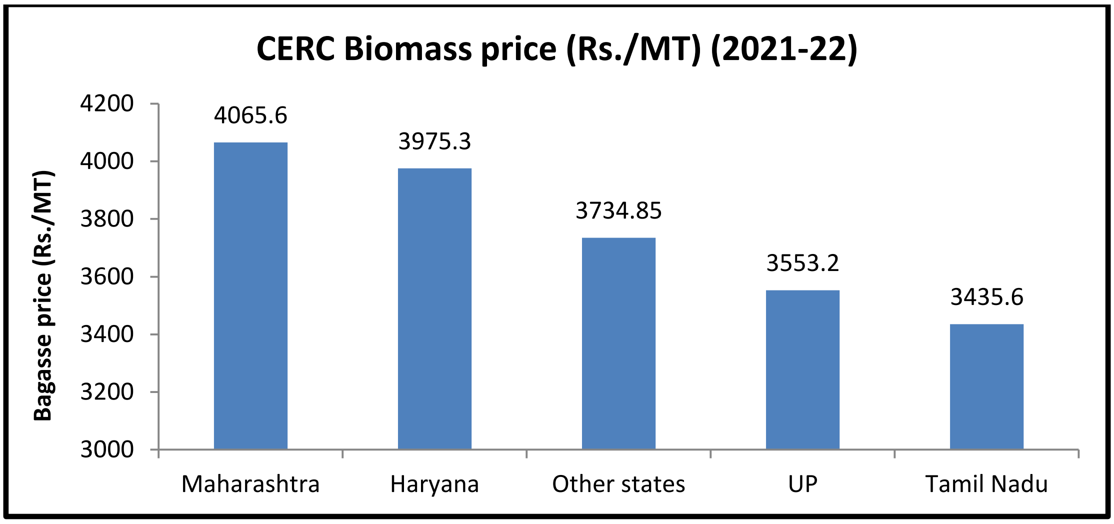


Figure 3.6: **Biomass Cost Comparison (2020-21)**

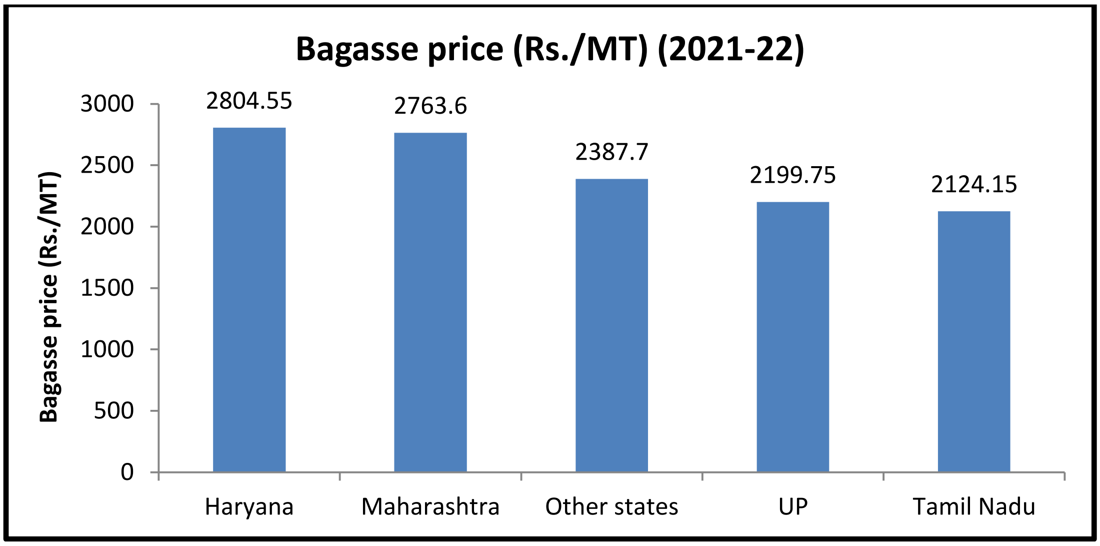


Figure 3.7: **Bagasse Cost Comparison (2020-21)**[43]

3.14. Bagasse cost considered by different SERC

Table 3.4 shows the year wise trend of cost of bagasse considered by different SERC. The cost considered by SERCs is also compared with bagasse cost provided by CERC. The price of Bagasse as specified by the CERC for the state of Maharashtra for FY 2020-21 is Rs. 2632/tonne and for the same financial year it shall be determined based on an independent study by the commission which shall be linked to the indexation mechanism as specified by MERC. In the state of Uttar Pradesh for the FY 2020-21, the cost of bagasse as specified by CERC is Rs. 2095/tonne. However, UPERC considered the bagasse cost as Rs. 1000/tonne as per the suggestion made by the utility and the price discovered by UPPCL. It is linked with coal equivalent basis i.e. weighted average coal price of pit head plants of UPRUVNL after deducting coal

[43] http://www.cercind.gov.in/2021/orders/2-SM-2021.pdf

transportation charges and relevant duties on it. Similarly, for financial year 2019-20, the cost of bagasse adopted by UPERC was half the value as determined by CERC. The price of bagasse in the state of Karnataka as determined by the CERC for FY 2020-21 is Rs. 2247/tonne. However, KERC considered bagasse cost as Rs. 1161.28/tonne with an annual escalation of 5.72% from FY 2019-20. These prices adopted by the KERC are 30% of the price of sugarcane and 20% of the production cost of sugar because, the bagasse is 30% part of the sugarcane and also the production cost of bagasse is considered equivalent to production cost of sugar. The Cost of bagasse as determined by Tamil Nadu is as specified by CERC for each financial year.

Table 3. 4: Year wise trend of bagasse cost (Rs/tonne)

Commissions costs	2018-19	2019-20	2020-21
CERC for Maharashtra	2387.44 (b)	2506.81 (b)	2632 (a)
MERC	2387.44 (c)	2506.81 (d)	To be Calculated
CERC for Uttar Pradesh	1900 (b)	1995 (b)	2095 (a)
UPERC	2000 (f), (h)	1010 (f), (g)	1000 (e)
CERC for Karnataka	2062.95 (b)	2166.09 (b)	2274 (a)
KERC	1039 (i)	1098.44 (i)	1161.28 (i)
CERC for Tamil Nadu	1834.89 (b)	1926.63 (b)	2023 (a)
TNERC	1834.35 (k)	1926.06 (k)	2022.37 (j)

3.15. Biomass cost considered by different SERC

Table 3.5 shows the year wise trend of cost of biomass considered by different SERC. The variation in cost of biomass considered by SERCs and CERC is analysed. The price of Biomass for FY 2020-21 as determined by CERC for Maharashtra is Rs. 3872/tonne whereas for the same financial year it has to be determined by MERC based on independent study by the commission which shall be linked to the indexation mechanism. For the previous financial year FY2019-20 the cost determined by MERC was Rs. 4295.57/tonne which is escalated price of the previous year by 5% as escalation factor determined by the CERC. For the same financial years the cost determined by CERC was lower. For the FY 2017-18 the biomass fuel price was calculated considering the principle of equivalent heat value and the price was Rs. 3896.21/tonne. In the Uttar Pradesh the cost of biomass determined in the financial year FY2018-19 was Rs. 3069/tonne which increased annually with an escalation factor of 5% for the biomass of calorific value 3100 kcal/kg and in FY2020-21 the price is Rs. 3384/tonne as determined by CERC. For the FY 2019-20 the price determined by UPERC for biomass was Rs. 2585/tonne after taking suggestion from the stake holders. As determined by KERC the cost of biomass for the financial year FY 2018-19 was Rs. 2500/tonne and increased every year with an annual escalation factor of 5.72%. Therefore in FY2019-20 it was Rs. 2643/tonne and in FY2020-21 it is Rs. 2794.18/tonne and these prices were adopted for the respective years. The cost adopted by TNERC for biomass is as specified by CERC for each financial year

Table 3. 5: Year wise trend of biomass cost (Rs/tonne)

Commissions	2018-19	2019-20	2020-21
CERC for Maharashtra	3512.09 (b)	3687.69 (b)	3872 (a)

Commissions	2018-19	2019-20	2020-21
MERC	4,091.02 (c)	4,295.57 (d)	To be calculated
CERC for Uttar Pradesh	3069.00 (b)	3222.45 (b)	3384 (a)
UPERC		2585 (e)	
CERC for Karnataka	3226.70 (b)	3388.04 (b)	3557 (a)
KERC	2500 (i)	2643 (i)	2794.18 (i)
CERC for Tamil Nadu	2967.35 (b)	3115.72 (b)	3272 (a)
TNERC	2967.35 (m)	3115.72 (m)	3271.51 (m)

a. http://www.cercind.gov.in/2020/regulation/159_reg.pdf
b. http://www.cercind.gov.in/2019/orders/Draft%20RE%20Tariff%20Order%20for%20FY%202019-20.pdf
c. https://www.mahadiscom.in/consumer/wp-content/uploads/2018/09/Order-204-of-2018-18082018.pdf
d. https://www.merc.gov.in/mercweb/faces/merc/common/outputClient.xhtml# (order 52 , 2019)
e. http://www.uperc.org/App_File/Draft_CRE_Regulations_2019-pdf44201991905PM.pdf
f. http://www.cogencis.com/newssection/mills-body-moves-hc-as-uttar-pradesh-halves-bagasse-price-for power/#:~:text=In%20April%20this%20year%2C%20Uttar,2%2C500%2D2%2C600%20rupees%20per%20tn
g. http://www.tnerc.gov.in/Concept%20Paper/2020/Bagasse-2020-2021.pdf
h. https://www.business-standard.com/article/economy-policy/up-sugar-mills-risk-rs-500-cr-loss-as-regulator-cuts-power-tariffs-119050900809_1.html
i. https://kredlinfo.in/General/KERC%20tariff%20orders/RE%20Tariff%20Order%202018.pdf
j. http://tnerc.gov.in/Concept%20Paper/2020/Bagasse-2020-2021.pdf
k. http://www.cbip.org/Regulations2018/Data/Tamil%20Nadu/TN_Tariff_Orders/4_TN_Cogen.pdf
l. http://www.tnerc.gov.in/Concept%20Paper/2018/BAGASSE-2018.pdf
m. http://tnerc.gov.in/Concept%20Paper/2019/Biomass-concult.pdf

3.16. Comparison of variable cost components from different SERCs for bagasse and biomass based power plants

In order to determine the variable cost component of tariff, important parameters are station heat rate, gross calorific value, Auxiliary consumption factor and fuel cost. Table 3.6 and 3.7 shows the comparison of variable cost components from different SERCs for bagasse and biomass based power plants respectively. It is observed that, in case of bagasse based power plants, fuel cost considered by different SERCs and CERC is main variable cost factor affecting the tariff rate. Hence, fuel cost is major factor responsible for variation in variable cost as well as tariff for different SERCs. For biomass based power plants, Maharashtra considers highest GCV of biomass for existing biomass plants i.e. 3611 kCal/kg while other state considers GCV value in the range of 3100-3200 kCal/kg. Similarly, Bagasse as well as biomass cost considered by MERC is highest among other states. Hence, biomass and bagasse tariff of Maharashtra is highest among selected states.

Table 3. 6: Variable cost components from different SERCs for bagasse based power plants

Variable cost Component	MERC	KERC	UPERC	CERC
Station Heat Rate (kCal/kWh)	3600	3600	3200	3600
GCV (kCal/kg)	2250	2250	2250	2250
SFC (kg/kWh)	1.6	1.6	1.42	1.6
Fuel Cost (2019-20) (Rs. per tonne)	2506.81	1098.44	1010	
Auxiliary Consumption (%)	8.5	8.5	8.5	8.5

Table 3. 7: Variable cost components from different SERCs for biomass based power plants

Variable cost Component	MERC	KERC		UPERC (ACC)	CERC (2020)	
		WCC	ACC		WCC	ACC
SHR (kCal/kWh)	4200			4200	travelling grate boilers: 4200 AFBC boilers: 4125	
GCV (kCal/kg)	For existing projects 3611 For new projects 3100			3200	3100	
SFC (kg/kWh)	To be determined	1.21	1.18	1.31		
Fuel Cost (2019-20)	4,295.57	2643		2585	Escalating @ 5% for all states from 1st year control period of 2017-18	
Use of Fossil fuel	15% of annual consumption. NA for new plants				15 % allowed only for plants commissioned before 2017	

Chapter 4: Analysis of survey outcomes and Parameter Settings

This chapter includes secondary analysis supported by primary data received during field visits and stakeholder consultations to estimate the availability and pricing of bagasse in the state of Maharashtra. Certain data from different authentic sources as well as thumb rules are applied to estimate the availability and pricing of bagasse on approximation basis.

4.1. Research Limitations and Mitigation

The cogeneration is considered to be the most viable option, in order to eliminate the waste heat in the plant and it also meets the electrical power requirement of the Sugar Industry.

The contracted capacity of bagasse cogeneration in Maharashtra is 2406 MW out of which 2301 MW[44] is commissioned till 2019-20. 2100 MW was operational as per the Cogen Association of India (CAI)[45]. Additional 1300 MW is proposed by government of Maharashtra as per the CAI records. In Maharashtra, total 3987 MUs were generated by bagasse cogeneration units in 2019-20[46]. MERC has fixed Renewable Purchase Obligation (RPO) targets for Non-Solar Category as 11.5% from FY 2020-21 till FY 2024-25 .The cost of fuel is very important constituent hence MERC has initiated the scientific evaluation of the Cost of Bagasse and Biomass.

The total number of plants to be surveyed was 40 during the primary survey as per research's prescribed scope. Experts surveyed 32 out of 33 Bagasse based power Plants & 7 Biomass based power plant. The Lokmangal Mauli cogeneration plant at Osmanabad did not allow experts for site visit. They did not provide any data either. The 6 bagasse based plants were closed during 2019-20 are listed in Table 4.1. The remaining 26 bagasse plants shared various technical data with experts during plant visits through physical interview. Table 4.2 shows the list of plants who provided cost audit report of year 2019-20.

Swaraj Agro India, Satara and "Urjankur Shree Tatyasaheb Kore Power, Kolhapur" avoided the financial data during interview and also did not share any financial reports.

[44] Secondary data provided by MEDA
[45] During interview CAI
[46] MEDA

Table 4. 1: The plants closed in year 2019-20

Sr. No.	Plant	Status
1	Loknete Baburao Patil Agro Industries Ltd ,Solapur	Closed in 2019-20
2	SMSN Nagawade SSK Ltd, Ahmednagar	Closed in 2019-20
3	Shri Saikrupa Sugar and Allied Ind. Ltd,Ahmednagar	Closed in 2019-20
4	Vasantraodada Patil SSKL,Nashik	Closed in 2019-20
5	Vikas Latur	Closed in 2019-20
6	M/s Gangakhed Sugar &Energy Ltd ,Beed	Closed in 2019-20

Table 4. 2: Plants which provided the cost Audit report of 2019-20

Sr. No.	Plant
1	The Saswad mali sugar factory Ltd, Solapur
2	Udagiri Sugar and Power Ltd, Sangali
3	The Malegaon Sahkari Sakhar Karkhana Ltd, Pune
4	Baramati Agro Ltd, Pune
5	Bhimashankar SSKL Ltd., Pune
6	Baramati Agro Ltd. Aurangabad
7	Gangamai Industries and constructions limited
8	Ashok SSKL, Ahamednagar
9	Manus 15 MW Unit -3 ,Nagpur

The same data is used for data analysis. Cost audit report for year 2019-20 is not received from other plants. Cost Audit was not done by Karmayogi Ankushrao Tope SSK Jalna and Shree Siddheshwar SSKL Solapur in the year 2019-20.

We received RT8C from 21 plants and Energy Audit Report of 8 Plants. The representatives of some plants avoided the answers to questionnaire. GCV of bagasse was provided by 18 plants. Working days of the season were not provided by some of the plants. FRP Rate was also not given by 5 plants. Also some plants could not give the information like generation cost/ unit, Tariff Rate, etc. All the information received is tabulated and presented in this report. Table 4.3 shows list of plants who have not given complete information/data in all respect. During the survey of the primary data, it was observed that the data provided regarding bagasse production and units generated by the sugar mills and the data in records of the RT8C shows variation. As the data of the RT8C is prescribed for particular season and the data given by the plants was for financial year.

Table 4. 3: List of plants provided incomplete data/information

Plant Name
Vikas SSKL, Latur
NSL Sugars Ltd, Beed
Gangakhed Sugars & Energy Ltd., Parbhani (www.gangakhedicpp.com)
Purna SSKL, Hingoli
Sant Muktai Sugar & Energy Ltd., Jalgaon
Manas Agro (Purti Sakhar Karkhana Ltd.), Nagpur (22MW)
Manas Agro Industries and Infrastructure Ltd., Wardha (15 MW)

The district wise Bagasse production, crushing was acquired by referring VSI data. The mismatch was observed within data given in RT8C and VSI report. Also there is mismatch in units generated in 2019-20 given by MEDA and data taken from RT8C. The RT8C report has seasonal data and hence the data provided by MEDA about units generated is considered. District officers were busy with COVID-19 duties and hence the district wise data of the sugarcane production and other crop cultivation could not be acquired. The boiler efficiency data acquired from sugar factories are almost near to the standard values. But the bagasse consumption collected during the primary survey found on higher side, which is self-contradictory. Table 4.4 shows status of surveyed plants

Table 4. 4: Data acquisition status on all the 40 plants

Data Status of all 40 plants		
Subject	**Number**	**Remarks**
Total number of plants to Survey	40	
Bagasse Plants to survey	33	
Biomass Plants to survey	7	
Bagasse Plants Visited	32	
Bagasse Plants not allow visit	1	Lokmangal Mauli (Osmanabad) not allowed visit
Biomass Plants Visited	7	
Bagasse Plants closed in 2019-20	6	Loknete (solapur), Saikrupa (Ahmednagar), Vasantraodada patil (Nashik), SMSN Nagwade (Ahmednagar),Vikas (Latur), M/s Gangakhed Sugar &Energy Ltd, Beed
Bagasse Questionnaire received for plants	29	
Farmers data received (Bagasse Plant related)	5 farmer /Plant	
Transporters data received (Bagasse plant related)	2 transporter /plant	
Traders data received(Bagasse plant related)		No bagasse plant took bagasse from traders
RT8C Received (2019-20) (Bagasse Plant)	19	
Cost Audit received (2019-20)	9	
Energy Audit report received	10	
Biomass Questionnaire received for plants	7	
Biomass Farmer / Transporter /Traders data available	4 plants	MVNL, Vayunandana, Sinewave, A A Energy
Fuel statement received (Biomass)	7	
Cost Audit received(2019-20) (Biomass)	2	

4.2. Secondary support for data analysis

- Niti Aayog report is used as reference for the number of farmers in Maharashtra who have cultivated the sugar cane. Technical report of Vasantdada Institute is used as reference for the production of sugar and bagasse
- The capacity utilisation of the cogeneration plants is derived based on the interviews
- The cost audit report of the plants is considered as per availability, for the calculation of the bagasse cost by split method.

4.3. Primary Survey

During primary survey, questionnaire based interaction with power plant officials, farmers, traders, transporters has been done to get the understanding of the biomass/bagasse costing, generation and consumption pattern and to estimate seasonal surplus biomass available for each selected plant round the year. The main objective of primary survey was to get the holistic understanding of following points:

- ➢ Identification of the final price of fuel including collection cost, harvesting, processing, transportation, loading, unloading and stacking cost etc.
- ➢ During primary survey data verification such as CRR, biomass cogen capacity, prices of biomass, market value of bagasse, surplus of biomass/bagasse available for power generation has been identified.

Primary survey covered 13 districts of the Maharashtra. The sugar belt of Maharashtra is covered during the survey. The highest concentration of sugarcane cultivation is in the southern reaches of Maharashtra (Pune Division).

The climate and water conditions required for sugarcane are fairly better here compared to other regions of Maharashtra. Here, there is regular rainfall along with several other sources of water for sugarcane cultivation such as rivers and canal irrigation. Though the water availability is critically low in the Marathwada and Vidharba regions (Aurangabad, Amaravati and Nagpur Divisions) the farmers are inclined towards sugar cane cultivation compared to the other crops. For many months in a year, these regions experience drought and critical water shortage. However, farmers continue to grow sugarcane as it fetches them an assured price unlike other crops.

The 38% of plants surveyed, has Tons Crushing per Day (TCD) in the range of 2500 to 5000. The total TCD covered during the primary survey was 139.15 thousand TCD whereas the cumulative cogeneration capacity was 542.5 MW. The cumulative 198.95 Million Unit generated by the visited cogenerations units as presented in the figure 4.1.

During primary survey, as seen from figure 4.2 the highest number of cogeneration in terms of MW capacity was observed in Solapur district. The maximum cogeneration capacity of Sugar mills in this district was 44 MW.

It has also been observed during primary survey that the coal requirement for the cogeneration is not more than 1% of total fuel used during season. Coal is used for the lighting up the boiler only. As the fossil fuel costing is less than 1% of total fuel cost, the fossil fuel cost is booked under miscellaneous account head and hence, cannot be separate out from the cost sheet.

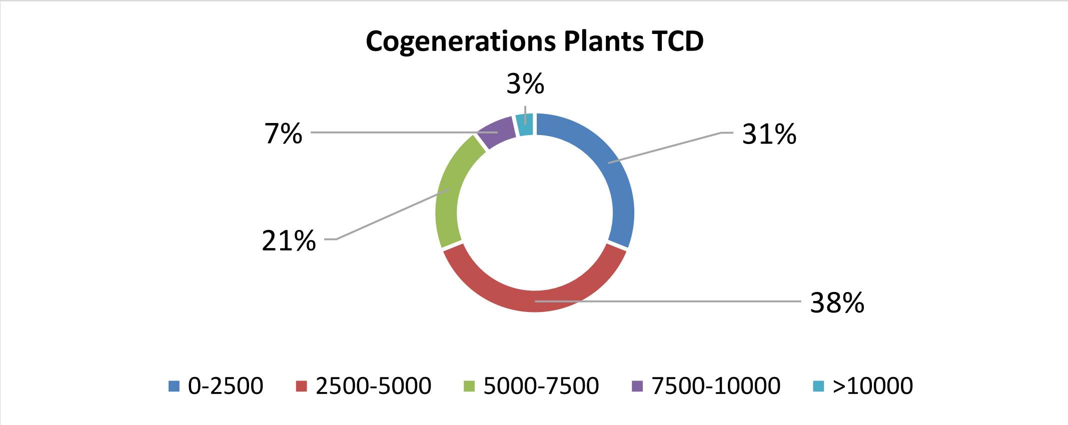


Figure 4.1: Primary surveyed TCD

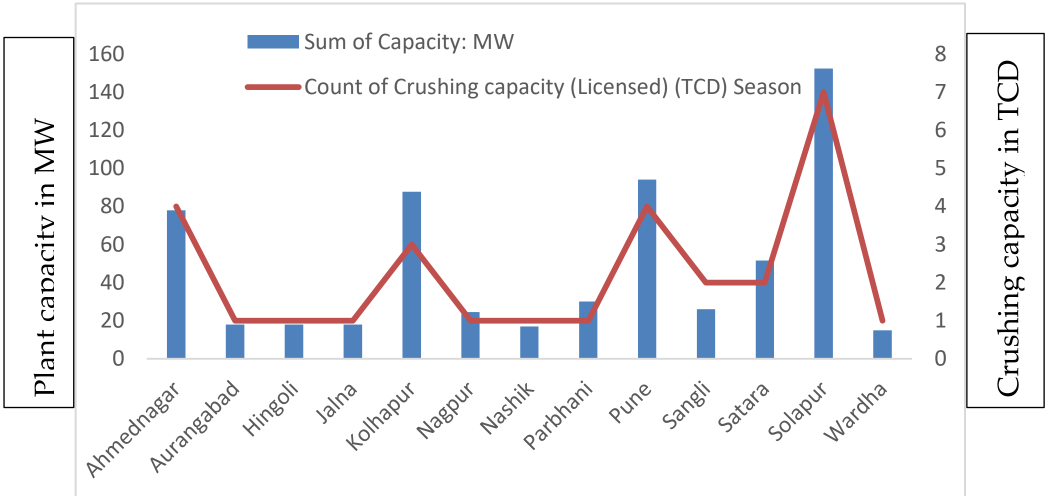


Figure 4.2: District wise MW of primary surveyed plants

During primary survey of Cogeneration units, the following data was collected

1. Capacity of the cogeneration plant
2. Crushing capacity of the plant
3. Station heat rate
4. Boiler type and technology
5. Plant load factor
6. Total Bagasse production
7. GCV of Bagasse
8. GCV Biomass
9. Purchase cost of Biomass

10. Type of Biomass used as fuel
11. Bagasse to steam ratio
12. Total Power units generated
13. Auxiliary consumption factor
14. F.R.P
15. Capital cost /MW
16. Harvesting and transportation cost

The average of GCV is taken out for the different biomass obtained while acquiring the data during primary survey and site visits. GCV value was measured as per sample collected from biomass plants. Secondary data was collected from the various stakeholders like MEDA, Sugar Commissioner Office and VSI. The reference data used for the data gaps is from the following reports & Website

1. Niti Aayog, march 2020
2. MERC regulation
3. Vasant dada sugar Institute Pune
4. Website of MNRE

These reports have helped in evaluating the primary data and defining the data ranges.

Team of Experts acquiring Primary Data

4.4. Data Analysis

The data validation was followed by collection of primary and secondary data.

The data validation of the primary survey was carried out via data as per the answers to the interview provided by the cogenerations head vs the data in the RT8C. The variation in the data was address by considering the RT8C data as the final data. Also, the data validation on the cost of the production and H&T was carried out by comparison of the cost audit report with the data collected during interview. Secondary data is mainly collected during meetings with MEDA, Sugar Commissioner Office and Vasantdada Sugar Institute, Pune.

The various parameters of bagasse pricing are used from the primary data collected from factories and the data insufficiencies are bridged by referring the RT8C and Cost Audit Reports.

Factors reviewed from RT8C Report

The important factors such as Station Heat Rate (SHR), GCV of Bagasse (wet Basis), Bagasse % Cane, Steam Generation, Steam to Bagasse Ratio, Bagasse Production and Auxiliary Consumption etc. are taken from RT8C report and used for analysis.

$$\text{Steam Generation Qty} = \frac{\text{Bagasse Qty} \times \text{GCV of Bagasse} \times \text{Boiler Efficiency}}{(\text{Steam Enthalpy} - \text{Feed Water Enthalpy})} \ldots (A)$$

$$\text{Power Generated in MUs} = \frac{\text{Steam Generation Qty} \times \text{Steam Enthalpy}}{\text{Steam Heat Rate}} \ldots\ldots\ldots (B)$$

$$Energy\ Exported = Energy\ Generated - \text{Auxiliary Consumption} \ldots\ldots\ldots (C)$$

Factors reviewed from Cost Audit Report

- The Power Revenue is referred from cost audit report.
- The various unit rates are assumed while evaluating the preferential tariff of the energy exported to the Grid.
- The Fixed cost, profit, variable cost, direct and chemical cost for the different power plants is averaged out for that particular district and those averaged values are subtracted from averaged Power Revenue in order to derive the steam cost.

Further, Steam Cost from Boiler is the rate obtained by using boiler efficiency factor and Steam Revenue is calculated based on quantity of Steam generated multiplied by the rate of steam cost from boiler which when further subtracted by Fixed Cost, Variable Cost, Chemical, DM Water Cost, Power Cost, etc.

4.5. Sugar Cane Production

In India, Maharashtra is one of the major sugarcane producing state and its trend of the sugar crushing is shown below in Figure 4.3. The sugarcane production has shown variation from 5 years in Maharashtra. The record sugar cane crushing of 953.73 lakh ton was done in 2017-18. The sugarcane crushing has increased from 373.29 to 953.73 lakh ton in 5 years starting from 2015-16 to 2019-20. The production of Sugar Cane is fluctuated year on year basis due to variation in area under sugar cane, climatic conditions, water availability during the crop growth period and most importantly remunerative and timely payment of cane prices to the sugarcane cultivators. During 2016, Maharashtra experienced drought so the sugarcane production reduced. It is estimated that the area under sugar cane declined by 15.8 %[47] in Maharashtra in 2019-20. During primary data collection, it was found that many of the farmers are inclined to grow sugar cane as it fetches them at least 77% [48] of return as against A2+FL cost of Rs 155 per quintal in 2018–19. (A2+FL: Actual paid out cost plus imputed value of family labour)

In 2019-20, Maharashtra produced 61.91[49] Lakh ton of sugar by crushing 548.85 lakh ton of cane with an average recovery of 11.29%. The four district count for 63% production of the Sugarcane in the Maharashtra State which includes Kolhapur (18.1%), Pune (18.0%), Sangli (15.1%) and Satara (12.3%).

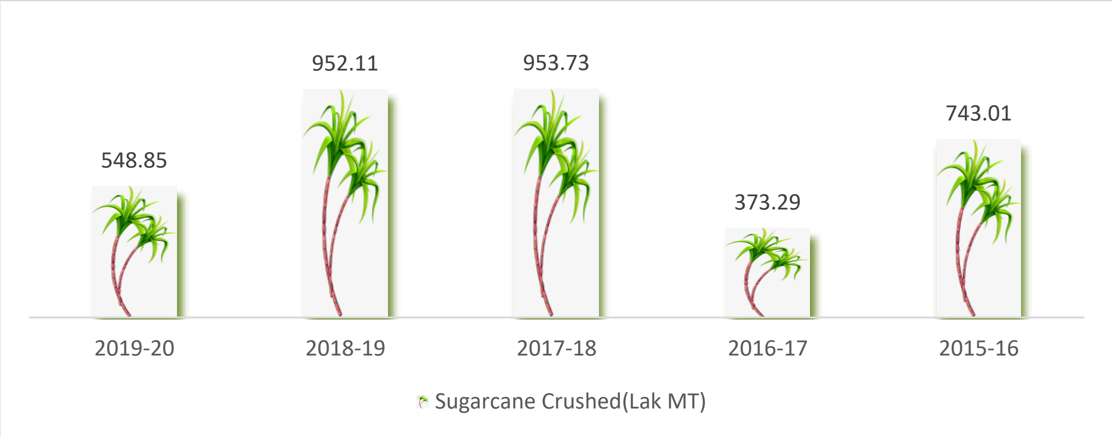


Figure 4.3: Year wise Sugar Crushed (Lakh MT)[50]

4.6. District-wise Crushing of Sugar cane

Figure 4.4 shows the district wise cane crushed during crushing season of 2019-20. It is clear from figure that Kolhapur, Pune, Satara, Sangli, Solapur and Ahmednagar had the crushing of around 83% of the total sugar cane in Maharashtra during 2019-20. Total 243 sugar mills are present whereas operational sugar mills are around 147[51] only.

[47] Price Policy for Sugarcane SUGAR SEASON 2020-21, Nov 2019, CCPA report.
[48] NITI Aayog Report March 2020
[49] VSI Technical performance of sugar mills in Maharashtra
[50] VSI REPORT 2019-20
[51] VSI report

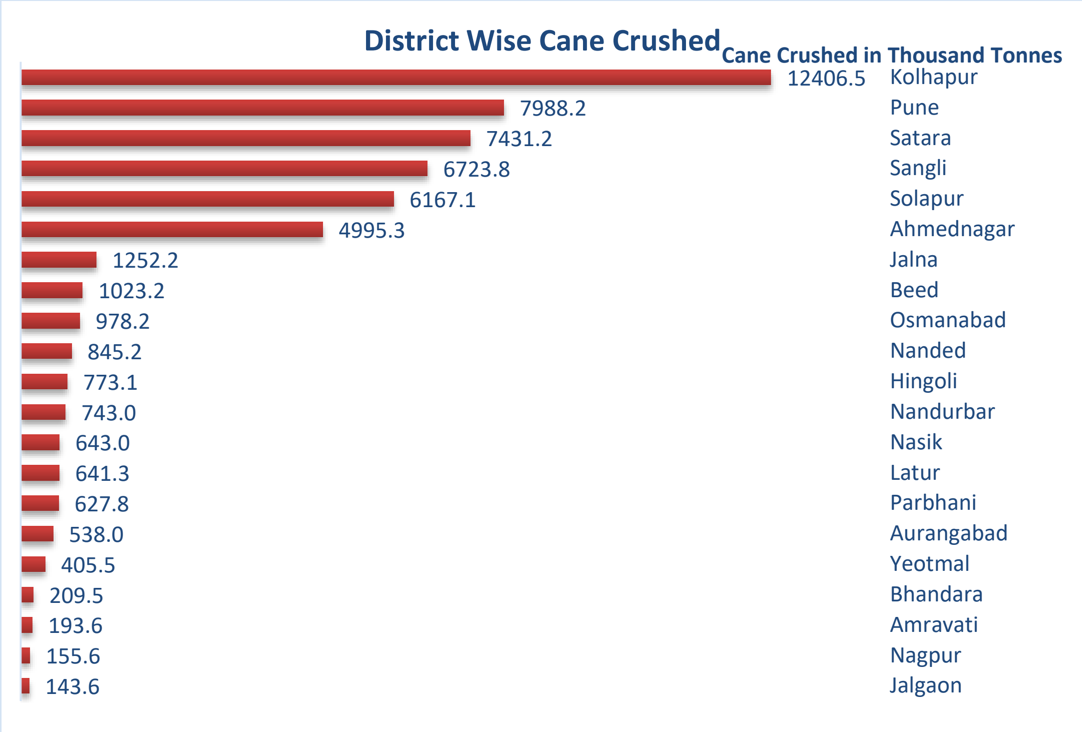


Figure 4.4: District wise cane Crushed (2019-20)

4.7. Bagasse Production

Bagasse is produced in sugar Industries while crushing the sugar cane in mill/ diffuser section. The juice is extracted in mill and collected separately. The leftover material is known as bagasse. The back pressure steam obtained after running the prime mover is used in sugar process. Thus, steam generated in boiler is used for dual purpose (Sugar Process & Prime mover energy). As shown in figure 4.5, the bagasse production trend for the last 5 years shows variation from 104 lakh MT to 266 lakh MT. This variation in production of bagasse is due to the deviations in sugar cane production. The total bagasse produced during 2019-20 is 152 lakh MT in Maharashtra, which is around 42% lower than the previous year. The lowest bagasse production of 104 lakh tonne was observed during 2016-17. The cane sugar production was less during 2016-17 due to draught in Maharashtra. Also the sugar cane production reduced due to less plantation and yields. The unfavourable weather conditions during the last year and significant flooding in major cane growing regions during the current monsoon season have also affected the cane sugar production in Maharashtra. Hence the cane sugar production is continually less in last 3 to 4 years.

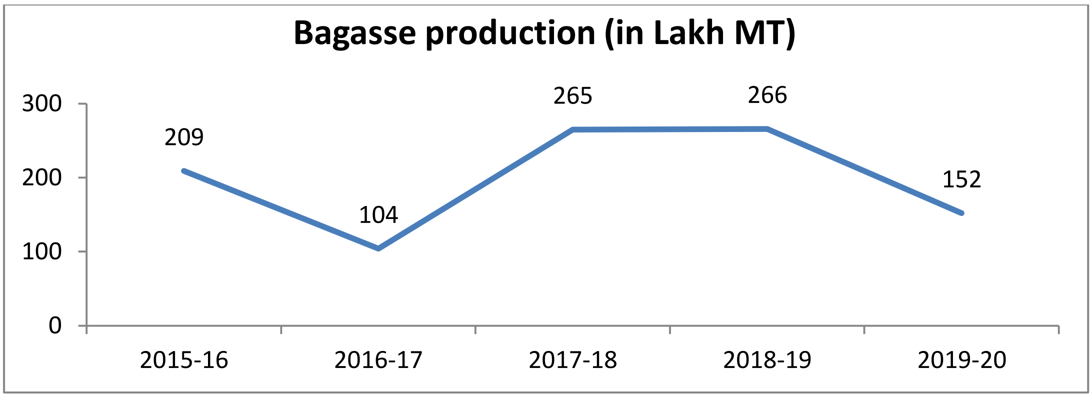


Figure 4.5: Year wise Bagasse Production (lakh ton)

Source: VSI report

As shown in figure 4.6, Kolhapur leads in bagasse production during 2019 compared to the remaining districts of Maharashtra. The bagasse production from sugarcane in Maharashtra for the last four years has been in the range of 27% to 28 % which is 2% less than the expected 30%. This is due the major reduction in fibre % of cane.

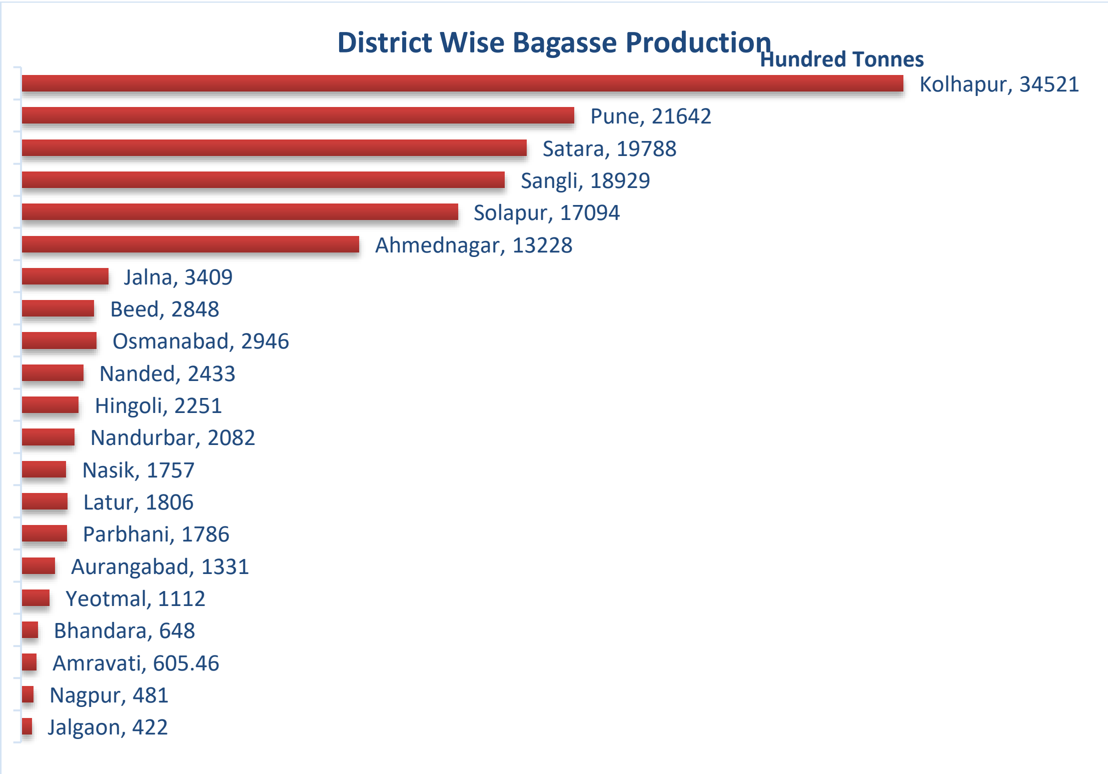


Figure 4.6: District wise Bagasse Production 00' ton

4.8. Gross Calorific values of Bagasse

The calorific value of Bagasse majorly depends on moisture content in Bagasse. Generally, moisture content of fresh Bagasse (from Mill without drier) is around 49% - 51%. The moisture content of dried bagasse reduces to 20-30%. However, the quality and calorific value of bagasse is adversely affected after getting wet in rainy season. The plant wise GCV is in the range of 2000 to 2580 kCal/kg, whereas the dried bagasse shows the average value in the range of 2900 to 3600 kCal/kg. The GCV of the samples were cross checked with proximate analysis by TERI form independent lab. Figure 4.7 shows the plant wise GCV of bagasse on wet basis.

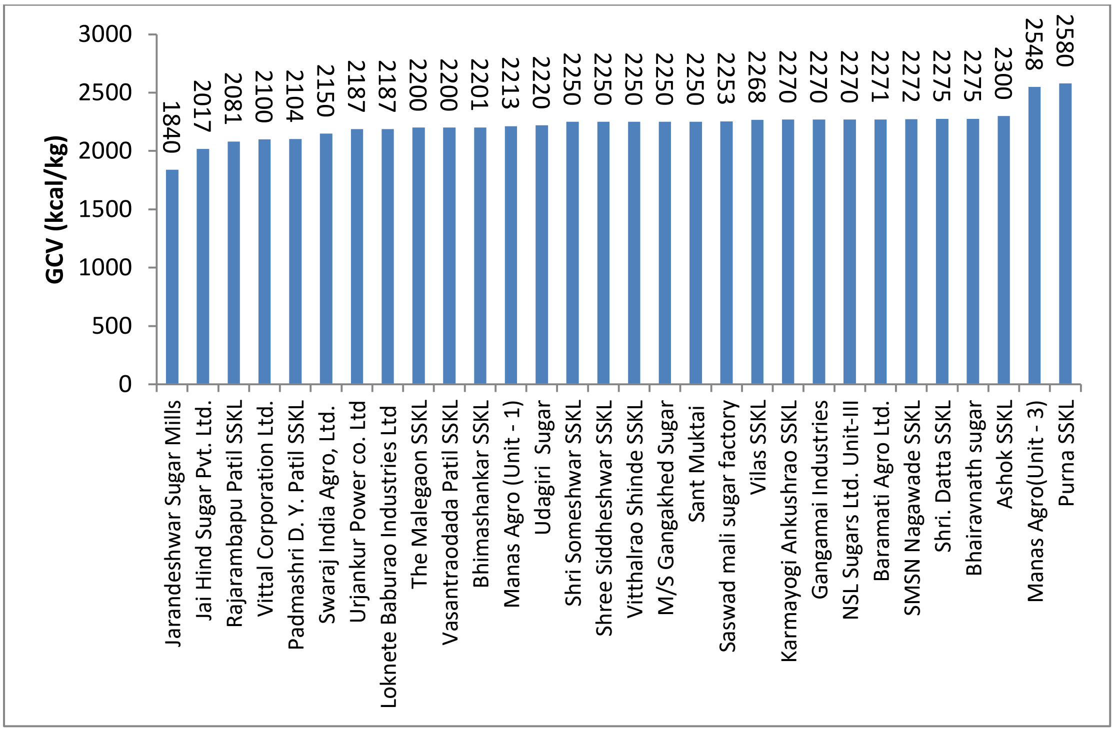


Figure 4.7: GCV Values

4.9. Station Heat Rate (SHR)

The amount of energy used by the power plants to generate one kilowatt-hour (kWh) of electricity is termed as station heat rate. It is reverse of efficiency. SHR helps in assessing the efficacy of the cogen plant. Lower the heat rate, better the efficiency of plant.

$$SHR = \frac{\text{Heat Input (kCal)}}{Energy\ generation\ (kWh)}$$

As per the RE tariff order the SHR for Maharashtra is to be 3600kCal/kWh. The average station heat rate observed as per the primary data is around 4200 Kcal/kWh. The higher the station heat rate signifies that, quantity of bagasse required is more for generation of electrical energy. The smaller value of SHR indicates that, the bagasse is optimally as well and efficiently utilised. The SHR gives the quantity of the bagasse required to generate 1kWh of power by cogeneration plants. Hence there is a scope of efficiency improvement by technology intervention and up-to-date plant maintenance.

4.10. Capacity Utilization Factor (CUF)

CUF in case of Non-Fossil Fuel Power plants is the ratio of energy sent out to energy that can be generated for that particular period. The CUF defines the overall efficiency of the plant and helps in apportioning the fixed overheads. Improved CUF (plant efficiency) will certainly help in reducing the tariff and in turn bagasse pricing. But this will require more CAPEX which will increase the fixed cost of plant and in turn tariff. Hence, CUF will affect the power tariff in totality. The primary data required for evaluating the CUF is collected and verified with various reports and tabulated for further evaluations is given in table 4.4 (a) shown below.

Here, it is pretty clear that increased CAPEX will increase the fixed cost and hence tariff. But the effect of fixed cost in tariff is around 10 to 20% whereas the impact of fuel in tariff is around 70% to 80%. Hence, the impact of higher CUF will not affect the tariff in totality though it will reduce the bagasse expenses by reducing the fuel demand due to improved plant efficiency as fixed cost component of tariff will be higher.

Table 4.4 (a): Plant wise data of SHR and CUF

Sr. No	Plant	SHR Kcal/kWh	Power to Heat Ratio for 1 KWh	Power Generated kWh	Averaged MW	Installed Capacity (MW)	CUF
1	Saswad mali sugar factory	4070	1.81	34847000	14	14.80	93%
2	Shree Siddheshwar SSKL	4771		39719096	16	38.00	43%
3	Jai Hind Sugar	4840	2.40	49749840	17	18.00	95%
4	Bhairavnath sugar	4160	1.83	8680000	3	12.00	24%
5	Vitthalrao Shinde SSKL	5850	2.60	106110000	37	38.00	97%
6	Vittal Corporation Ltd.			14278000	6	12.00	50%
7	Rajarambapu Patil SSKL; (Unit No. 2)	NA		33093000	11	11.00	102%
8	Udagiri Sugar	4098	1.85	43008000	14	14.00	100%
9	Malegaon SSKL	4115	1.87	75986000	20	35.00	58%
10	Shri Someshwar SSKL	6416	2.85	69258000	18	18.00	100%
11	Baramati Agro Ltd.	5175	2.28	54984977	16	22.00	74%
12	Bhimashankar SSKL	4693		54697200	16	19.00	82%
13	Urjankur shree Tatyasaheb Kore Power	NA		66849000	25	44.00	57%
14	Padmashri Dr. D. Y. Patil SSKL	3402	1.62	44323000	16	20.65	78%
15	Shri. Datta SSKL	4098	1.80	156380000	22	23.00	96%
16	Baramati Agro Ltd. Aurangabad	4490		19351895	10	18.00	57%
17	Gangamai Industries	NA		54291900	23	32.00	73%
18	Ashok SSKL	4801	2.07	27384000	12	15.00	79%
19	Karmayogi Ankushrao tope SSKL	4801	2.11	51964732	16	18.00	89%

The cogeneration plants which worked properly and had less hrs lost showed good CUF. The capacity utilisation factors were provided by the Cogeneration plants during survey. The crushing days were collected from RT8C but actual working hours lost was not provided by all the cogeneration plants. The detail cost audits were not provided by the all the cogeneration. Hence the further evaluation of the CUF was limited during the Study.

Chapter 5: Bagasse Availability & Pricing

5.1. Cost of Sugarcane

Table 5.1 shows the plant wise FRP of surveyed plant. FRP provided by different sugar mills for 2019-20 varies from 1955 to 3190 Rs/ton. The variation in FRP is due to variation in H&T cost. The average FRP of these plants comes out to be Rs 2646 per ton.

The FRP for different sugar mills varies as due to some of the listed parameters like:

- Cost of Capital of sugar mills
- Employee cost
- Availability of sugar cane within 50 km to 100 km radius
- Interest on loan
- Sugar quality etc.

FRP is recommended after due consideration given to the relevant factors listed in the Sugarcane (Control) Order, 1966, as amended from time to time. These factors range from the cost of production of sugarcane, to the price of sugar and by-products and reasonable margins for the farmers on account of risk and profits.

Table 5.1: Plant wise FRP 2019-20

District	Plant	FRP
Satara	Jarandeshwar Sugar Mills Pvt. Ltd.	2800
	Swaraj India Agro, Ltd.	2143
Solapur	The Saswad mali sugar factory Ltd	2998
	Shree Siddheshwar SSKL, Solapur	2116
	Jai Hind Sugar Pvt. Ltd.	2989
	Bhairavnath sugar works Ltd, Solapur	1956
	Vitthalrao Shinde SSK LTD	2051
	Vittal Corporation Ltd.	2211
	Loknete Baburao Patil Agro Industries Ltd	NA
Sangli	Rajarambapu PatilSahakari Sakhar Karkhana Ltd	3030
	Udagiri Sugar and Power Ltd.	2627
Pune	The Malegaon Sahkari Sakhar Karkhana Ltd.	2458
	Shri Someshwar SSK Ltd.	2788
	Baramati Agro Ltd.	2492
	Bhimashankar SSKL Ltd.	2690
Kolhapur	Urjankur shree tatyasaheb Kore Power co. Ltd	NA
	Padmashri Dr. D. Y. Patil Sahkari Sakhar Karkhana Ltd.	2716
	Shri. Datta Sahkari Sakhar karkhana Ltd.	2943
Aurangabad	Baramati Agro Ltd. Aurangabad	NA
Ahmednagar	Gangamai Industries and constructions limited	3037

District	Plant	FRP
	SMSN Nagawade SSK Ltd.	NA
	Shri Saikrupa Sugar and Allied Ind. Ltd.	2633
	Ashok SSKL	2552
Jalna	Karmayogi Ankushrao tope sskl	3190
Nashik	Vasantraodada Patil SSKL	NA
Hingoli	Purna Sahkari Sakhar Karkhana Ltd.	3151

5.2. Working Days of Sugar mill

The majority of the cogeneration units are operational for around 100 to 150 days in a season as per the information acquired during the site visit and primary data collection. The average working days varied from 120 to 130 Days whereas the range of working days is from 63 to 295 days.

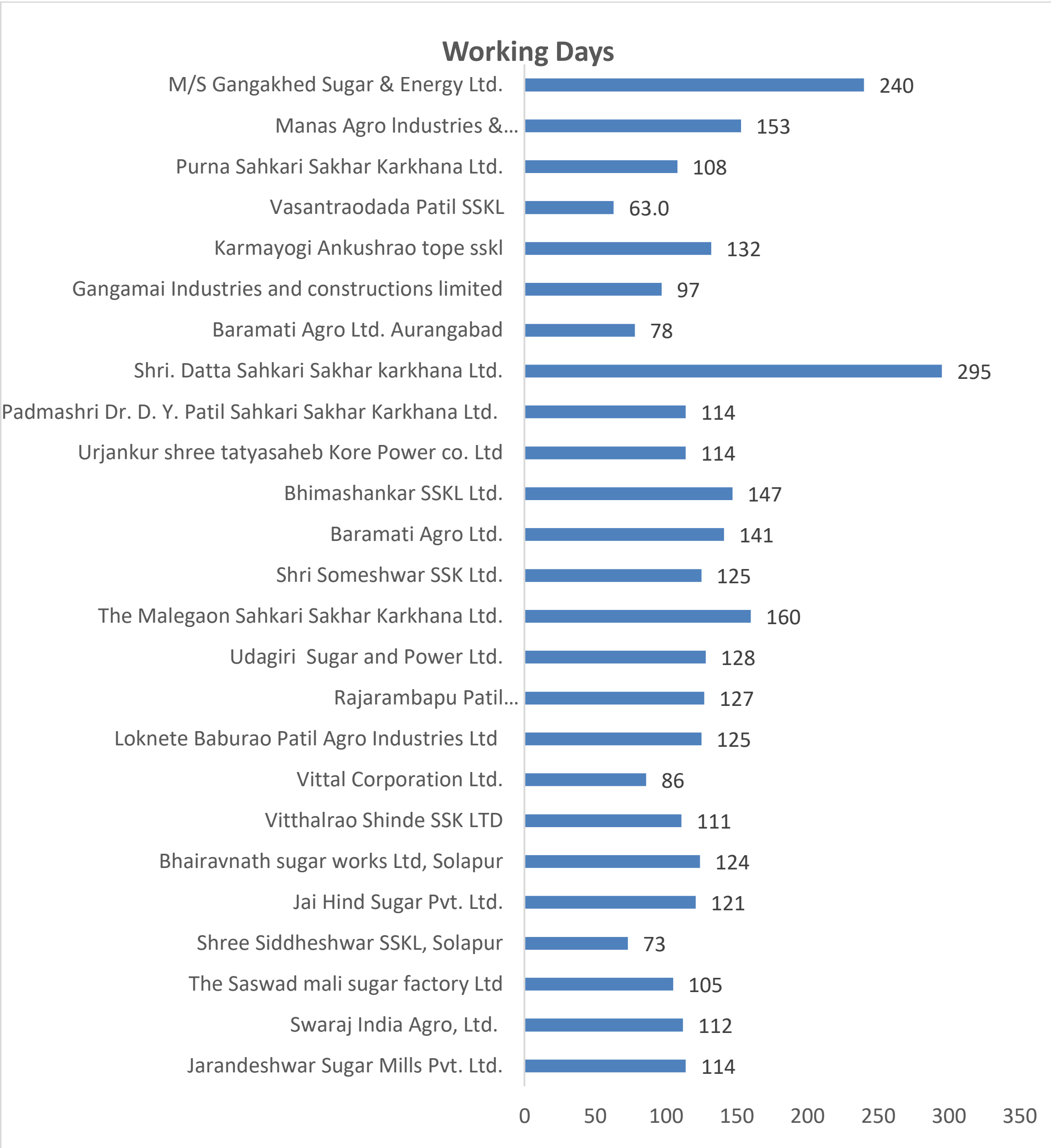


Figure 5.1: Working days of sugar mills

5.3. Alternate usage of bagasse

During primary survey, it was found that, there is no alternate/competitive market of bagasse. We tried to approach paper mills to understand the competitive market of bagasse. The BILT (Ballarsha) paper mill does not use bagasse as per the verbal information. Bhigwan paper industry (Indapur) uses imported pulp and the bagasse as per the verbal information. Both the companies didn't allow us to visit inside the plant due to pandemic

5.4. Harvesting and Transportation cost (H & T)

The harvesting and transportation cost when analysed for different power plants, has a wide variation from 127 to 874.22 Rs/tonne. This is due the fact that, some of the plants are within radius of 10 km, hence the cost of the transportation is very less. Whereas some of the plants like Jarandeshwar Sugar Mills and Shree Siddiheshwar SSKL import the sugarcane from another districts having higher transportation cost. The average H&T cost varies from 550 to 650 Rs/ton.

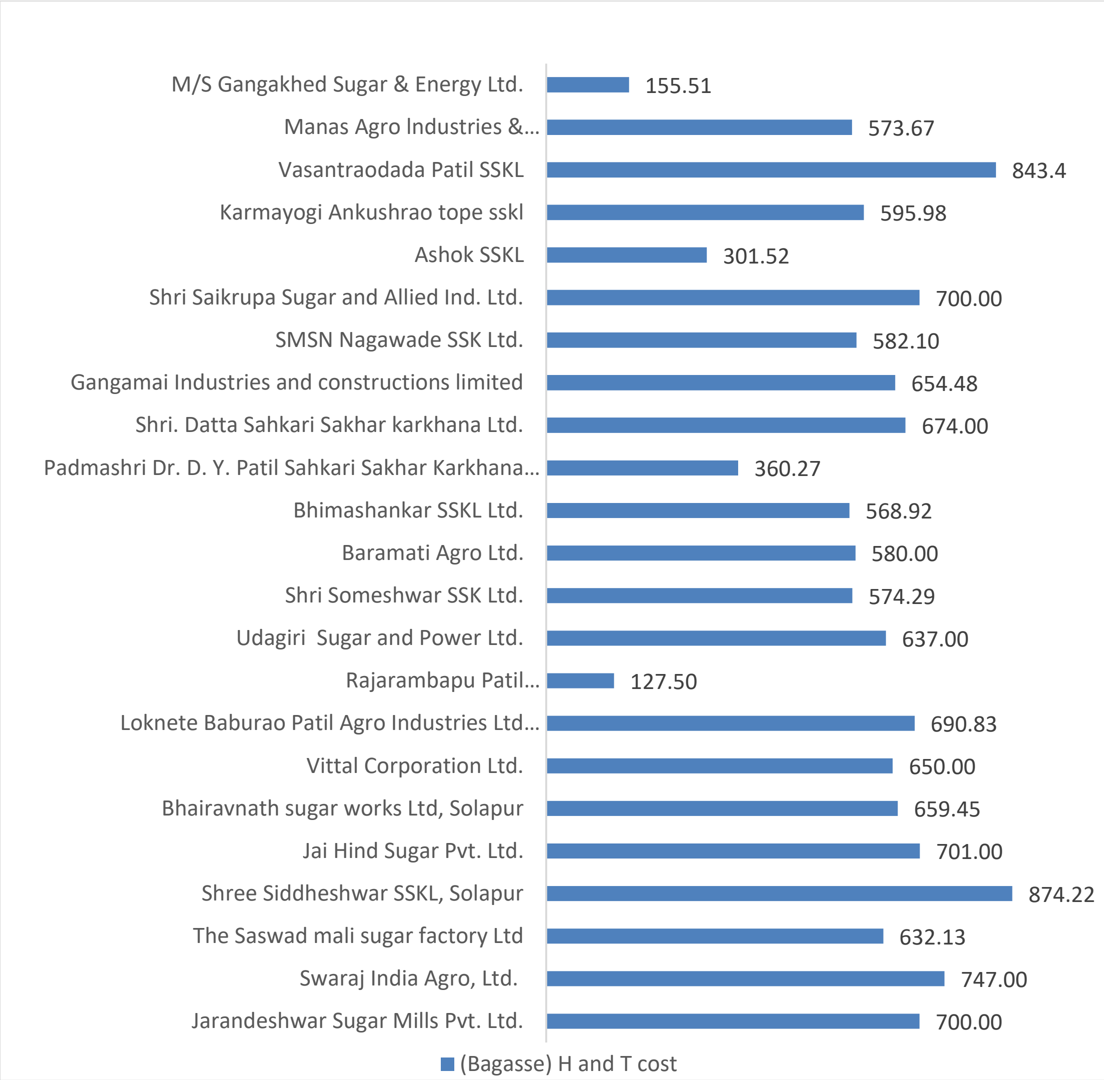


Figure 5.2: Plant wise H & T cost

5.5. District wise bagasse availability

During this analysis, it is assumed that, 1.8 tons per hour bagasse is required to generate 1 MW power in a bagasse cogen unit[52]. It is also assumed that, bagasse is majorly consumed only in bagasse cogen plants for power generation. Based on data received during primary survey, cane to bagasse ratio is considered as 27.4%. Table 5.2 shows the major districts having surplus and deficit bagasse after consumption of bagasse in cogen units in their respective districts. Total bagasse generated in Maharashtra during year of 2019-20 is 178 lakh tons out of which 148 lakh tons is used in bagasse cogen plants and around 30 lakh ton is surplus available. Almost all districts have surplus bagasse except few such as Solapur and Ahmednagar. This is be due to the fact that these two districts stood 1st and 2nd respectively in terms of total installed capacity of bagasse cogen sharing 38% of total installed cogen capacity of Maharashtra. However, these districts purchase sugarcane from neighbouring districts and hence do not face deficit of sugarcane in actual scenario.

Table 5.2: District wise bagasse availability

Districts	Sugarcane production in 2019-20 (00 Ton)	Bagasse generation (00 Ton)	Total plants capacity (MW)	Bagasse used in power plants		Surplus (00 Ton)
				(00 Tonne)	%	
Sangli	98271	26926	137.7	9013	33%	17913
Pune	116880	32025	264	17280	54%	14745
Kolhapur	117835	32287	323	21142	65%	11145
Satara	79641	21822	188	12305	56%	9516
Nashik	13646	3739	30	1964	53%	1775
Jalna	15883	4352	42	2749	63%	1603
Aurangabad	7409	2030	20.75	1358	67%	672
Latur	14881	4077	61	3993	98%	85
Jalgaon	4612	1264	12	785	62%	478
Hingoli	3367	922	18	1178	128%	-256
Parbhani	8667	2375	45	2945	124%	-571
Wardha	1862	510	15	982	192%	-472
Nagpur	2213	606	22	1440	238%	-834
Osmanabad	14403	3946	98.2	6428	163%	-2481
Beed/Bid	6361	1743	83	5433	312%	-3690
Ahmednagar	54617	14965	342.9	22444	150%	-7479
Solapur	57281	15695	562.25	36802	234%	-21107

5.6. Estimation of bagasse price

In order to estimate bagasse price in Maharashtra through secondary approach, following secondary data/assumptions are considered[53],[54].

[52] https://www.researchgate.net/publication/308012314_Study_of_a_Cogeneration_Plant_in_Sugar_Mill_by_using_Bagasse_as_a_Fuel
[53] https://www.researchtrend.net/ijet/pdf/17-F-767.pdf
[54] https://www.hilarispublisher.com/open-access/performance-of-coal-based-thermal-power-plant-at-full-load-and-part-loads-2229-8711-1000205.pdf

1. Average FRP of sugarcane for surveyed plants in Maharashtra is 2646 Rs. /ton, which is 204 Rs./ton less than FRP of Maharashtra for FY 2020-21 i.e. 2850 Rs./ton.
2. Average GCV of sugarcane bagasse for surveyed cogeneration plants is 2226 kCal/kg which is closed to GCV value considered by MERC for generic tariff determination
3. GCV, SFC and SHR of coal based thermal power plant is 3000 kCal/kg, 0.67 kg/kWh and 2010 kCal/kWh respectively.

Price of bagasse is estimated by following six approaches:

1. Coal equivalent method
2. Alternate fuel GCV equivalent method
3. Based on market value of bagasse
4. Split off cost method
5. Preferential tariff based calculation
6. Production cost method (KERC and UPERC approach)

5.7. Approach 1: Coal equivalent method

This method is generally adopted by commissions to evaluate bagasse price by comparing GCV of coal with bagasse. In this method, equivalent heat value approach for landed cost of coal for thermal power stations at respective States is used. During the year of 2019-20, the average landed procurement cost of the coal in Maharashtra is estimated to be Rs. 3649 per ton (Information collected from the different bagasse based power plants). Table 5.3 shows the average coal procurement cost in Maharashtra.

Table 5.3: Average coal procurement cost in Maharashtra

Plant Name	Biomass	Cost (Rs./ton)
Vayunandana Power Ltd	Coal	4271
Manas Agro Industries & Infrastructure Ltd., Nagpur	Coal	3141
Greta Energy	Coal	3610
Manas Agro. Industries and Infrastructure Ltd.(Unit-2)	Coal	3490
A.A. Energy Limited	Coal	2952
Sinewave Biomass Power Pvt Ltd	Coal	4429
Average Landed cost (Rs./ton)	Coal	**3649**

For calculating the bagasse price, first we tabulated the current price and calorific value of coal. From this Table 5.4 average coal landed coal price, GCV, Fuel Rate, Cost average price of fuel per unit of energy is calculated. The average price of fuel per unit of energy is multiplied by calorific value of bagasse.

Table 5.4: Coal Rate, GCV, Fuel Rate, and Cost

Type of fuel	Rate (Rs/kg)	Average GCV (kcal/kg))	Fuel Rate Rs/kcal
Coal	3.65	3600	1014

While comparing the GCV of coal and bagasse to estimate the price of bagasse, the price of bagasse comes out to be Rs. 2281 per ton.

In order to derive the cost of the bagasse, the typical GCV value of bagasse is considered as 2250 Kcal/Kg. The cost of the bagasse is calculated based on the following formula

$$\text{Cost of bagasse (Rs./ton)} = \frac{(\text{Average derived fuel rate (Rs./kcal)} \times \text{GCV of bagasse(kcal/kg)})}{1000}$$

Hence, the total bagasse cost per ton is **2281** Rs/Ton.

5.8. Based on GCV of alternate fuels which can substitute bagasse

Bagasse is used as fuel in the boiler. However, various other fuels (Bio mass, Fire wood, coal, briquettes etc.) can also be used in boiler as a substitute of bagasse. These fuels can be used along with bagasse and mixing ratio depends on the boiler design. The price of these fuels varies from season to season and area to area depending on demand & supply. For calculating the bagasse price, first we tabulated the current price and calorific value of these fuels. From this Table 5.5 Biomass Rate, GCV, Fuel Rate, Cost average price of fuel per unit of energy is calculated. The average price of fuel per unit of energy is multiplied by calorific value of bagasse.

Table 5.5: Biomass Rate, GCV, Fuel Rate, and Cost

Type of fuel	Biomass Rate (Rs/kg)	GCV (kcal/kg)	Rs./ kcal
Fire wood -mix wood	3.0	3290	930
Fire wood -brown wood	5.3	4613	1150
Rice husk	3.4	3207	1070
Sawdust	2.8	3800	740
Sugar cane leaves/ traces	0.625	3996	160
Soya been husk briquette	3.8	4170	910
Bio coal briquette	3.7	4050	910
Average value (Rs./ kcal)			**840**

In order to derive the cost of the bagasse, the typical GCV value of bagasse is considered as 2250 Kcal/Kg. The cost of the bagasse is calculated based on the following formula

$$\text{Cost of bagasse (Rs./ton)} = \frac{(\text{Average derived fuel rate (Rs./kcal)} \times \text{GCV of bagasse(kcal/kg)})}{1000}$$

Hence, the total bagasse cost per ton is 1892 Rs/Ton.

5.9. Based on Market Rate of Bagasse

The Bagasse is a freely traded as a good in Market. However, the price of bagasse changes based on locality, season and quality of bagasse. We have selected one sugar industry from each district on random basis. Three samples of each purchase rates and sales rate from different district has been considered. These figures are derived from financial record of the sugar industry. Also we have collected three samples of spot trading rates from secondary data (Web on 19 Feb 2021). These internet rates are used as indicated there on websites without any negotiations. The average purchase price, sales price, trading price and overall average (Simple average) are considered.

Table 5.6: Market Rate Analysis

Sr. Nos	District	Quantity (MT)	Amount (Rs.)	Unit Rate (Rs.)
1	Jalna	18609	50,066,515	2,690
2	Nagar	11201	35,364,254	3,157
3	Solapur	1195	3,106,116	2,600
4	Satara	59142	112,031,038	1,894
5	Pune	67	166,825	2,489
6	Nasik	6402	14,721,064	2,299
8	Mumbai -India Mart			3,000
10	Overall Average			2,590

The market prices of various districts are averaged as shown in table 5.6 district wise market price for different districts and the market prices of various agencies are considered for evaluating the base price by averaging out all the available market rates. **The Landed price of bagasse calculated under this method is Rs 2590 per MT.**

5.10. Split off cost method

The Price of Sugar cane and price of Sugar are controlled by Govt. Other parameters like recovery (Pol % of Cane), Fiber % of Cane, Java ratio etc. vary from area to area and depend on variety of cane, rain fall, soil quality, atmospheric condition (temperature & humidity) etc. The sugar loss in POL with Molasses and expenses will vary from plant to plant based on equipment condition, technology and skill of man power employed. It is complex to calculate uniform bagasse rate.

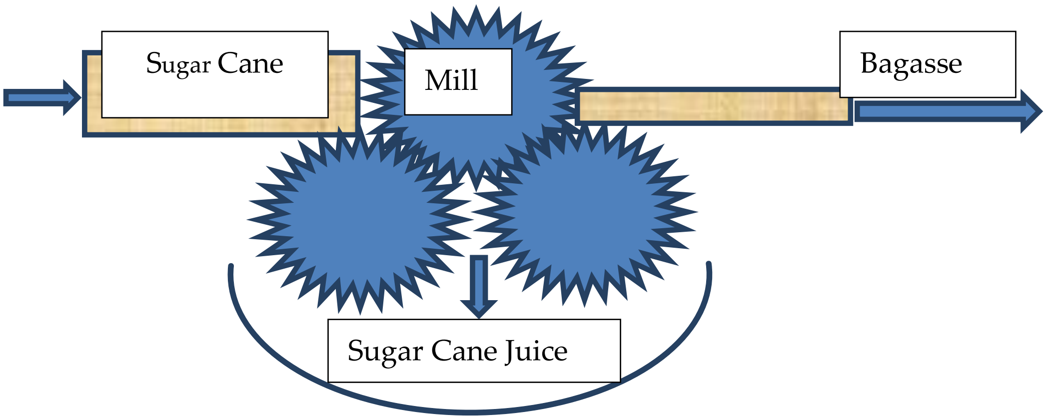


Figure 5.3: Block Diagram of Sugarcane to Bagasse Process

One factory is randomly selected from each district and four districts of Maharashtra selected for calculation purpose as listed in the Table 5.9. The actual data from financial (P&L and Balance Sheet) and RT 8(C) / RT 7 (C) has been extracted for calculation. This exercise is for evaluating the bagasse cost hence, the mixed juice cost is evaluated by reducing the sugar process cost from total revenue i.e.

Input Cost = Sugarcane cost (Including H&T cost) + Mill power cost + water cost ... (1)

The total revenue earned is tabulated in table 5.8 and power generated and power revenue is tabulated in table 5.10. As the Bagasse and Mix juice are the intermediate stages of Power generation and Sugar manufacturing respectively. The absence of Bagasse expenses account head, makes it difficult to evaluate the Bagasse price, similarly the mix juice cost evaluated above is insufficient as it ignores the profit and loss of sugar business. Hence, in view to evaluate the bagasse price the total input cost is bifurcated in the proportion of the revenue earned from both the process of Power generation and sugar manufacturing.

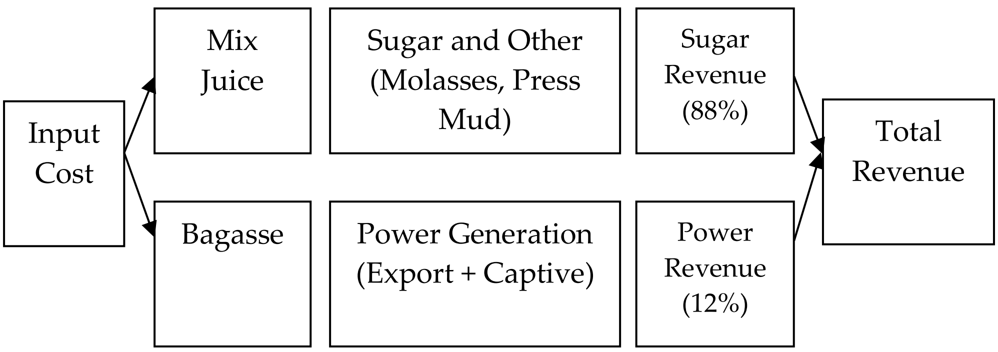


Table 5.7: Input Cost of bagasse generation

Sr. No.	Particulars	Amount (Rs. Cr.)
1	Cane Cost	476.02
2	H & T Cost	120.39
3	Other Cane related Expense	8.16
4	Water	0.57

Sr. No.	Particulars	Amount (Rs. Cr.)
5	Power	18.17
6	Sub Total at Split off (Input Cost)	623.32

Table 5.8: Total Revenue

Sr. No.	Particular	Unit	Amount (Rs. Cr.)
1	Sugar Revenue	Rs. Cr.	567.85
2	Molasses Revenue	Rs. Cr.	51.29
3	Press Mud Revenue	Rs. Cr.	1.64
	Total Revenue	**Rs. Cr.**	**620.79**

Table 5.9: Sugar Process cost

Sr. No.	Particulars	Unit	Amount (Rs. Cr.)
1	Chemical	Rs. Cr.	4.7
2	Power	Rs. Cr.	2.1
3	Steam	Rs. Cr.	94.0
4	Employee	Rs. Cr.	36.1
5	Direct Expense	Rs. Cr.	1.4
6	Consumable & Stores	Rs. Cr.	0.5
7	Repair & Maintenance	Rs. Cr.	19.4
8	Quality	Rs. Cr.	1.7
9	Technical Know How	Rs. Cr.	0.0
10	Depreciation	Rs. Cr.	16.4
11	Production Over Head	Rs. Cr.	7.7
12	Industry Sp. Expenses	Rs. Cr.	1.2
13	Packing Cost	Rs. Cr.	8.0
14	Admin Overhead	Rs. Cr.	23.9
15	Selling Expense	Rs. Cr.	6.1
16	Interest & Finance Ch.	Rs. Cr.	84.7
17	**Sub Total**	**Rs. Cr.**	**308.0**

Table 5.10: Bagasse Price evaluation in proportion with % Power Generation revenue of total Input Cost

S. No	Particulars	Unit	Ashok Sugar Nagar	Samarth Jalana	Malegaon Pune	Aggregate of 3 plants
1	Bagasse Intake	MT	88,762	126,161	250,240	465,163
2	Total Power Generated	kWh	33,523,000	53,990,000	80,507,800	168,020,800
3	Total Power Exported	kWh	21,530,881	37,748,964	41,771,520	101,051,365
4	Captive Consumption	kWh	11,992,119	16,241,036	38,736,280	66,969,435
5	Revenue from Power Export	Rs. Cr.	14.55	24.95	28.28	67.78
6	Revenue Captive consumption (@ Rs. 7/kWh (industrial)	Rs. Cr.	8.39	11.36	27.11	46.87
7	Revenue from Total	Rs.	22.95	36.32	55.40	114.67

S. No	Particulars	Unit	Ashok Sugar Nagar	Samarth Jalana	Malegaon Pune	Aggregate of 3 plants
	Power (5+6)	Cr.				
8	Revenue from Sugar and other (from table 4.14)	Rs. Cr.	130.98	174.29	315.52	620.79
9	Total Revenue earned (7+8)	Rs. Cr.	153.93	210.61	370.92	735.46
10	% Power Generation revenue of Total Revenue	%	12	12	12	12
11	Total Input Cost (from table 4.13)	Rs. Cr.	121.24	156.72	345.37	623.32
12	Power Generation expenses from bagasse	Rs. Cr.	14.54	18.80	41.44	74.79
13	**Bagasse Price (Rs./MT) (S. NO. 12/ S. NO. 1)**		**1638**	**1490**	**1656**	**1608**

The aggregate values plants data is taken for this calculation as tabulated in table 5.10.

$$\text{Power generation revenue} = \%\ \text{Power Generation revenue of Total Revenue} * \text{total input cost}$$

$$\text{Bagasse cost} = \frac{\text{Power generation expenses (Rs)}}{\text{Total bagasse generated (MT)}}$$

Bagasse cost = Rs. 1608 per MT

Note: Total power generation expenses are being loaded on Bagasse. If we reduce fixed cost expenses such as O&M & Capex, bagasse cost would be much lower

5.11. Costing based on preferential tariff

In Maharashtra, the tariff rate for the new bagasse cogen plants for 20 years period derived through competitive bidding is Rs.4.75/kWh. Hence to ensure that the tariff of old plants whose EPA expired after 13 years does not exceed the tariff for new plants, it was decided that the PPA will be signed at Rs 4.75/kWh. Keeping this in mind, tariff rate is considered as 4.75 Rs./kWh to evaluate the bagasse cost using preferential tariff method. Fixed cost contribution is considered as 35% in levellised tariff as determined by commission for bagasse based cogeneration plants[55]. Reverse calculation is carried out in order to derive the cost of the bagasse. The following steps are used as shown in table 5.11. In absence of data average figure considered for calculation as assumptions shown in table 5.12.

Table 5.11: Steps of calculating costing by preferential tariff method

Step 1	Bagasse Produced (MT) = Cane Crushed (MT) × % of Bagasse per Ton

[55] Case No. 204 of 2018 in the matter of determination of generic tariffs for renewable energy for FY 2018-19, dated: 18-08-2018.

Step 2	$\text{Steam Generated (MT)} = \frac{\text{GCV of Bagasse (w.b.)} \times \text{Bagasse Produced} \times \text{Boiler Efficiency}}{\text{Inlet Feed Water} - \text{Steam out}}$
Step 3	$\text{Steam To Bagasse Ratio (MT/MT)} = \frac{\text{Bagasse Produced(step 1)}}{\text{Steam Generated(step 2)}}$
Step 4	$\text{Power Generated (kWh)} = \frac{Steam\ \text{Generated} \times 1000 \times \text{Enthalpy of steam}}{\text{Station Heat Rate}}$
Step 5	$\text{Auxiliary Consumption (kWh)} = \text{Power Generated} \times \text{\% Auxiliary Consumption} \times [(1 - \text{Boiler Auxiliary to Cogen Auxiliary Power})/100]$
Step 6	$\text{Net power (kWh)} = \text{Power Generated (step 4)} - \text{Auxiliary Consumption(step 5)}$
Step 7	$\text{Power Revenue (Rs)} = \text{Net Power (Step 6)} \times \text{power tariff}$
Step 8	$\text{Steam Cost (Rs.)} = \text{Power Revenue (Step 7)} - \text{Fixed cost} - \text{Profit} - \text{Direct \& Chemical Cost}$
Step 9	$\text{Steam rate (Rs/MT)} = \frac{\text{Steam Cost (Step 8)}}{\text{Steam Generated (Step 2)}}$
Step 10	$\text{Steam cost from Boiler (Rs/MT)} = \frac{\text{Steam rate (step 9)}}{\text{Enthalpy utilization by Power Turbine}}$
Step 11	$\text{Steam revenue (Rs)} = \text{Steam Cost from Boiler (Step 10)} \times \text{Steam Generated (Step 2)}$
Step 12	$\text{Fixed Cost of Boiler (Rs)} = \text{\% of Revenue (Assumption)} \times \text{Steam revenue (step 11)}$
Step 13	$\text{Cost of Bagasse (Rs)} = \text{Steam Revenue(step 11)} - \text{Fixed Cost of Boiler} - \text{Chemical cost} - \text{DM Water cost} - \text{Power Cost}$
Step 14	$\text{Bagasse Rate (Rs/MT)} = \frac{\text{Bagasse cost (Step 13)}}{\text{Bagasse produced (Step 1)}}$

Table 5.12: Assumptions

Sr.	Particulars	UOM	Value
Assumption			
1	Specific Steam Consumption	Kg /KWh	5.50
2	Steam To Bagasse Ratio	MT / MT	2.20
3	Power Tariff Rate	Rs / Kwh	4.75
4	Operational Days	Days	150
5	Co-gen Capacity	MW	15
6	Boiler Capacity	MT / Hr	100

Sr.	Particulars	UOM	Value
7	Boiler Efficiency	%	65%
8	Make up Feed Water	%	15%
9	Fixed Cost Share in Total Rev	%	35%
10	Boiler Fixed Cost	%	20%
11	DM Water Cost	Rs / Lit	100
12	Boiler Auxiliary to Cogen Auxiliary Power		65%
13	Cogen Profit Margin	%	5%
14	Boiler - Chemical & Direct exp.	Rs / MT	23.00

Table 5.13: Bagasse price based on preferential tariff

Sr. No.	Particulars	Unit of M	Data received during primary survey
1	Average Plant Load factor	% (season)	86.97
2	Station Heat Rate	K Cal/Kwh	4,662.96
3	Boiler Temperature	°C	514.42
4	GCV of Bagasse Wet Basis	kCal/Kg	2,188.62
5	Bagasse % Cane	%	26.71
6	Bagasse Production	MT	1,301,005.24
7	Auxiliary Consumption	% of Total	8.88
8	Cane Crushing	MT	4,856,673
9	Steam Generation	MT	2,828,746
10	Steam To Bagasse Ratio	MT/MT	2.17
11	Power Generated	MU	438.66
	Power Generation	kWh	438,656,520
12	Less - Auxiliary Consumption Turbine	kWh	13,659,689
13	Sub Total – Power	kWh	424,996,831
14	Power Revenue	Rs	2,018,734,949
15	Less Fixed Cost (Salary, Depreciation, Interest etc.)	Rs/Annum	706,557,232
16	Less – Profit	Rs	100,936,747
17	Variable Cost -	Rs	1211240969
18	Direct & Chemical Cost etc.	Rs	13,159,696
19	Steam Cost	Rs	1198081274
20	Steam Rate for Power Turbine	Rs/MT	424
21	Steam Cost from Boiler	Rs/MT	1,168
22	Steam Revenue	Rs	3,304,496,372
23	Less - Fixed Cost	Rs	660,899,274
24	Variable Cost	Rs	264,359,7098
25	Less - Chemical etc.	Rs	65,061,152
26	Less DM Water Cost	Rs	42,431,186
27	Less Power Cost	Rs	120,497,968
28	Bagasse Cost	Rs	2,415,606,791
29	**Bagasse Rate**	**Rs/MT**	**1,857**

The bagasse cost of Rs. 1857 per MT is evaluated as per actual calculation are carried out in the table 5.13.

5.12. Production cost method

This method evaluated the production cost of bagasse such as cost of crushing. There may be two approaches to evaluate price of bagasse through this method.

1) Based on primary survey output, average cane to residue ratio of all surveyed plant comes out to be 27.4%. According to this approach, as bagasse is the fuel generated as well as consumed within cogeneration facility, hence, it doesn't contain cost factors such as loading, unloading, transportation, trader's margin etc. Therefore, price of bagasse should be 0.274 times the price of sugarcane. This approach is proposed by UPERC to evaluate price of bagasse in Uttar Pradesh. In case of Maharashtra, FRP of sugarcane is Rs. 2850 per ton at 10 % sugar recovery while during primary survey, average FRP of sugarcane for all surveyed plants comes out be Rs. 2621 per ton. The difference in FRP is possibly due to the variation of sugar recovery rate. Based on primary survey data;

$$\textbf{Price of bagasse} = \textbf{Cane to bagasse ratio} \times \textbf{FRP of sugarcane in Maharashtra}$$

Hence, price of bagasse comes out to be Rs. 718 per ton

2) The production cost of sugar from sugarcane is 20%-30%[56]. This method of evaluating bagasse price is successfully adopted by KERC. The price of bagasse by this approach can be evaluated as:

$$\textbf{Price of bagasse} = \textbf{0.274} \times (\textbf{FRP of sugarcane} + \textbf{20\%} \times \textbf{FRP of sugarcane})$$

Hence, price of bagasse comes out to be Rs. 862 per ton

Taking the average of these two approaches, estimated price of bagasse would be **Rs. 790 per ton**.

Table 5.14: Cost due to different Method

Sr. No.	Price Evaluation Method	Bagasse Price (Rs./MT)	Average Value (Rs./MT)	Remarks
1	Coal equivalent method		2281	
2	Based on Calorific Value of alternate fuels which can substitute bagasse		1892	
3	Based on Market Rate of Bagasse	1894 to 3157	2590	
4	Split off cost method considering Bagasse as Joint / Co-product of sugar		1608	Bagasse Price based on input cost in proportion of Power Revenue of the total revenue
5	Costing based on preferential tariff		1857	

[56] https://kredlinfo.in/General/KERC%20tariff%20orders/RE%20Tariff%20Order%202018.pdf

Sr. No.	Price Evaluation Method	Bagasse Price (Rs./MT)	Average Value (Rs./MT)	Remarks
6	Production cost method	718 to 862	790	Approach adopted by UPERC and KERC
7	Bagasse cost derived by CERC for MERC for year 2020-21		2632	

5.13. Final estimated price of bagasse

Final price of bagasse has been estimated by allocating the equal weightages to above mention six approaches. Table 5.15 shows the weighted cost of bagasse from different approaches

Table 5.15: weighted cost of bagasse from different approaches

Approaches	Bagasse cost (Rs/MT)	Weightage	Weighted cost
Coal equivalent method	2281	16.7%	380.1
Alternate fuel GCV equivalent method	1892	16.7%	315.3
Market rate of bagasse	2590	16.7%	431.7
Modified Split off cost	1608	16.7%	268
Preferential tariff method	1857	16.7%	309.5
Production cost method (UPERC + KERC)	790	16.7%	131.7
Average cost (Rs./ton)		**100%**	**1836.3**

Hence, proposed weighted average cost of bagasse comes out to be Rs 1836 per MT.

Chapter 6: Biomass Availability & Pricing

6.1. Estimation of biomass generated in Maharashtra

Based on the CRR values and crop production data, residue generation from each crop is calculated as per calculations discussed in previous chapter. As shown in figure 6.1, major residue for power production includes bagasse for cogeneration followed by cotton stalk, soybean stalk, rice straw and maize stalks for non-bagasse based power generation. The data has been compiled and analysed to calculate the crop residue/biomass available in each district. The crop to residue ratio is used to calculate the amount of residue production from different crops. Annexure II shows the district-wise crop residue generation (in Hundred Ton) for 2019-20, 2018–19 and 2016-17. Out of total residue generated from major crops, sugarcane bagasse shares the highest proportion of 35% with bagasse generation of 21.53 million tons. Cotton stalk is the second highest crop residue generated in Maharashtra and shares 27% of total residue generation followed by soybean stalk which shares 13%.

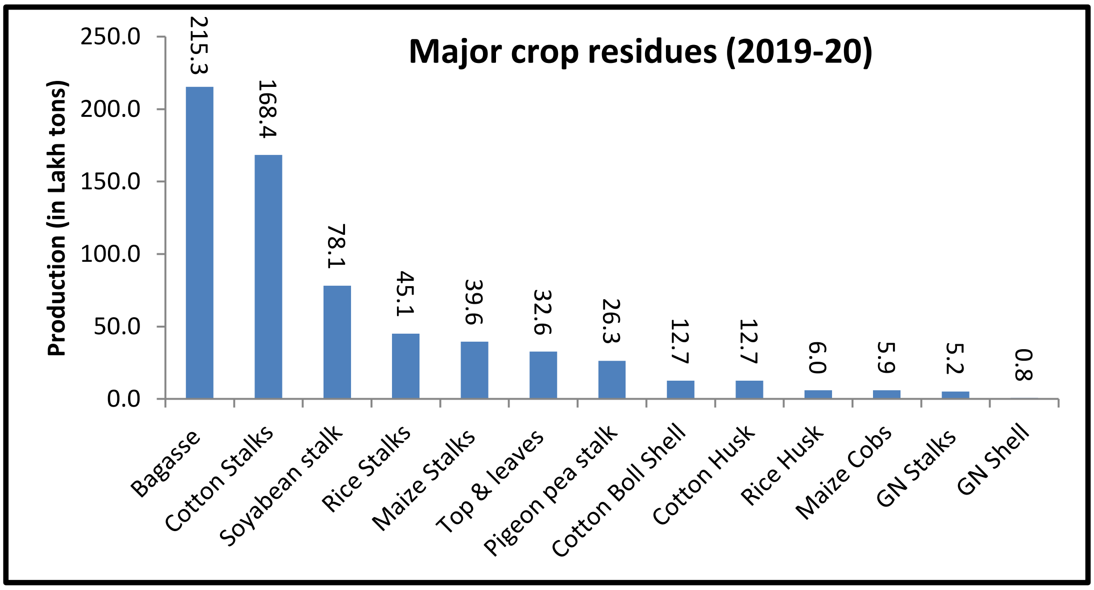


Figure 6.1: Major crop residue generation in Maharashtra 2019-20

6.2. District wise biomass availability

In order to estimate biomass availability in various districts, the major crop residues considered are stalks of cotton, groundnut, wheat, rice, maize, soybean and pigeon pea. Other than this, rice husk is also considered as crop residue available for power generation in biomass based power plants. In addition to this, biomass availability is estimated to only those districts in which biomass power plants are located. However, if availability of biomass in any of district is less, neighbouring district must be taken into consideration for biomass availability. For analysis purpose, crop residue generation latest data for year 2019-20 is taken into consideration. Unlike bagasse, crop residues such as stalks of different crops and rice husk are agriculture or industrial residue and do not generate in power plant. Therefore, biomass availability estimation methodology is different as compared to bagasse availability estimation.

In case of biomass other than bagasse, other usage such as household cooking and fodder are estimated in order to estimate surplus biomass available for power generation. In case of Maharashtra, only 7 biomass power plants of total capacity of 65 MW are in working condition. These plants are situated in 5 districts namely, Chandarpur, Gadchiroli, Wardha, Nagpue and Sangli. Table 6.1 shows the district wise biomass generation, consumption and surplus availability. The data of total number of household (HH) in each district and number of HH using crop residues are taken from "Office of the Registrar General & Census Commissioner, India"[57]. As per FAO report, it is assumed that Average crop residue consumption for cooking/heating is 20.5 kg per household per day[58]. Based on this, annual residue consumption by HH is estimated. Other than this, it is also assumed that stalks of wheat, groundnut and maize are fully consumed locally as fodder. Subtracting the consumption values of crop residues from crop residue generation, surplus crop residue left for power production is estimated.

In case of Sangli, it is observed that, consumption of biomass is more than generation. In this case, it might be possible that, power plant of Sangli (M/s Sinewave Biomass Pvt. Ltd., 10 MW) is utilizing biomass from neighbouring district. As Kolhapur is the nearest neighbouring district to Sangli (40-50 Kms), hence, combined crop residue data of Kolhapur and Sangli is taken into consideration for estimating biomass availability for Sangli power plant.

Table 6.1: District wise crop residue generation, estimation and surplus estimation

District Name	Total number of house-holds	HH using Crop residue	Annual crop residue consumption by HH (lakh tons)	Fodder (stalks of wheat + ground nut + maize)	Stalks + husk generated (lakh tons)	Surplus left (lakh tons)
Gadchiroli	2,45,745	2,472	0.18	0.178	8.224	7.87
Chandrapur	5,29,612	12,464	0.91	0.32	13.12	11.89
Wardha	3,02,680	24,122	1.76	0.59	13.589	11.24
Nagpur	9,95,808	9,442	0.69	1.934	18.203	15.58
Kolhapur	8,21,483	17,427	1.27	1.252	7.082	4.56
Sangli	5,85,227	24,837	1.81	3.777	4.76	-0.83
Sangli + Kolhapur	14,06,710	42,264	3.09	5.029	11.842	3.73

[57] Office of the Registrar General & Census Commissioner, India
[58] http://www.fao.org/3/a-i7849e.pdf

6.3. Plant wise biomass availability and costing

Out of 7 Biomass plant, only 2 plants (M/s. Sinewave Biomass Power Pvt. Ltd., Sangli and M/s. Maharashtra Vidhyut Nigam Pvt. Ltd., Wardha) purchase Biomass from Farmers. Remaining 5 plants use majorly rice husk which is by-product of the rice mill industries and procured from rice mills. Although in north east Maharashtra major crop is cotton, it is not used as fuel, the reason being the high processing cost like cutting it in small size and storage problem. During storage the cotton straws have to be moved/flipped every 6 hrs in order to protect it from getting damaged. Mostly rice husk, soya husk, tur husk and mix of agricultural waste are used as fuel for biomass based power plants in Maharashtra. However, 15% coal is also allowed to be used by power plants. GCV of rice husk is around 3200 Kcal/ Kg while cost of rice husk is in the range of 3100- 4200 Rs/ton with 10% moisture. Table 6.2 shows GCV of major biomass used for power generation. The range of average purchase price calculated, based on the primary data survey of the different biomass plants shows that fuel price varies from 3000 to 3431 Rs/Ton. The landed price of biomass fuel includes Labour cost, transportation cost, storage cost and GST. The loading and unloading cost ranges from 5% to 7% of fuel cost whereas the storage cost varies from 7% to 9.5%. Transportation cost is not fixed as it depends on the distance from where the fuel is purchased. GST is applicable as per the GST law.

Table 6.2: GCV of Biomass

Biomass	GCV (kcal/kg)
Rice Husk	3207
Soya Husk	3214
Cotton chips	3502
Pigeon pea (tur) husk	3304

6.4. Impact of Policy of biomass co-firing in coal-based power plants

Government of India vide its Notification dated 8 October 2021 notified the revised its policy of biomass utilization for power generation in coal-based plants. Important stipulations in revised policy are as below:

1. All coal based thermal power plants of power generation utilities with bowl mill, shall on annual basis mandatorily use 5 percentage blend of biomass pellets made, primarily, of agro residue along with coal with effect from one year of the date of notification. The obligation shall increase to 7 percent with effect from two years after the date of issue of notification i.e. 8 October 2021 and thereafter.

2. All coal based thermal power plants of power generation utilities with ball and race mill, shall on annual basis mandatorily use 5% blend of biomass pellets (torrefied only) made, primarily, of agro residue along with coal. This is to be complied within one year starting from this notification. Two years from the date of issue of this notification and thereafter the obligation will increase to 7 percent.

3. All coal based thermal power plants of power generation utilities with ball & tube mills, 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.
4. Generating Utilities having certain units under reverse shutdown or not being despatched due to MOD (Metri Order Despatch) 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).
5. The policy for co-firing of biomass would be in force for 25 years or till the useful life of the thermal power plant whichever is earlier. The minimum percentage of biomass for co-firing will be reviewed from time to time.
6. The minimum contract period for procurement of biomass pellets by generating utilities shall be for 7 years so as to avoid delay in awarding contracts by generating companies every year and also to build up long term supply chain.

Admittedly, the above policy framework will increase demand for biomass and their exist a possibility that 100% biomass based projects will have to source biomass from larger area than that exists today. This will lead to increase in transportation cost and ultimately landed price of the biomass. At this juncture it is not possible to evaluate the policy implications. Hence, it is prudent to highlight the same but not factored in to computation of fuel price.

6.5. Plant wise biomass consumption

The quantity and types of Biomass consumed by the Power plants are shown in table 6.3 respectively. The Biomass Power Plants “M/s Greta Energy Ltd., Chandarpur” has the highest consumption of Biomass. Weighted average price of “M/s Vayunandana power Ltd., Gadchiroli” is highest. Unlike bagasse, biomass is the commodity generated outside the biomass power generated Unit. Biomass can be classified as agricultural residues such as stalks of crops and industrial residues such as groundnut shell, rice husk etc. Therefore, the cost of biomass fuel for power generation depend upon various factors such as uprooting cost, bundling cost, transportation charges, shredding cost, loading and unloading cost, stacking cost, farmer’s remuneration, trader’s margin, processing cost of fuel etc. Moreover, generally all biomass are available seasonally, hence, power plants are generally use fuel mix to operate their plants based on seasonal availability of biomass. Consequently, GCV of all biomass differs from each other. Therefore, weighted average of GCV of biomass w.r.t. their proportional use of in power plant is taken into consideration while evaluating final cost of biomass.

Table 6.3: Biomass consumption

	Plant Name	Description	Consumption (tons)	Fuel consumed in Tons	% consumption of Biomass	Average Cost Fuel as per Fuel Type	Weighted Average Price of Biomass
1	M/s Vayunandana power Ltd., Gadchiroli	Rice Husk, Soya Husk, Cotton etc.	52203	92218	56.6%	4338	4530
		Fire, scrap wood, Waste	26054		28.3%	4517	
		Agriculture and Mix Biomass	13960		15.1%	5274	
2	M/s Maharashtra Vidhyut Nigam Pvt. Ltd., Wardha	Soybean & Cotton Stick	55151	84185	65.5%	2814	2898
		Wood Chips & Briquettes	29034		34.5%	3058	
3	M/s Manas Agro Industries & Infrastructure Ltd., Nagpur	Rice Husk	20273	33397	60.7%	3069	3638
		Other Biomass	13123		39.3%	4517	
4	M/s. Manas Agro Industries & Infrastructure Ltd., Chandrapur	Rice Husk	24698	41874	59.0%	3075	2968
		Other Biomass	17175		41.0%	2814	
5	M/s A A Energy Ltd., Gadchiroli	Rice Husk	68770	71535	96.1%	3170	3160
		Bamboo Dust	1545		2.2%	2814	
		Sal Seed Meal	1220		1.7%	3063	
6	M/s Greta Energy Ltd., Chandrapur	Rice husk	82699	137684	60.1%	2929	2981
		Wood chips	47287		34.3%	3100	
		Soya husk	7697		5.6%	2814	
7	M/s Sinewave Biomass Power Pvt. Ltd. Sangli Unit	Agro waste	35433	96279	36.8%	3517	2493
		firewood	21011		21.8%	3508	
		Other waste	39834		41.4%	1047	

6.6. Biomass cost analysis

Weighted average of the fuel cost has been calculated based on considering the fact that rice husk is available for during harvesting season, that is, October to December Mostly the rice husk is purchased from rice mills by the plants.

While evaluating the average of plant wise weighted average price of biomass from table 6.3, the average cost of biomass comes out to be **3238 Rs. per ton**.

The cotton stalk are not used as the maintaining inventory of cotton stalk for more than a month is difficult as long term-storage has its own problems of safety and deterioration in quality due to degradation. The weighted average costing is done for each plant as per the fuel type shown in table 6.4. So, weighted average cost of fuel comes out to be **Rs. 3195 per ton.**

Table 6.4: Plant wise biomass cost and consumption pattern

Plant Name	Total fuel consumed (in ton)	% of Consumption	Weighted Average price of the Biomass (Rs/Ton)	Weighted Average in-terms of Consumption
M/s Greta Energy Ltd., Chandrapur	137684	25%	2981	736.7
M/s Vayunandana Power Ltd., Gadchiroli	92218	17%	4530	749.8
M/s Sinewave Biomass Power Pvt. Ltd. Sangli Unit	96279	17%	2493	430.8
M/s Maharashtra Vidhyut Nigam Pvt. Ltd., Wardha	84185	15%	2898	437.9
M/s A A Energy Ltd., Gadchiroli	71535	13%	3160	399.0
M/s. Manas Agro Industries & Infrastructure Ltd., Chandrapur	41874	8%	2968	223.0
M/s Manas Agro Industries & Infrastructure Ltd., Nagpur	33397	6%	3638	218.1
Total	**557172**			**3195**

Hence, final weighted average cost of biomass can be estimated as **Rs. 3238 per ton** at corresponding weighted average **GCV of 3307 kcal/kg**.

Chapter 7: Observations and Findings

7.1. Reason for loss/profit making of sugar industry business

Sugar industry business comprises of mainly five components named below:

1. Sugar business
2. Power business (cogeneration)
3. Distillery - Spirit
4. Distillery – Ethanol
5. Others

Table 7.1 shows the component wise profit/loss of sugar industry business. Profit/loss analysis of one surveyed plant (Ashok SSKL, Ahmednagar) is done on sample basis. Similar analysis can be replicated for other plants. It is clearly observed from the table that the sugar business in loss and is the main reason over loss of the sugar industry.

Table 7.1: The overall plant and section wise profit/loss (Amount in Rs. Lakh) for FY 2019-20

Total (Profit/loss) [in INR Lakhs]	- 848.48
Power	130.38
Sugar	-1,480.72
Distillery - Sprit	40.25
Distillery - Ethanol	91.72
Others	369.89

The seasonal variation affect the cane availability and process material and utilities sharing, which plays an important role in evaluation of the sugar overall plant profit/loss. Apportioning the material cost and common utilities cost is the basic challenge before the cost auditors as there are no clear demarcations and measurement points of utilities available in the plants.

Cost auditors have tried there level best to sort out the same based on their expertise. The various components and its effect on profitability is group wise listed below. This clearly indicates that listing the probable reasons for unit wise profit/losses is challenging task and will be based on some assumptions which may not be widely acceptable, hence defining clear reasons of unit wise loss/profit can be treated as the study limitations for this study.

7.2. Other observations

- FRP cost of sugarcane is constant for sugar year (from Oct- Sept). Avg, Min, Max cost is not in practice.
- Transportation cost per tonne of sugarcane to the power plant is constant up to certain distance like 0 to 50 km and 50 to 75 km.

- Transportation cost, loading and unloading of sugarcane is subset of harvesting and transportation cost (H&T)
- Cost of sugarcane is given as per FRP decided by govt. after deducting H & T (Harvesting and Transporting) Cost from the F.R.P
- Farmers received the payment in 2 to 3 instalments from majority of sugar factories. As per the primary survey the instalments received were 70% to 80% and 30% to 20% in case of 2 instalments and 50%, 30% and 20% in case of more than 2 instalments.

The Recommendation in NITI Ayog towards the payment of sugar cane dues is that, mills should be allowed to stagger the payment for sugarcane in the following manner: 60% payment within 14 days; another 20% within next two weeks and balance 20% within another one month (or upon sale of sugar, whichever is earlier), so that the entire dues are cleared within 2 months.

- Storage cost of sugarcane is not readily available. As it is running process that is sugarcane imported from field is directly poured into machines.
- Few cogeneration use firewood for start-up Process for Co-Gen Plant
- Cane loading in all the sugar factories is done mechanically
- Bagasse is stored in open for the next seasons
- The bagasse is directly fed into the boiler. Only two cogeneration units Malegaon and Ashok cogeneration units had mechanical dryers. E.g. in Ashok cogeneration unit the 2.29 MT of steam is being generated from 1 MT of bagasse. It is higher than previous year 1.95 MT.
- The cane crushing is mostly steam powered while very few are electrical powered
- The boilers are water tube with pressure ranging from 45 to 125 atm.
- Steam requirement of the various curved cogeneration units were in the range of 70 to 150 TPH.
- The bagasse to steam ratio ranges from 2.10 to 2.40 as observed during the survey
- Sugar cane is weighed at the input point and finished sugar at output points. As there is no separate weighing mechanism for the bagasse, the bagasse weight is derived from weights of sugar cane and finished sugar.
- Sugar mills with Cogeneration units do not sale bagasse to other plants in Maharashtra.

The back pressure turbines are basic turbines and other turbines such as condensing, extraction cum condensing requires more capital investments compared to the back pressure turbines. The condensing and equivalent turbines are more efficient compared to the back pressure due to inbuilt waste heat recovery system. Back pressure type has the highest population of 38% in the surveyed cogeneration units.

The Sugar mills are under financial problems due ever increasing Fair and Remunerative Price (FRP), harvesting cost and insufficient sugar prices etc. Sugar mills have cane arrears of more than Rs.20000 Crores[59] for year 2019-20. Sugarcane

[59] Niti ayog report March 2020, point in 2.30.page no 10

FRP accounts for about 70 % of the sugar price. In order to get relief from financial stress various diversified products like ethanol from sugar syrup and generation of power via cogeneration units are being promoted by Government with financial incentives.

The FRP and tariff both are defined by Govt. and it is not under sugar factory management, hence management have no control over the various prices and get dragged on by Govt. policies. "The Commission for Agricultural Costs and Prices (CACP), in their sugarcane pricing policy report, also stated that the net return on cultivating sugarcane is 200%–250% higher than cotton and wheat. Even if the two crops are added, sugarcane profitability rule is much higher[60]". The average GCV of the used bagasse is 2200 kCal/Kg and the average station heat rate is 3721kcal/kWh of the surveyed plants.

[60] Niti Aayog report march 2020 point 2.17

Annexure-I: Fuel price Indexation Mechanism

For determining the variable charge component of the tariff the following indexing mechanism for adjustment of fuel prices for each year of operation will be applicable in case of both existing and new Biomass-based Power Projects,

The Variable charge component for the n^{th} year shall be calculated as

$$VC_n = VC_1 \times (P_n / P_1)$$

Where, VC_1 represents the Variable Charge based on Biomass Price P_1 for first year as specified under regulation 46 for existing and new Biomass-based Power Projects and regulation 56 for non-fossil fuel-based Co-Generation Projects

$$VC_1 = \frac{Station\ Hear\ Rate\ (SHR)}{Gross\ Calorific\ Value\ (GCV)} \times \frac{1}{(1 - Auxiliary\ Consumption\ Factor)} \times \frac{P1}{1000}$$

P_n = Price per tonne of biomass for n^{th} year

P_{n-1} = Price per tonne of biomass for $(n-1)^{th}$ year

P_1 = Price of the biomass for FY 2020-21

Annexure-II: Crop residue generation

Table A2. 1: District-wise crop residue generation (in Hundred Ton) for 2019–20

2019-2020 (in Hundred Tonne)																
	Sugarcane		Maize		Rice			Wheat		Cotton			Groundnut		Pigeon pea	Soybean
	Bagasse	Top & leaves	Cobs	Stalk	Husk	Stalk	Straw	Pod	Stalk	Boll Shell	Husk	Stalks (3.8 tonne/hectare)	Shell	Stalk	Stalk	Stalk
CRR / Districts	0.33	0.05	0.3	2	0.2	1.5	1.5	0.3	1.5	1.1	1.1	3.8	0.3	2	2.5	1.7
Ahmednagar	18024	2731	378	2522	40	297	297	581	2903	271	271	4956	19	124	409	1249
Akola	6	1	2	14	0	0	0	132	661	661	661	5868	10	66	2859	2710
Amravati	28	4	64	427	3	21	21	265	1324	881	881	10491	6	43	2277	3220
Aurangabad	2445	370	853	5686	0	0	0	626	3129	1081	1081	15250	16	109	617	192
Beed/Bid	2099	318	31	209	0	0	0	212	1058	699	699	14142	15	100	989	3115
Bhandara	786	119	0	2	901	6754	6754	61	306	2	2	33	0	0	130	6
Buldhana	52	8	143	956	0	0	0	394	1972	343	343	8015	3	19	2002	7085
Chandrapur	0	0	1	6	471	3532	3532	63	314	765	765	7039	0	1	987	770
Dhule	0	0	314	2091	19	146	146	324	1622	312	312	8529	34	224	58	364
Gadchiroli	3	0	16	109	664	4978	4978	2	12	76	76	540	0	0	156	2
Gondia	153	23	1	8	989	7421	7421	9	46	0	0	0	0	0	84	0
Hingoli	1111	168	7	50	0	0	0	173	866	227	227	1786	2	16	1020	8258
Jalgaon	1522	231	1028	6854	0	0	0	810	4050	790	790	19288	28	187	157	169
Jalna	5241	794	508	3384	0	0	0	602	3011	1612	1612	11584	8	53	1873	4053
Kolhapur	38886	5892	22	149	514	3855	3855	10	48	0	0	1	158	1055	26	1435
Latur	4911	744	18	122	0	1	1	32	160	28	28	421	4	26	2647	7751
Nagpur	730	111	26	176	410	3071	3071	347	1736	1250	1250	8940	3	22	1530	2317
Nanded	4950	750	32	216	1	9	9	156	778	547	547	8809	23	151	1450	8768

2019-2020 (in Hundred Tonne)																
	Sugarcane		**Maize**		**Rice**			**Wheat**		**Cotton**			**Groundnut**		**Pigeon pea**	**Soybean**
Nandurbar	3658	554	257	1713	73	546	546	177	887	392	392	4875	10	66	140	496
Nashik	4503	682	1144	7629	218	1635	1635	618	3092	80	80	1429	75	503	72	1277
Osmanabad	4753	720	41	273	0	3	3	106	531	11	11	436	4	26	636	6120
Parbhani	2860	433	14	96	0	0	0	259	1293	484	484	7865	36	242	1427	4314
Pune	38570	5844	167	1110	273	2049	2049	206	1031	0	0	2	45	300	17	284
Raigarh					378	2837	2837	0	0	0	0	0	1	5	4	0
Ratnagiri	0	0	0	1	384	2879	2879	0	0	0	0	0	1	6	3	0
Sangli	32429	4914	347	2311	35	264	264	180	899	0	0	2	85	567	67	616
Satara	26282	3982	157	1048	123	925	925	210	1051	0	0	1	106	704	28	1446
Sindhudurg	0	0	3	18	289	2165	2165	0	0	0	0	0	21	143	0	0
Solapur	18903	2864	359	2394	0	0	0	108	541	2	2	23	36	241	1268	486
Thane			4	24	227	1705	1705	0	0	0	0	0	0	0	8	0
Wardha	614	93	1	5	0	1	1	113	567	1044	1044	8928	3	18	1714	2356
Washim	16	2	3	23	0	0	0	162	808	78	78	988	10	67	768	5391
Yavatmal	1752	265			0	0	0	218	1088	1017	1017	18123	18	120	923	3887
Maharashtra	**215286**	**32619**	**5944**	**39626**	**6013**	**45095**	**45095**	**7158**	**35788**	**12652**	**12652**	**168363**	**781**	**5205**	**26347**	**78138**

Table A2. 2: District-wise crop residue generation (in Hundred Tonne) for 2018–19

2018-2019 (in Hundred Tonne)														
	Sugarcane		Maize		Rice			Wheat		Cotton			Groundnut	
	Crop Residue		Crop Residue		Crop Residue			Crop Residue		Crop Residue			Crop Residue	
CRR	Bagasse	Top and leaves	Cobs	Stalks	Husk	Stalks	Straw	Pod	Stalks	Boll Shell	Husk	Stalks (3.8 tonne/hectare)	Shell	Stalks
Districts	**0.33**	**0.05**	**0.3**	**2**	**0.2**	**1.5**	**1.5**	**0.3**	**1.5**	**1.1**	**1.1**	**3.8**	**0.3**	**2**
Ahmednagar	42161	6388	434	2896	15	113	113	144	722	295	295	4209	11	77
Akola	3	1	1	6	0	0	0	104	519	663	663	5464	5	33
Amravati	40	6	53	356	6	44	44	117	585	1225	1225	7964	4	29
Aurangabad	4367	662	616	4104	0	0	0	32	160	758	758	14646	7	45
Beed/Bid	5042	764	15	102	0	0	0	10	52	275	275	14346	2	15
Bhandara	903	137	15	98	774	5807	5807	24	120	3	3	37	0	0
Buldhana	46	7	112	747	0	0	0	69	345	628	628	7082	1	7
Chandrapur	13	2	0	2	599	4495	4495	59	297	658	658	7127	0	0
Dhule	675	102	381	2543	13	100	100	138	691	550	550	8842	16	106
Gadchiroli	2	0	12	79	656	4918	4918	1	5	56	56	531	0	0
Gondia	227	34	1	5	1075	8064	8064	6	28	0	0	0	0	0
Hingoli	2476	375	3	21	0	0	0	112	559	179	179	1747	0	0
Jalgaon	2311	350	743	4953	0	0	0	112	562	1693	1693	18681	6	40
Jalna	6605	1001	186	1242	0	0	0	25	124	811	811	11504	4	24
Kolhapur	40050	6068	40	267	667	5000	5000	25	125	0	0	0	196	1309
Latur	12335	1869	22	149	1	4	4	9	47	26	26	365	1	8
Nagpur	926	140	16	110	424	3181	3181	228	1139	918	918	8324	3	18
Nanded	3461	524	20	132	2	12	12	79	394	768	768	9114	0	0
Nandurbar	4753	720	160	1068	33	250	250	8	38	345	345	4463	8	56
Nashik	4568	692	2086	13904	306	2294	2294	126	628	58	58	1616	66	443
Osmanabad	8022	1216	47	312	0	3	3	41	206	18	18	771	8	50
Parbhani	6334	960	5	31	0	0	0	55	277	627	627	7595	0	0
Pune	51448	7795	151	1008	283	2126	2126	78	388	0	0	2	37	247

2018-2019 (in Hundred Tonne)														
	Sugarcane		Maize		Rice			Wheat		Cotton			Groundnut	
Raigarh	0	0	0	0	590	4427	4427	0	0	0	0	0	1	7
Ratnagiri	0	0	0	1	423	3173	3173	0	0	0	0	0	0	3
Sangli	30622	4640	303	2019	70	527	527	63	313	0	0	2	82	546
Satara	29343	4446	209	1395	225	1687	1687	155	777	0	0	0	120	797
Sindhudurg	0	0	0	3	322	2418	2418	0	0	0	0	0	8	51
Solapur	44521	6746	133	888	0	0	0	40	201	1	1	33	3	22
Thane	0	0	0	0	283	2124	2124	0	0	0	0	0	0	0
Wardha	579	88	3	19	0	1	1	83	415	1150	1150	8703	2	16
Washim	30	5	0	3	0	0	0	116	582	98	98	1014	3	17
Yavatmal	758	115	6	42	0	0	0	118	592	1527	1527	17462	11	75
Maharashtra	**302624**	**45852**	**5776**	**38505**	**6769**	**50766**	**50766**	**2178**	**10889**	**13330**	**13330**	**161644**	**606**	**4040**

Table A2. 3: District-wise crop residue generation (in Hundred Tonne) for 2016–17

2016-2017 (in Hundred Tonne)														
	Sugarcane		Maize		Rice			Wheat		Cotton			Groundnut	
	Crop Residue		Crop Residue		Crop Residue			Crop Residue		Crop Residue			Crop Residue	
	Bagasse	Top and leaves	Cobs	Stalks	Husk	Stalks	Straw	Pod	Stalks	Boll Shell	Husk	Stalks (3.8 tonne/hectare)	Shell	Stalks
CRR / Districts	0.33	0.05	0.3	2	0.2	1.5	1.5	0.3	1.5	1.1	1.1	3.8	0.3	2
Ahmednagar	13799	2091	736	4908	52	393	393	382	1908	261	261	5031	66	438
Akola	12	2	1	8	0	0	0	83	413	828	828	5894	17	110
Amravati	39	6	15	100	9	69	69	336	1679	1503	1503	7611	18	122
Aurangabad	2881	437	683	4550	6	47	47	406	2031	1856	1856	19247	18	122
Beed/Bid	1636	248	247	1649	0	1	1	238	1191	892	892	12973	33	222
Bhandara	941	143	3	18	757	5676	5676	41	207	966	966	6443	0	0
Buldhana	118	18	400	2666	0	0	0	487	2436	0	0	0	17	114
Chandrapur	7	1	0	2	491	3683	3683	75	375	1027	1027	6186	0	2
Dhule	1724	261	554	3694	21	158	158	262	1310	646	646	7452	43	284
Gadchiroli	0	0	15	102	571	4280	4280	4	20	27	27	186	0	0
Gondia	93	14	1	7	1021	7655	7655	6	32	0	0	0	0	0
Hingoli	1032	156	17	114	0	0	0	150	749	294	294	2850	7	44
Jalgaon	2791	423	2011	13406	0	0	0	318	1592	2735	2735	19160	20	136
Jalna	2018	306	624	4158	0	0	0	189	945	1307	1307	10123	2	16
Kolhapur	41247	6250	133	888	796	5967	5967	29	146	0	0	0	278	1854
Latur	1681	255	25	168	2	14	14	292	1461	22	22	103	12	78
Nagpur	654	99	2	13	341	2556	2556	698	3489	1029	1029	5187	20	134
Nanded	2839	430	58	388	3	20	20	227	1136	1188	1188	13843	31	204
Nandurbar	2879	436	362	2410	59	441	441	113	566	284	284	3249	11	72
Nashik	3188	483	2101	14008	292	2187	2187	533	2664	296	296	1775	112	744
Osmanabad	1412	214	35	234	2	18	18	33	167	39	39	505	9	58
Parbhani	1909	289	31	209	0	0	0	144	719	1437	1437	6370	14	90
Pune	29934	4535	772	5148	231	1731	1731	496	2478	0	0	0	85	564

2016-2017 (in Hundred Tonne)														
	Sugarcane		**Maize**		**Rice**			**Wheat**		**Cotton**			**Groundnut**	
Raigarh	0	0	0	0	618	4637	4637	0	0	0	0	0	1	6
Ratnagiri	32	5	0	0	473	3546	3546	0	0	0	0	0	0	2
Sangli	25771	3905	587	3914	86	644	644	191	954	3	3	23	125	836
Satara	20657	3130	233	1554	164	1232	1232	214	1068	0	0	4	178	1186
Sindhudurg	401	61	1	4	418	3134	3134	0	0	0	0	0	6	42
Solapur	15715	2381	313	2088	0	1	1	233	1167	3	3	34	17	114
Thane	0	0	0	0	299	2246	2246	0	0	0	0	0	0	0
Wardha	595	90	0	2	0	0	0	66	330	1344	1344	9139	16	108
Washim	45	7	3	22	0	0	0	163	813	70	70	699	23	156
Yavatmal	2931	444	21	140	0	0	0	234	1169	2053	2053	15987	82	544
Maharashtra	**178982**	**27118**	**9986**	**66572**	**6711**	**50330**	**50330**	**6642**	**33209**	**20112**	**20112**	**160074**	**1260**	**8402**