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The Electricity Generation Potential in Sugar Mill of Bhenda factory and Energy Conservation Activities

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Abstract: The cogeneration system is one of the most important parts of sugarcane mills which use the bagasse as fuel. In the recent years, modern equipment's and energy efficiency measures made possible to the sugarcane industry, the production of surplus electricity which become, besides the sugar and ethanol, a third product from the same renewable source, the sugarcane. This work analyses the surplus electric power systems for three different schemes of cogeneration system in the sugarcane industry through the simulator thermoflow. The analysis is made considering both the available bagasse and sugarcane straw recovery as fuel in three different scenarios for the industrial process energy requirements.
Keywords: Sugar Mills, Bagasse, Electricity, CEST

I. INTRODUCTION

India has been known as the home of sugar and sugarcane. Indian mythology supports the above fact as it contains legends showing the origin of sugarcane. India is the second largest producer of sugarcane next to Brazil. Presently, about 4 million hectares of land is under sugarcane with an average yield of 70 tons per hectare. In India, about 60% of the cane produced goes into making refined (centrifugal) sugar, while the remaining 40% is used by the small-scale industry. The Indian sugar industry uses sugarcane for production of sugar and hence maximum number of the companies is likely to be found in the sugarcane growing states of India including Uttar Pradesh, Maharashtra, Gujarat, Tamil Nadu, Karnataka, and Andhra Pradesh. The northern state of Uttar Pradesh is the leading producer of cane, accounting for over 97 million tons or 44.6% of the total. Maharashtra and Tamil Nadu are the second and third ranking sugarcane producers, with 34,008,000 tons or 13.5% of total and 21,918,000 tons or 11.2% of total, respectively

In January 2012, the installed capacity of renewable power generation in India was 23 GW, which is equivalent to nearly 12% of total power capacity (MNRE, 2012; CEA, 2012). Bagasse cogeneration contributes 9% capacity represented by 2 GW. The principal fuel used to raise steam in India's sugar mills is bagasse. Bagasse is the fibrous waste that remains after recovery of sugar juice via crushing and extraction. The fiber content of sugar cane varies somewhat but averages about 15% on cane, which is equivalent to approximately 30% by weight of the cane on a mill-wet basis (48-52%). The gross heating value of mill-wet bagasse is approximately 2300 kcal/kg (4100 Btu/lb) — one ton of bagasse is equal to about two barrels of oil on an energy basis

Depending on the technology deployed, and the corresponding efficiency, about 75- 90% of the bagasse available at Indian mills is used to produce internal steam and electricity; the balance is considered surplus and is either discarded or used for other purposes. The availability of surplus bagasse, or other fuels, is a major issue when considering year-round cogeneration with power export to the grid the potential from all operating sugar mills of India spread over 9 major states has been identified at 3,500 MW of surplus power by using bagasse as the renewable source of energy. The project involves employment of extra high-pressure boiler configurations of 67 kg/cm2 or 87 kg/cm2 or 105 kg/cm2 the high-efficiency cogeneration design not only uses the available bagasse efficiently, but also yields substantial quantities of power for exporting to the grid, over and above their enhanced energy needs. Improved energy efficiency of sugar mill operations to a maximum possible extent is a pre-requisite for building highefficiency grid-connected cogeneration power plants. Reduced captive steam and power consumptions enhance bagasse availability for extra power generation and for extending their period of operation beyond the crushing season. The potential of 3,500 MW can be easily increased to over 5,000 MW by employing equipment and systems for reduction of steam and power in sugar processes (from present 50-52% steam on cane and 22 units of electricity per ton of cane crushed to 42-45% steam on cane and 16 units of electricity per ton of cane crushed), as well as for the manufacture of by-products

The electricity generation from sugar mills waste can play. a major role to meet the growing electricity demand of our Country.
This paper aims at evaluating the potential of electricity generation from bagasse produced in sugar mills of Ahmednagar. The paper is organized in the following manner:
Section II gives related work in connection with bagasse cogeneration Section III illustrates the status of LMGP sugar mills Section IV presents analysis and methodology adopted for the research Section V includes discussion on results Section VI gives recommendations for bagasse used electricity generation projects. The paper is finally concluded in Section VII

A. Nomenclutre

1) Mula Sahakari Sakhar Karkhana (MSSK)
2) Kukadi Sahakari Sakhar Karkhana (KSSK)
3) Loknete Marutrao Ghule Patil (LMGP)
4) Pravara Sahakari Sakhar Karkhana (PSSK)
5) Karmaveer Shankarrao Kale (KSKSSK)
6) Sahakari Sakhar Karkhana

II. RELATED WORK

India is one of the largest sugarcanes growing nations with an estimated production of around 300 million tons in the marketing year 2009-10 [3]. Now a day's sugar-distillery- cogeneration complexes, integrating the production of cane sugar and ethanol, constitute one of the key agro based industries. There are nearly 500 sugar factories in India along with around 300 molasses-based alcohol distilleries. Karnataka in 2014 stands 3rd in cane crushing, cane recovery and 3rd in sugar production in India.The cooperative movement for the sugar industry started in the 1960s in Maharashtra with the announcement of 12 places in the state where sugar factories could be established **Sugarcane** is the primary cash crop among farmers of the western Maharashtra region. The sugarcane is mostly sold to sugar mills for sugar production. Majority of these mills are cooperatives owned by the sugarcane growers. Solapur district has highest number of sugar factories in Maharashtra.
Ahmednagar district occupies an important place in Maharashtra State both from the point of view of the land under sugarcane crop and production of sugar. The cultivation of sugarcane in the district is mainly concentrated in Nevasa, Shrirampur, Rahta, Shrigonda and Kopargaon Tahsil. In recent years, the increase in the area under the sugarcane crop is mainly due to increased irrigation facilities in the district. The changes in the Area, Production and Yield of Sugarcane in Ahmednagar District for the forty years (1970-71 to 2010-11) During 1970-71 to 2010-11, the area, production and yield of sugarcane crop in the district have fluctuating trends. The area under sugarcane crop in the district increased from 317 hectares in 1970-71 to 1295 hectares in 2010-11. In 2004-05, minimum area under sugarcane crop (i.e., 170 hectares) is observed. On the contrary, maximum area under sugarcane crop (i.e., 1295 hectares) is seen in 2010-11. The production of sugarcane in the district has more fluctuating trend than the trend of sugarcane area. The highest production of sugarcane is found in 2010-11 and the lowest in 2002-03. The productivity of sugarcane in the district decreased from 113562 kg/hectare in 1970-71 to 90314 kg/hectare in 2010-11
There are also large variations in the yield of sugarcane in different tahsils. The largest yield (131111 Kg/hectare) has been observed in Jamkhed Tahsil (in 2005-06) and smallest yield (21009 kg/hectare) in Shevgaon Tahsil (in 2001-02). The number of tahsils which have the higher yield than the district's average yield increased from five in 1997-98 to six in 2010-11. During (1970-71 to 2010-11), out of 14 tahsils in the district, 3 tahsils i.e., Akola, Parner and Shevgaon Tahsil have the negative trends. The highest positive change in the yield of sugarcane is seen in Pathardi Tahsil and smallest or negative change in Parner Tahsil.
On the basis of the average sugarcane productivity of different tahsils, the entire district is divided into three broader productivity regions. These are as follows:

Sr.no	Regions	Class Interval (Metric Ton/Hector)	Included tahsils	No. of Tahsil
1.	Hight productivity	More than 75	Akola, Kopargaon, Parner, Nevasa, Rahuri, Sangamner and Shrigonda,	7
2.	Medium	65-75	Ahmadnagar, Pathardi, Karjat, Rahta and Shrirampur	5
3.	Low Productivity	Less than 65	Shevgaon and Jamkhed	2

The per hectare productivity is below 65 M.T./Hec. in only two tahsils of the district. About 35 percent of tahsils recorded productivity between 65 and 75 M.T./Hec. and fifty percent tahsils recorded productivity above 75 M.T./Hec. Low- productivity tahsils are generally found to be smaller in area than the high productivity tahsils. Generally, tahsils of low productivity are characterized by low rainfall and low irrigated area which also result in a lesser amount of fertilizer use. In terms of regional variations in sugarcane productivity it has been observed that sugarcane productivity per unit of net sown area in most productive tahsil (Sangamner Tahsil) in Ahmednagar District is more than 54 percent of the tahsil having lowest productivity (Jamkhed Tahsil).

III. STATUS OF AHMEDNAGAR SUGAR MILLS

Ahmednagar, the largest district in the State. It is home to 19 sugar factories and is also the birthplace of the cooperative movement. Sugar, milk and bank cooperatives flourish here. Exactly 100 years ago, a great visionary was born in deep into the heartland of Maharashtra. Padmashree Dr. Vithalrao Vikhe Patil was one such visionary. the first industrial co-operative venture in Asia – Pravara Sugar Factory (1948) was started.

What started as a small step, soon developed into an approach that has since been widely recognized as The Pravara Model of Integrated Rural Development. He established the first sugar Factory at Pravaranagar for uplifting socio-economic condition of the farmers.

In Ahmednagar there are 19 sugar mills, out of them Mula sahakari sakhar karkhana (MSSKL), Loknete marutrao ghule patil (LMGP), Dr. vittalrao vikhe patil sugar factory (PSSK), karmaveer Shankar Rao kale sahakari sakhar karkhana (KSKSSK), Kukadi sahakari sakhar karkhana (KSSK) this are cogeneration plant.

Mula sahakari sakhar karkhana (MSSKL) is placed in Post Sonai, Taluka Newasa, District Ahmednagar, Maharashtra state MSSKL is an existing Co-op sugar factory with present cane crushing capacity of 7500 TCD along with 30 MW Co-gen project and 30. Average cane crushed per year 2372500 & Average bagasse production per year 711750, Also average cane crushed by sugar mill is 6500.

Loknete Marutrao Ghule Patil Dnyaneshwar Shakari Sakhar Karkhana Ltd. Is placed in AT VILLAGE BHENDE, TEHSIL - NEWASA AND DISTRICT AHMEDNAGAR LMGPDSSKL is an existing operating Sugar plant of sugar crushing capacity of 9000 TCD along with Cogeneration Plant of 31.5 MW & 45 KLPD distillery unit 7 for existing 7,000 TCD along with Cogeneration Plant of 31.5 MW and sugar expansion 7000 TCD to 9000 TCD. Distillery will be operated round the year for 330 days. Sugar mill crushing capacity is 9000 TCD and crush 14.40 lac tons of cane. The C- Molasses Production 4.25 % of cane worked out 61200 MT per season & B-molasses production 6.5 % of cane works out to 93600 MT per season.

The information has been collected through a survey conducted and the data provided by LMGPL sugar mills. The general information regarding Ahmednagar sugar mills are summarized Table 1

TABLE I. GENERAL INFORMATION OF ASM SUGAR MILES

Sr.no	Name of sugar mill	Location	Installed capacity (TCD)	Boiler pressure (Bar)&Temp	Type of turbine
1.	MSSK	Newasa	7500	80 TPH	BPST
2.	RSSK	Pravaranagar	7200	160TPH	BPST
3.	LMRGR	Bhenda	8000	4.5TPH	BPST
4.	KSKSSK	Kopargaon	4000	120 TPH	BPST
5.	KSSK	Pimpalgaon pisa	5500	130 TPH	BPST

IV. ANALYSIS

Bhenda factory has substantial biomass resources such as animal waste, municipal solid waste, rice husk and sugar mills waste etc. These resources should be exploited to cope with the electricity shortage. This work focuses on electricity generation from sugarcane waste i.e. bagasse produced in sugar mills of bhenda. The methodology adopted for the analysis is carried out in the following stages.

A. Data Collection

Various sugar mills of Ahmednagar were visited. Technical data such as pressure and temperature of boiler and steam turbine, and production data like sugarcane crushed per day and bagasse production per day were collected by filling questionnaires. Fig. 1 and 2 show the average sugar cane crushed and bagasse production per day of each sugar mill respectively. Technical managers were also interviewed and discussed the relevant data like steam to bagasse ratio, steam consumption per KWh and electricity consumption per tone cane crushed.

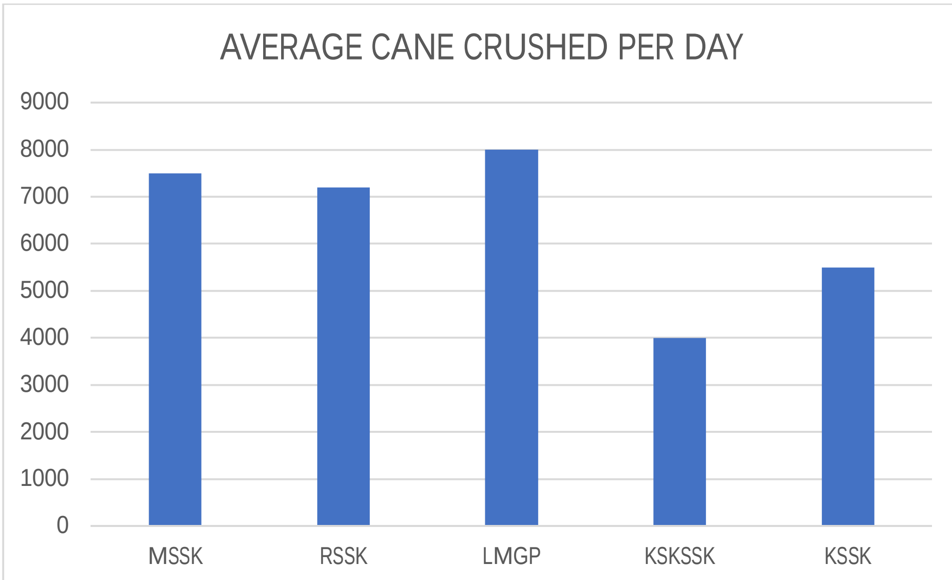

FIG.1. Average cane crushed per day by ASM

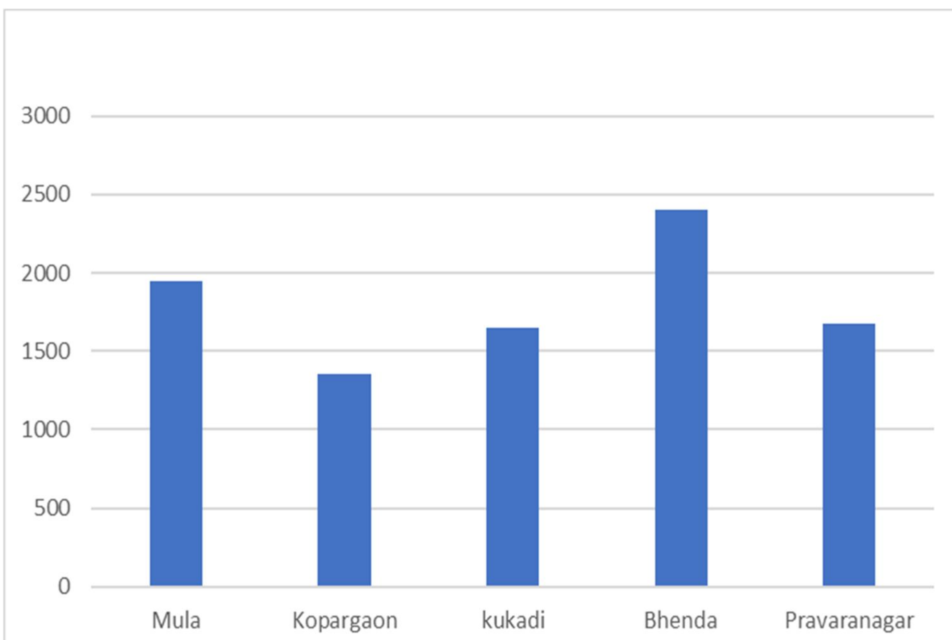

Fig.2.Average bagasse production per day by ASM

B. Scenario Approach

The following four scenarios are used to determine the potential of electricity generation in sugar mills of Bhenda factory

1) *Scenario 1:* In this scenario, potential of electricity generation is determined on the basis of average cane crushed per day and the existing technology used in sugar mills of ASM.

2) *Scenario 2:* Most of the sugar mills in ASM use inefficient boilers and steam turbines to fulfill their in-house electricity and steam demands. In this scenario, it is suggested to develop and install high pressure (65 bar) boilers and condensing extraction steam turbines (CEST) in sugar mills, so that high steam production per ton bagasse and maximum electricity generation is possible in ASM sugar mills. Higher the pressure of boiler, greater will be the steam production and vice versa. Moreover, higher the steam pressure and temperature of CEST, greater will be electricity generation. This scenario evaluates the potential of electricity generation in KPK sugar mills on the basis of daily average cane crushing and modern cogeneration technology suggested for mills
3) *Scenario 3:* The average cane crushed per day by mills is very low as compared to their installed crushing capacity. Increasing the crushing capacity of sugar mills will raise the bagasse production. Due to increase in bagasse production, more electricity will be generated. This scenario estimates the potential of electricity generation in ASM sugar mills on the basis of installed crushing capacity and existing technology.
4) *Scenario 4:* This scenario gives an assessment about the potential of electricity production on the basis of installed crushing capacity and modern cogeneration technology suggested for ASM sugar mills.

LMGP is considered as a sample for calculations of electricity generation potential on the basis of above four scenarios and the results of all other Five sugar mills along with LMRGR are summarized in tables.

C. Loknete Marutirao Ghule Patil Sugar Mill (LMGP)

LMGP is located in Newasa Ahmednagar District. The installed capacity of sugar mill is 7500 TCD (Table I) whereas the average cane crushed per day is about 6500 tone (Fig. 1). The average bagasse production is about 1950 tone (Fig. 2). The mill uses low pressure (22 TPH) boiler and steam turbine to generate steam and electricity for mill purposes. The electricity generation potential of LMGP and other five sugar mills is determined on the basis of scenario approach discussed in the previous section.

1) Calculations Based on Scenario 1

Average cane crushed per day = 8000 tone
Average cane crushed per hour = 333.33 tone
Average bagasse production per day = 2400 tone
Average bagasse production per hour = 100 tone
Boiler having pressure and temperature 4.5TPH produces approximately 2.20 tons steam per ton bagasse.
Steam production per hour = 100*2.20*1000 kg = 220000kg
As per information provided, the steam required per kilowatt is approximately 11kg.
Electricity production = 220000/11*1000 = 20 MW
It is estimated that electricity consumption of the mill is about 32.5 KWh per tone cane.
Electricity for mill use = 32.5*333.33/1000=10.83 MW
Exportable Electricity = 20 – 10.83 = 9.16 MW
The results obtained on the basis of this scenario for all sugar mills are summarized in Table II.

Table Ii. Electricity statistics of kpk sugar mills on the basis of scenario 1

Sr.no	Name of sugar mill	Total electricity production (MW)	Electricity for mill purpose (MW)	Exportable Electricity (MW)
1.	MSSK	16.25	10.83	5.42
2.	PSSK	14	9.3	4.7
3.	LMGP	20	10.83	9.16
4.	KSKSSK	11.25	7.5	3.75
5.	KSSK	11.25	5.06	7
	Total	72.75	43.52	30

2) Calculations Based on Scenario 2

The information collected from ASML through questionnaire shows that one tone bagasse produces 2.40 tons steam, while using boiler of pressure 65 bar and temperature 490 C.

Steam production per hour = 100*2.40*1000 kg = 240000 kg

Steam required for CEST to generate one kilowatt is approximately 5 kg.

Electricity production = 240000/5*1000 = 48 MW

Electricity for mill purposes = 10.83 MW (Table 2)

Exportable electricity = 48 – 10.83= 37.17 MW

The results obtained on the basis of this scenario for all sugar mills are summarized in Table III.

Table III. Electricity statistics of kpk sugar mills on the Basis of scenario 2

Sr.no	Name of sugar mill	Total electricity production (MW)	Electricity for mill purpose (MW)	Exportable Electricity (MW)
1.	MSSK	39	10.83	28.17
2.	PSSK	33.6	9.3	24.3
3.	LMGP	48	10.83	37.17
4.	KSKSSK	27	7.5	19.5
5.	KSSK	27	5.06	21
	Total	174.6	43.52	130.14

3) Calculations Based on Scenario 3

Installed cane crushing capacity of mill = 9000 tone

Sugar cane crushed per hour = 375 tone

The average bagasse content is about 30 – 32 % in sugar cane.

For safe limit we consider 30%.

Bagasse production per day = 9000*.30 = 2700 tone

Bagasse production per hour = 2700/24 = 112.5 tone

Steam production per hour = 112.5*2.20*1000 kg = 247500 kg

Electricity production (11 kg/kW) = 247500/11*1000 =22.5 MW

It is estimated that electricity consumption per tone of cane crushed is about 32.5KWh.

Electricity for mill use = 375*32.5/1000 = 12.18 MW

Exportable Electricity = 22.5– 12.18 = 10.31 MW

The results obtained on the basis of this scenario for all sugar mills are summarized in Table IV.

TABLE IV. Electricity statistics of kpk sugar mills on the Basis of scenario 3

Sr.no	Name of sugar mill	Total electricity production (MW)	Electricity for mill purpose (MW)	Exportable Electricity (MW)
1.	MSSK	18.75	12.5	6.25
2.	PSSK	18	12	6
3.	LMGP	22.5	12.18	10.14
4.	KSKSSK	12.5	8.3	4.2
5.	KSSK	13.7	6.1	7.5
	Total	85.45	51.08	34.08

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4) Calculations Based on Scenario 4

The information collected from ASML through questionnaire shows that one tone bagasse produces 2.40 tons steam, while using boiler of pressure 65 bar and temperature 490o C.

Steam production per hour = 112.5*2.40*1000 kg = 270000 kg

Electricity production (5 kg/kW) = 270000/5*1000 = 54 MW

Electricity consumption = 12.18MW (Table 2)

Exportable electricity = 54 – 12.18= 41.82 MW

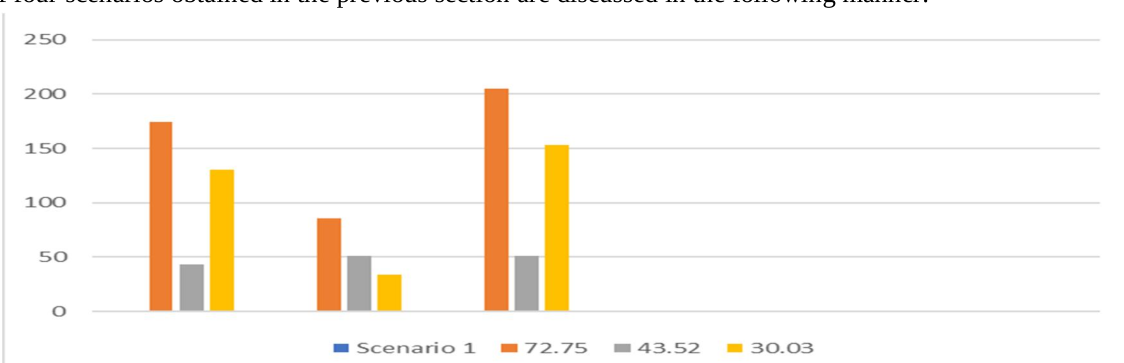
The results obtained on the basis of this scenario for all sugar mills are shown in Table V.

TABLE V. Electricity statistics of kpk sugar mills on theBasis of scenario 4

Sr.no	Name of sugar mill	Total electricity production (MW)	Electricity for mill purpose (MW)	Exportable Electricity (MW)
1.	MSSK	45	12.5	32.5
2.	PSSK	43.2	12	31.2
3.	LMGP	54	12.18	41.82
4.	KSKSSK	30	8.3	21.7
5.	KSSK	33	6.1	26
	Total	205.2	51.08	153.22

V. RESULTS AND DISCUSSION

The results of four scenarios obtained in the previous section are discussed in the following manner.



From scenario 1, it is clear that the total electricity generation potential of LMGP sugar mills calculated on the basis of average cane crushed per day and existing technology, is about 72.75 MW. The electricity used for mill purposes is about 43.52 MW. In this scenario, the LMGP sugar mills are capable of exporting surplus power of about 30 MW.

Scenario 2 indicates that electricity production can be increased up to 174.6 MW, when high pressure (65 bar) boilers and condensing extraction steam turbines are used instead of low pressure (21 – 28 bar) boilers and back pressure steam turbo alternators. The surplus power that can be exported using this scenario is about 130.1 MW.

Scenario 3 predicts that increasing the crushing capacity of sugar mills will not only increase the bagasse production, but also increases the electricity generation. In this scenario, the total electricity potential calculated on the basis of installed crushing capacity and existing technology, is about 85.45 MW, in which electricity used by mills is approximately 51.08 MW. The sugar mills of LMGP are capable of exporting surplus power of about 34.08 MW.

Scenario 4 determines the electricity generation potential on the basis of installed crushing capacity of LMGP sugar mills and proposed technology. The power generation potential determined is about 205.2 MW. The sugar mills of LMGP are capable of exporting surplus power of about 153.22 MW. These results are summarized in Fig. 3.

VI. RECOMMENDATIONS

The owners of sugar mills can be encouraged to implement modern cogeneration technology in their sugar mills, which is already experienced in LMGP. Generating electricity from wastes of sugar mills will significantly increase their revenue generation. The following suggestions are given so that generation of electricity from sugar cane wastes (bagasse) can be realized in true sense:

1) Increase the crushing capacity of sugar mills, so that more bagasse production is possible. Greater the bagasse production by mills, higher will be the electricity generation.
2) Responsibility of farmers to provide sugar cane stalk to sugar mills for 4 months, so that mills run for maximum days in a season. This will lead to more bagasse production in a season.
3) Bagasse dryer should be installed so that more steam is produced as compared to wet bagasse with 50 % moisture content
4) Existing low-pressure boilers (21 – 28 bar) should be replaced by high pressure boilers (65 bar). Higher the pressure and temperature of boiler, greater will be the steam to bagasse ratio.
5) CEST should be installed so that more electricity is exported to the grid.
6) Government should make attractive policy and offer incentives for bagasse-based electricity generation projects
7) Government should provide funds for generation of electricity from sugar mills wastes i.e. bagasse.
8) Government should enforce sugar mills to generate surplus power and export it to local grid stations.

VII. CONCLUSION

From the analysis, it is concluded that there is a vast potential of electricity generation in sugar mills of LMGP.The average sugar cane crushed per year is approximately 2920000 tons, which results in 876000 tons bagasse production. The installed crushing capacity of sugar mills ranges between 7000 - 9000TCD, while the average cane crushed by sugar mills varies between 6000-8000 TCD. This shows the underutilization of mills. Except LMGP, all other four sugar mills use low pressure boilers and back pressure steam turbines. Replacing these low-pressure boilers and back pressure steam turbines by high pressure (65 bar) boilers and condensing extraction steam turbines, will provide a two-fold advantage. Firstly, it can potentially increase the revenue generation for mills. Secondly and most importantly, it will help in mitigating the electricity shortfall in the province.

The total electricity generation potential calculated on the basis of four different scenarios varies between 73 MW and 205 MW, depending on the crushing capacity and technology used in sugar mills. This shows that, technically it is feasible to generate electricity from bagasse produced by sugar mills of LMGP. Hence, for all practical purposes, there is a need of doing extensive economic and cost benefit analyses on the bagasse-based electricity generation projects so that its potentials can be utilized in real sense to meet our energy requirements.

VIII. ACKNOWLEDGMENT

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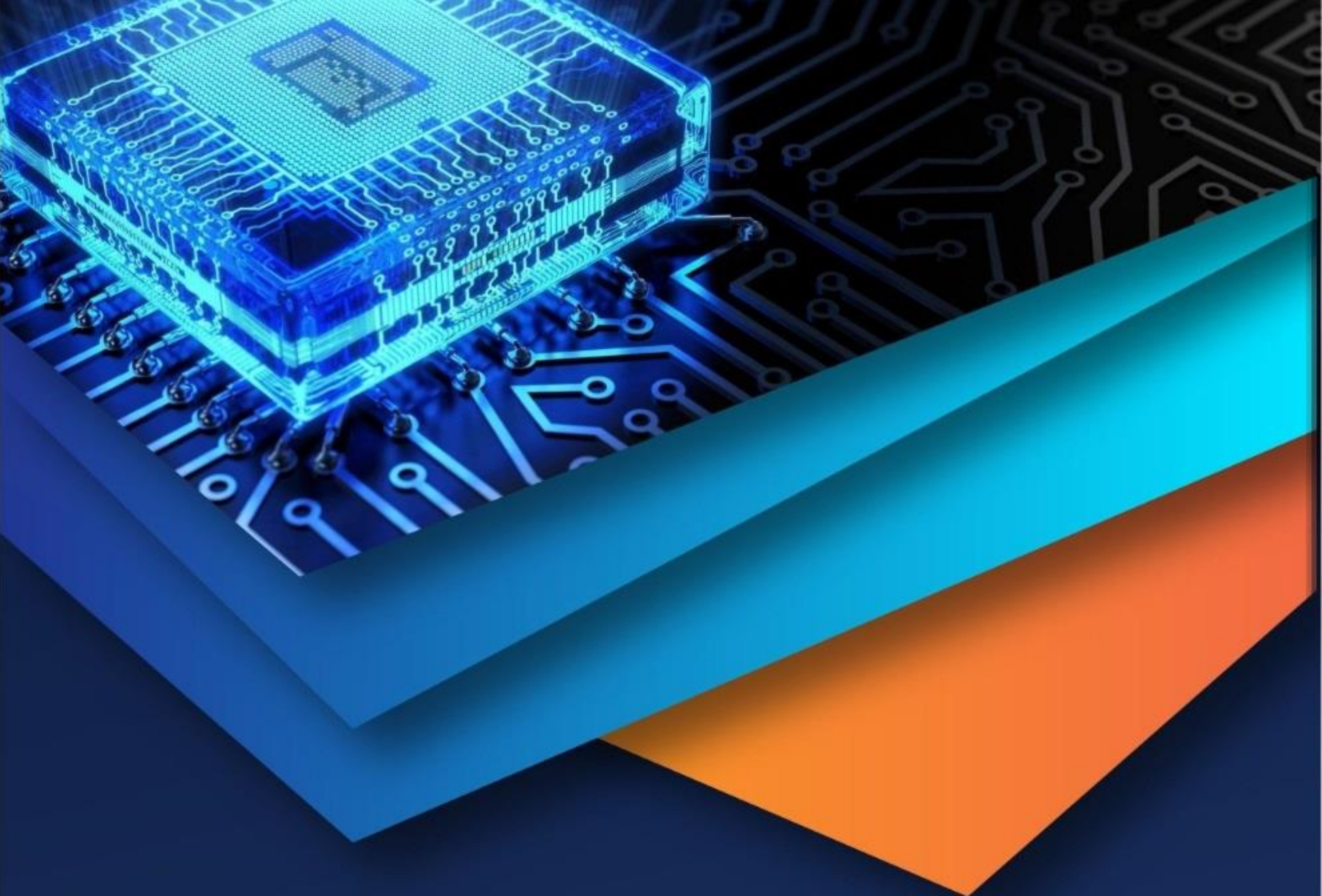

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