MATTER: International Journal of Science and Technology
ISSN 2454-5880

Soppimath & Hudedmani, 2017

Volume 3 Issue 1, pp. 10-26

Date of Publication: 15th March, 2017

DOI- https://dx.doi.org/10.20319/Mijst.2017.31.1026

This paper can be cited as: Soppimath, V. M., & Hudedmani, M. G. (2017). Energy Audit and Energy Management in the Sugar Industry. MATTER: International Journal of Science and Technology, 3(1), 10-26.

ENERGY AUDIT AND ENERGY MANAGEMENT IN THE SUGAR INDUSTRY

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Abstract

Energy audit plays a vital role in deciding energy conservation practices. The systematic and scientific way of use of electrical energy is guaranteed. Electricity is playing a crucial role in everybody's life alternatively, energy usage index indicate the country's economy, growth and standard of living. In contrast to this increasing energy demands and prices are alarming greatly and retarding overall growth. Energy audit provides a solution to reduce the consumption of energy. Energy audit is the beginning of energy management program which report the possible opportunities. The energy audit projects the possible conservation opportunities in enhancing the energy efficiency of the system considering and not limited to electrical, thermal and other areas of a system where energy is involved. About 35 to 45 % of conservation potential in the existing industrial sector is noticed. This clearly brings out the need for efficient machines and mechanisms to be manufactured to reduce the burden on the energy systems when in service considering the cost and efficiency.

Keywords

Energy Audit, Energy conservation, Sugar Industry, Energy efficiency, Management

1. Introduction

Industrial sector in India consumes 45-50% of the commercial energy consumption. The sector is becoming increasingly energy intensive and there exist a great energy saving potential (Balrampur Chini Mills Limited Company presentation, December 2015), (Dr G S C Rao, Indian Sugar Industry At A Glance), (Energy Statistics 2016), (Mallikarjun G Hudedmani & Vishwanath M Soppimath). In sugar sector it is estimated to be at least 30% (Mallikarjun G Hudedmani & Vishwanath M Soppimath). (Mukund Bapat), (Prabhulingeshwar Sugars and Chemicals Ltd). The sector can easily be termed as rural power houses and any conservation here will not only serve the cause of national economy but also enhance the profitability and stability. The energy audit and energy norms are vital for the sugar sector as a whole (Prabhulingeshwar Sugars and Chemicals Ltd), (Premium Efficiency Motor Selection And Application Guide, A Handbook for Industry, U.S. department of Energy, Energy efficiency and Renewable energy, Advanced Manufacturing), (Radha Charan & others), (Soltan & Thorman). To realize the potential of energy efficiency in the country the government of India enacted the Energy conservation act 2001. This act came into force from 1st March 2001. Bureau of Energy Efficiency (BEE) has been established basically to implement the provisions of the Energy conservation act. The ever increasing energy costs, fast depleting energy resources and inability to decrease the cost of finished products call for regular energy audit. The action plans of such minimize energy loss or leakage. The proposed work is taken up to facilitate the industry in identifying the energy wastage by extensive survey of energy usage in the Sugar plant (Mallikarjun G Hudedmani & Vishwanath M Soppimath), (Mukund Bapat), (Sugar Expertise, Indian Sugar Policy: Government role in production expansion and transition from importer to exporter), (The Effect of Repair/Rewinding on Motor Efficiency, EASA/AEMT Rewind study and Good practice Guide to maintain Motor Efficiency), (The Indian Sugar Industry Sector Roadmap 2017). The evaluation of seasonal energy savings and payback period for each recommended action are worked out. The present work mainly focuses on identification of costeffective measures to improve the efficiency and estimate the potential energy saving, implementation costs and payback periods (Vision 2030, Compilation & Editing).

2. Sugar Manufacturing Process

A flow diagram of a sugar manufacturing is shown in Figure 1 followed by brief description.

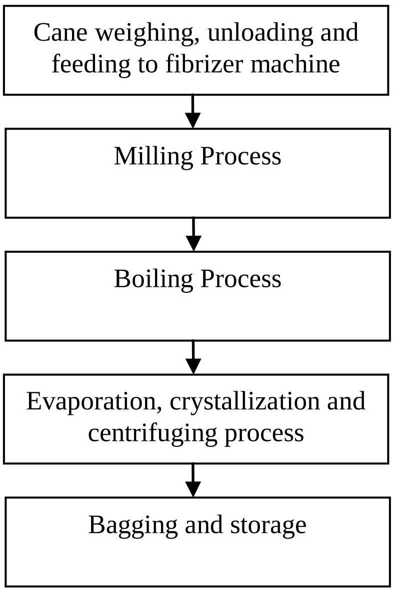

Figure 1: *Flow Diagram of Sugar Manufacturing*

The sugar manufacturing process normally comprises of juice extraction, juice clarification, and evaporation, crystallization, centrifuging, drying, and packing. Sugar cane must be crushed to extract the juice and the crushing process must break up the hard nodes of the cane and flatten the stems. The collected juice is filtered and sometimes boiled to drive off the excess water. The dried cane residue (bagasse) is often used as fuel for Steam generation for cogeneration units.

3. Electrical Energy Audit in Sugar Industry

Electricity is one of the most convenient forms of energy among others because of clean and clear nature. The use of electricity for various needs is increasing everyday but the cost of electricity rising due to increase in the fuel cost. Truly the energy usage index represents standard of living and economy. Preliminary energy audit is essentially a quick walk through energy survey identifying the scope and opportunities to improve energy efficiency. An optimistic and scientific approach to measure, monitor and manage industrial energy consumption to identify and arrest sources of wastage is known as Energy management system. Energy audit is very necessary in the present energy scenario to know and categorize energy utilization and identify areas to reduce energy wastages. Energy conservation methods improve energy efficiency, reduce energy wastage and improve overall efficiency by substantial reduction in energy costs. Energy Audit figures out the energy consumption of all the energy streams in an area. Thus key to a systematic approach for decision-making in the area of Energy Management. The present works use the following steps in carrying out electrical energy audit of sugar industry.

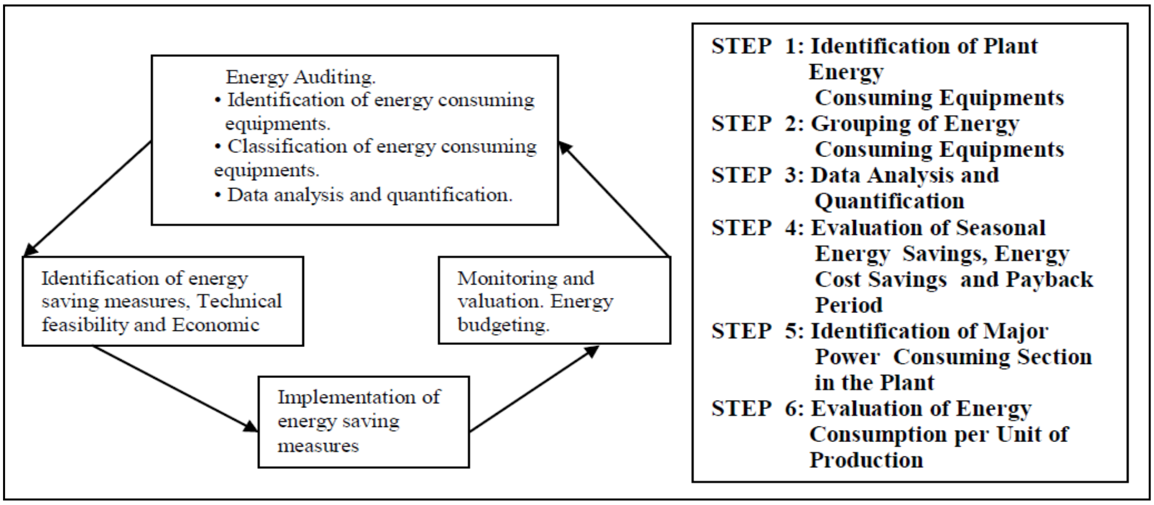

Figure 2: *Energy audit Methodology and steps in Energy audit*

Energy audit will help to generate energy utilization patterns and practices followed and best practices. Energy audit educates and gives greater awareness of energy usage to obtain better profit. Figure 2 outlines the energy audit methodology followed in the sugar industry.

4. Data Analysis and Quantification

The classification of motors in the plant with reference to rated capacity is done and Table 1 shows the same. The study on these groups is made. The actual power consumption and load factor of each group comprising the motors is calculated and analyzed in the following sections Group A motor represent nearly 99% of total capacity even though total motors are 23% of total motors in the system.

Table 1: *Grouping of Energy Consuming Equipments*

Group	Rating of the motor (KW)	Description	No of Motors
Group A	Above 40	Higher rating motor	44
Group B	20 to 40	Medium rating motor	16
Group C	Below 20	Smaller rating motor	128

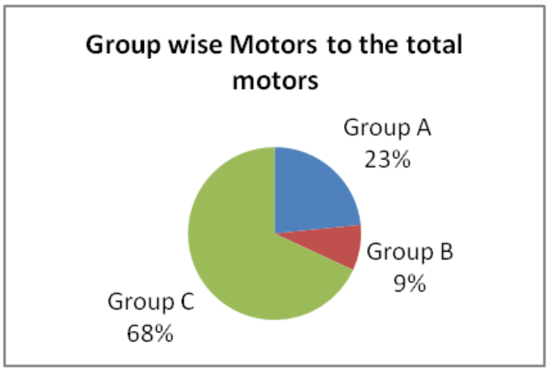

Figure 3: *Group wise Motors in the plant*

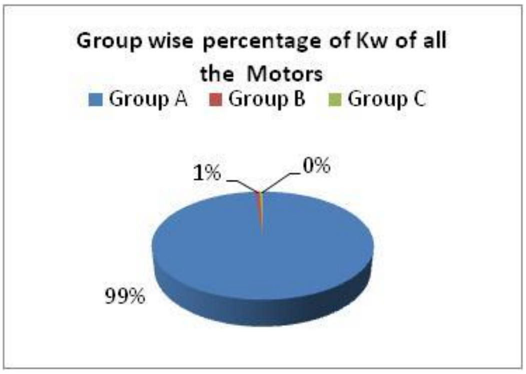

Figure 4: *Group wise Motors Load in the plant*

4.1 Group a motor Data Analysis and Quantification

The motor considered in the study is Clear Juice Pump Motor of 60 HP.

4.1.1 Per phase, total power and load factor

Clear Juice Pump Motor of 60 HP, its actual load current in R Y B phases are 49.8 amps, 50.6 amps and 49.0 amps respectively,

Power, P =VICOSΦ / 1000 KW

Where P = Power in KW, V = Voltage in volts

I = Phase current in amps, COSΦ = Power factor

Actual Power in R phase

P_r = ((415/√3) x 49.8 x0.8) / 1000

= 9.56 KW

Actual Power in Y phase

P_y = ((415/√3) x 50.6 x0.8) / 1000

= 9.71 KW

Actual Power in B phase

P_b = ((415/√3) x 49.0 x0.8) / 1000

= 9.40 KW

Total Actual Power Consumed by the motor

$P_{tot} = P_r + P_y + P_b = 9.56 + 9.71 + 9.40 = 28.68$ KW

% Load factor, L = Actual Power / Rated Power

= (28.68 / 44.76) x 100

= 64.09 %

Table 2: *Actual Power Consumption and Load Factor for Group 'A' Motors*

Sl. No.	Equipment	Rated kW	Rated HP	Actual kW	% Load Factor
1	Air Compressor motor	44.76	60	33.77	75.45
2	Cooling tower fan motor	55.95	75	40.32	72.06
3	Air compressor Motor	55.95	75	42.18	75.39
4	Continues C/F motor – 1	76.6	100	56.44	75.67
5	Continues C/F motor – 3	74.6	100	66.81	89.74
6	Continuous C/F motor – 5	74.69	100	65.45	87.74
7	Continuous C/F motor – 6	74.6	100	59.63	73.94
8	Aux CWP Motor	74.6	100	69.12	92.65
9	FD fan Motor – 2	89.52	120	69.12	77.21
10	Injection water pump motor-1	11.9	150	90.43	80.82
11	Injection water pump motor-2	11.9	150	108.86	97.28
12	Injection water pump motor-3	11.9	150	105.40	94.20
13	Injection water pump motor-4	11.39	150	88.70	79.27
14	Cooling tower pump motor -1	149.2	200	119.42	80.04
15	Cooling tower pump motor -2	149.2	200	122.68	82.23
16	Cooling tower pump motor -3	149.2	200	115.96	77.73
17	ID FAN Motor	246.18	330	209.28	85.01
18	Boiler feed water pump motor – 1	24618	330	209.66	85.17
19	Boiler feed water pump motor – 2	246.18	330	210.08	85.32

4.2 Group B motor Data Analysis and Quantification

All the motors of this group are considered and results are shown in the Table 3.

Table 3: *Actual Power Consumption and Load Factor for Group 'B' Motors*

Sl. No.	Equipments	Rated kW	Rated HP	Actual kW	%load Factor L
1	Aux feed water Pump motor -1	37.3	50	28.39	76.13
2	1st Mill Intercarrier Motor	29.84	40	20.9	69.36
3	2nd Mill inercarrier Motor	29.84	40	18.45	61.83
4	Unscreened juice pump motor – 2	29.84	40	23.50	79.78
5	Imtribution water pump motor	29.84	40	18.33	61.44
6	Bagasse blowing Motor-2	29.84	40	20.25	67.88
7	Slat conveyer sdc – 2 motor	22.38	30	14.66	65.54

4.3 Group C motor Data Analysis and Quantification

All the motors of this group are considered and results are shown in the Table 4.

Table 4: *Actual Power Consumption and Load Factor for Group 'C' Motors*

Sl. No.	Equipments	Rated kW	Rated HP	Actual kW	%load Factor L
1	Vertical crystallizer motor	14.92	20	11.92	79.91
2	'C' Mosciut pump motor	14.92	20	11.86	79.52
3	Feeder table pump – 1	11.19	15	10.32	92.31
4	Feeder table pump – 2	11.19	15	10.44	93.34
5	Pan cond water pump motor	9.32	12.5	6.85	73.50
6	Dry seed pump motor-1	7.46	10	6.87	92.09
7	Hot air blow motor (new)	5.59	7.5	4.35	77.89
8	Cold air blow motor (new)	5.59	7.5	4.32	77.21
9	Hot air blow motor (Old)	5.59	7.5	4.32	77.89
10	Cold air blow motor (old)	5.59	7.5	4.35	77.89
11	Heavy filtrate pump motor	3.73	5	3.39	90.88
12	Cake wash motor	3.73	5	2.70	72.57
13	Mud mixture motor	3.73	5	2.66	71.54
14	'B' pug mill motor	3.73	5	2.93	78.75
15	Melt tank stirrer motor	3.75	5	3.28	87.46
16	Make up water transfer pump motor	3.73	5	2.78	74.63
17	Make up water transfer pump motor	3.73	5	3.36	90.08
18	Vapour condensate transfer pump motor	3.73	5	2.85	76.40
19	Oil pump motor – 1	2.23	3	1.90	84.93
20	Oil pump motor – 2	2.23	3	1.95	87.50
21	Oil pump motor – 3	2.23	3	1.70	76.35
22	Oil pump motor – 4	2.23	3	2.13	95.22
23	RAV motor – 1	1.11	2	0.86	77.21
24	RAV motor – 2	1.11	2	0.96	85.79
25	RAV motor – 3	1.11	2	1.03	92.65

4.4 Evaluation of Seasonal Energy, Energy Cost Savings and Payback period

4.4.1 Sugar cane season and types of motors

Total duration of sugar cane crushing in a year is known as season. The duration in which there is no sugar cane crushing in a year is known as off-season. Here 220 days is considered as one season.

Standard Motor (SM): This type of motors are having considerable stray, stator and rotor losses with that will be low as compared with energy efficient motors.

Energy Efficient Motor (EEM): This type of motors is having considerably less losses due do to this, these motors are having more efficiency as compared with SM.

Table 5: *Nominal Efficiencies of Standard Motor and Energy Efficient Motor*

HP	SM	EEM
1	73	83
2	77	83
3	80	86
5	82	87
7.5	84	88
10	85	89
15	86	90
20	87.5	90.5
25	88	91.5
30	88.5	92
40	89.5	92.5
50	90	93
60	90.5	93
75	91	93.5
100	91.5	94
125	92	94
150	92.5	94.5
200	93	94.5
Above 200	93.5	95

Source: National Electrical motor Manufacturer's Association (NEMA).

4.4.1 Comparative study of Group 'A' Motors

A comparative study is performed in this section with standard motor and energy efficient motor from the available Table 5.

a) Calculations with Standard Motor

Energy consumption of standard motor/day,

E_{std} = HP x L x 0.746 x hr $(100/\eta_{std})$

=60 x 0.6401 x 0.746 x 24 (100/90.5)

= 759.68 KWh / day

= 759.68 x 220 = **1,67,129.60** KWh / season (units)

Cost of the energy consumption / season,

$C_{std} = E_{std}$ x 6.50

= 167129.60 x 6.50

= **10,86,342.40** Rs /season

b) Calculations with Energy Efficient motor;

Energy consumption of Energy Efficient motor/day,

E_{ee}= HP x L x 0.746 x hr (100/η_{ee})

= 60 x 0.6401 x 0.746 x 24 (100/93)

= 739.26 KWh / day

= 739.26 x 220 = **1,62,637.20** KWh / season (units)

Cost of the energy consumption / season,

$C_{ee} = E_{ee}$ x 6.50

= 162637.20 x 6.50

= **10,57,141.80** Rs /season

Total energy savings / season after the replacement of existing Standard Motor by Energy Efficient motor is as below,

$E_{tot} = E_{std} - E_{ee}$

= 167129.60 – 162637.20

= 4,492.40 KWh / season (units)

Total energy cost saved / season after replacement of Standard Motor by Energy Efficient motor is

$S_{tot} = E_{tot}$ x 6.50

= 4492.40 x 6.50

= **29,200.60** Rs / season

4.4.2 Payback period P_d calculation

P_d = Price of Motor / Seasonal amount savings

= 175204 / 29200.60

= **6** Seasons, it means payback period will be within 6 seasons.

Table 6: *Results and comparison for Group 'A' Motor*

Sl. No.	Equipment	HP	Load factor 'L'	Energy consumption per season (Kwh / season)	Cost of the energy consumption in Rs / season	Energy Savings per season ,E_{toi}(Kwh / season)	Cost of the energy Saved, Stot (Rs/Season)	Percentage savings
1	Standard Motor	60	64.04	1,67,129.6	10,86,342.4	4,492.4	29200.60	2.69
2	Energy Efficient Motor	60	64.04	1,62,637.2	10,57,141.8			

With these results graphs are obtained and are shown in Figure 5 and 6.

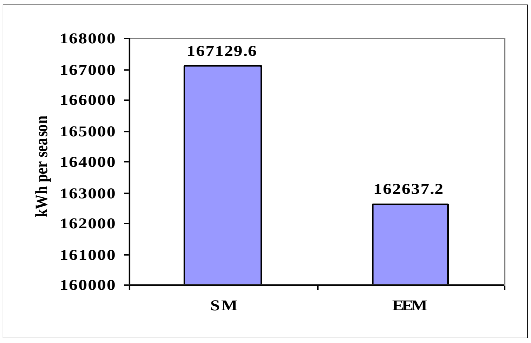

Figure 5: *Group A Motors comparative Analysis*

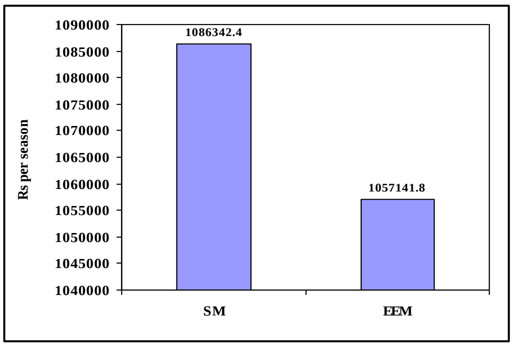

Figure 6: *Group A Motors cost Comparison*

With this it can be concluded that in group A if existing standards motors(SM) are replaced by the energy efficient motors(EEM) the total energy about 3,38,482 KWh/season (units) and total energy cost about Rs. 22,00,130.00 can be achieved.

4.4.3 Calculations related to Group 'B' Motors

A comparative study is performed in this section with standard motor and energy efficient motor from the available Table 5.

Table 7: *Results and comparison for Group 'B' Motor*

Sl. No	Equipment	HP	Load factor 'L'	Energy consumption per season in Kwh / season	Cost of the energy consumption in Rs / season	Energy Savings per season ,E_{tot}, in Kwh / season	Cost of the energy Saved , Stot,in Rs/Season	Percentage savings
1	Standard Motor	50	37.06	81,096.4	5,27,126.6	2,615.8	17,002.7	3.22
2	Energy Efficient Motor	50	37.06	78,480.6	5,10,123.9			

With above results the graphs are obtained and are shown below.

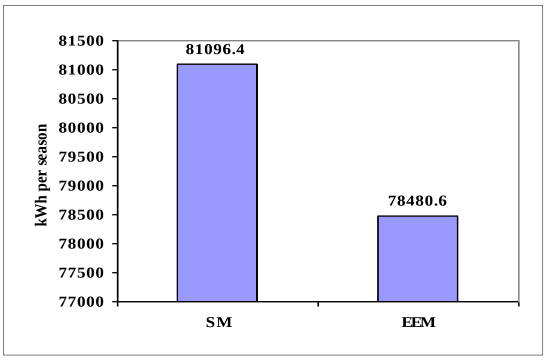

Figure 7: *Group B Motors comparative analysis*

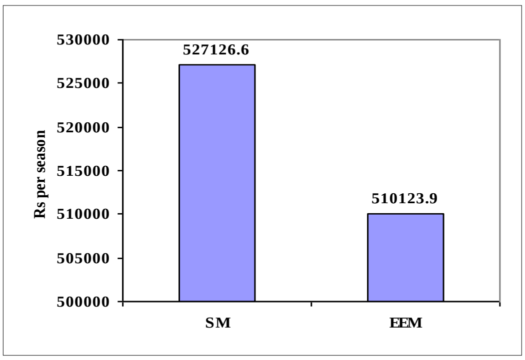

Figure 8: *Group B Motors cost Comparison*

With this it can be concluded that in group B motor, if existing standard motors(SM) are replaced by the energy efficient motors (EEM), the total energy about 56,912 KWh/season (units) and total energy cost about Rs. 36,930.00 can be achieved.

4.4.4. Calculations related to Group 'C' Motors

A comparative study is performed in this section with standard motor and energy efficient motor from the available Table 5 and graphs are obtained and are shown in Figure 9 and 10.

Table 8: *Results and comparison for Group 'C' Motor*

Sl. No.	Equipment	HP	Load factor 'L'	Energy consumption per season in Kwh / season	Cost of the energy consumption in Rs / season	Total Energy Savings per season, E_{tot}, kWh/Season	Cost of the energy Saved, Stot,in Rs/Season	Percentage savings
1	Standard Motor	20	79.91	71,942.2	4,67,624	2382.6	15,486.9	3.31
2	Energy Efficient Motor	20	79.91	69,559.6	4,52,137			

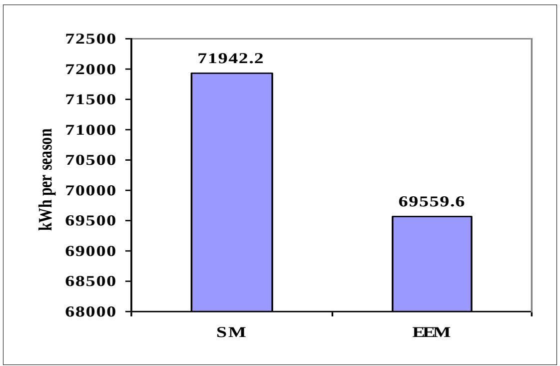

Figure 9: *Group C Motors comparative analysis*

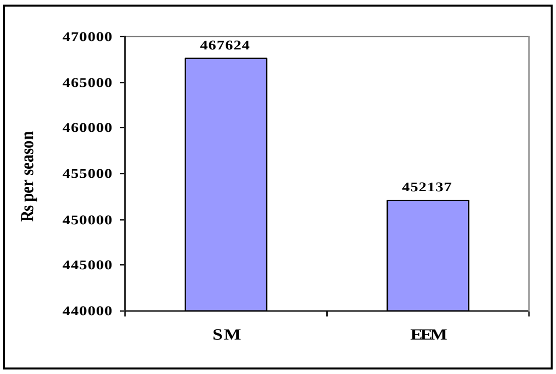

Figure 10: *Group C Motors Cost comparison*

With this it can be concluded that for group C motor if existing standards motors (SM) are replaced by the energy efficient motors (EEM) the total energy about 1,36,359 KWh/season (units) and total energy cost about Rs. 8,86,336.00 can be achieved. For entire plant energy consumption comparison with standard motor and energy efficient motor is given in the Table 9.

Table 9: *Energy consumption comparison with standard and energy efficient Motors*

Si No	Group	Energy consumption/season with standard motor (kWh/season)	Energy consumption/season with energy efficient motor (kWh/season)	Energy savings per season (kWh/season)	% Energy saving
1	A	1,68,17,064	1,64,78,582	3,38,482	2.01
2	B	15,46,248	14,89,336	56,912	3.68
3	C	24,94,853	23,58,494	1,36,359	5.46

From the Table 9 it can be concluded that energy efficient motors (EEM) can save the average energy nearly 3.75% as compared to existing standard motors (SM).

4.5 Section wise Power Consumption and Production in the Plant

Motor Control Centers (MCC) and the total power consumed by each section for a day are given in Table 10 to 13.

Table 10: *Power House*

Sl. No	MCC	Avg Load Current (Amps)
1	Co gen MCC- I	196.30
2	BLR – 1, MCC – I	1003.33
3	BLR – 2, MCC – II	979.83
4	BGS Handling MCC	195.70
5	Co-gen AUX MCC	3395.40
6	TG – 2, MCC	27.80
7	TG – 3, MCC	24.27
Total		2766.63
Total Power Consumed (kW)		1590.88

Table 11: *Mill House*

Sl. No	MCC	Avg Load Current (Amps)
1	MCC – 4	599.37
2	MCC- 5	439.40
3	Fibrizer Motor – I	51.00
4	Fibrizer Motor – II	53.00
5	Pump House	0.700
6	DC Motor – I	452.00
7	DC Motor – II	560.00
8	DC Motor – III	480.00
9	DC Motor – IV	511.00
Total Current		3152.77
Total Power Consumed (kW)		3611.12

Table 12: *Boiling House*

Sl. No	MCC	Avg Load Current (Amps)
1	MCC – 6	274.87
2	MCC- 7	85.60
3	MCC – 8	436.13
4	MCC- 9	344.93
5	MCC- 14	195.43
Total		1336.97
Total Power Consumed (KW)		768.79
Lighting Power Consumed (kW)		100.43

Table 13: *Sugar House*

Sl. No	MCC	Avg Load Current (Amps)
1	MCC – 10	265.83
2	MCC- 11	157.37
3	MCC – 12	351.83
4	MCC- 13	278.90
5	MCC- 15	192.23
6	DC Motor – I	MCC- 16
7	DC Motor – II	MCC- 17
8	C/F Motor	615.00X4
Total Current		4823.50
Total Power Consumed (kW)		1999.07

Table 14: *Power Consumption in various sections in the Plant*

Power house (kW)	Mill house (kW)	Boiling house (kW)	Sugar house (kW)	Lighting Power Consumed (kW)	Total Power Consumed (kW)
1590.88 (19.71%)	3611.12 (44.75%)	768.79 (9.53%)	1999.07 (24.77%)	100.43 (1.24%)	8070.29

Table 14 section wise consumption is plotted as in Figure 11. From the Figure 11 it can be concluded that mill house is the major power consuming section in the plant.

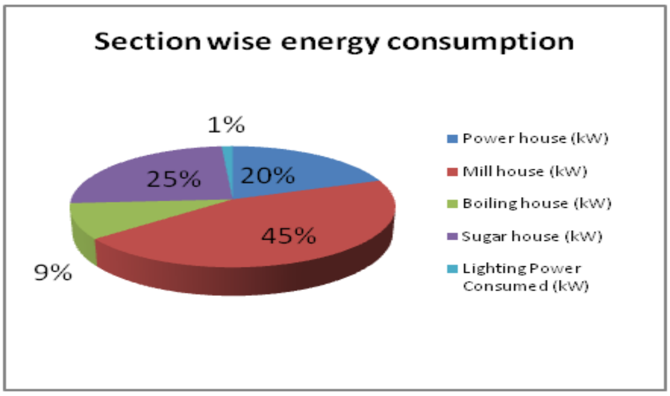

Figure 11: *Section wise Power consumption in the Plant on a specific observation*

4.6 Energy Consumptions per Unit of Production

Table 15 gives the production details in the plant. Production in mill house, boiling house, sugar house and power house per day referred from energy data log book of the plant.

Table 15: *Production details in the plant*

Sl. No.	Product	Quantity
1	Cane crushing (tons /Day)	5310
2	Baggasse (Tons /day)	1596
3	Juice (Tons/day)	3714
4	Sugar (Qtls/Day)	6796
5	Molasses (Tons/Day)	174
6	Power (KWh/Day)	339000
7	Steam (Tons/day)	2526

Table 16: *Energy consumption per unit production*

Process	Product	Quantity (Tons/day)	Demand with existing SM (kWh / day)	Demand per unit Product with existing SM (kWh / Ton)	Demand with existing EEM (kWh / day)	Demand per unit Product with existing EEM (kWh / Ton)	Demand Saved (kWh/Ton)	% Saved
Power house	Steam	2526	38181.12	15.11	36749.33	14.55	0.56	3.70
Mill house	Bagasse	596	86666.88	16.32	83416.88	15.70	0.62	3.80
	Juice	3714						
Boiling house and Sugar house	Sugar	679.6	66428.64	77.82	74.90	74.90	2.92	3.75
	Molasses	174						

Table 16 gives the information about energy consumption per unit production and Figure 12 shows the same.

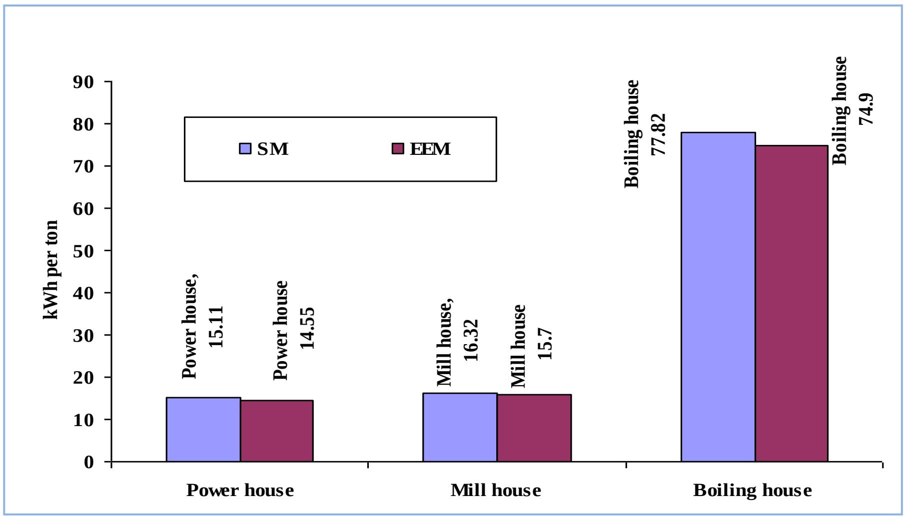

Figure 12: *Energy Consumptions per Unit of Production Comparison*

From Table16 it can be concluded that if existing standard motor (SM) are replaced by energy efficient motor (EEM), energy consumption per unit production can be reduced by average 1.36 KWh / ton and average 3.75 % power consumption with that of existing standard motor (SM).

5. Recommendations

After studying the entire energy audit of the plant it is observed that mill house section is the major energy consuming section in the whole plant. Therefore it is necessary to take energy conservation measures in this section as well as in Power house.

Following are the major recommendations made for Energy conservation in electrical system in the plant.

- Power factor improvement in fribrizer machines HT motors.
- By installation of VFD to feeder table dyno drive motors.
- By installation of VFD to cane carrier motor.
- By installation of VFD to boiler feed water transfer pump motor.
- By installation of VFD to boiler feed water pump motors.
- Automatic shut down of motors which are idle or not in use
- Switch off one of the standby/parallel motors if not required
- Switch off the cooling pump motors if not required

6. Conclusions

The Energy Audit study carried out is an extensive survey of energy in the plant and how the energy is utilized in the plant. Based on the data analysis and quantification it brings out the energy conservation opportunities in the plant and reduces the power wastage more effectively. The work provides the guidelines to the efficient use of power in the plant. The study reveals that the mill house section is a major energy consuming section in the plant. By implementing energy conservation measures like replacing selected exiting standard motors by energy efficient motors a greater seasonal energy saving can be achieved and is justified. As the scope for future work a thermal energy audit can be conducted to arrest the wastage of thermal energy in plant. This is due to the fact that thermal energy leakages cause additional electrical energy consumption and wastage.

Acknowledgments

The authors heartily thank and acknowledge the support of Ms Prabhulingeshwar Sugars and Chemicals Ltd., for providing favorable work environment, data and study materials during the work.

REFERENCES

Balrampur chini mills Limited Company presentation, December 2015. www.chini.com/BCML_Q3_FY2016_Results_Presentation.pdf

Dr G S C Rao, Indian Sugar Industry At A Glance, What To be Learned from Indian Sugar Industry, 3rd India Sugar expo presentation. http://www.staionline.org/pdf/latest%203rd%20India%20Sugar%20Expo%20Presentations.pdf.

Energy Statistics 2016. Ministry of statistics and program implementation government of India. www.mospi.gov.in/sites/default/files/publication_reports/Energy_statistics_2016.pdf

Mallikarjun G Hudedmani,Vishwanath M Soppimath. Energy Audit: an initiative to energy conservation. Discovery, 2015, 38 (173), 46-51. https://discoveryjournals.com/discovery/current_issue/v38/n173/A2.pdf

Mallikarjun.G. Hudedmani, Vishwanath M. Soppimath and S.N.Mathad, Impacts Of Energy Generation On Environment, International Journal Of Electrical & Electronics Engineers Volume 8 (1), 111-118, http://www.arresearchpublication.com/images/shortpdf/1452848031_228I.pdf

Mukund Bapat, Power Factor Improvement And Energy Conservation Through Use Of Intelligent Power Factor Controller, GM, Business Development Conzerv Systems Pvt Ltd.,http://documentslide.com/documents/power-factor-improvement-and-energy-conservation.html

Prabhulingeshwar Sugars and Chemicals Ltd, http://prabhusugar.com

Premium Efficiency Motor Selection And Application Guide, A Handbook for Industry, U.S. department of Energy, Energy efficiency and Renewable energy, Advanced Manufacturing. Office.. https://www.energy.gov/sites/prod/files/2014/04/f15/amo_motors_handbook_web.pdf

Radha Charan et al., Optimized Energy Efficient Solution With Stand Alone Pv System, MATTER: International Journal of Science and Technology, ISSN 2454-5880, Special Issue Volume 3 Issue 1, pp. 16 -27. DOI-https://dx.doi.org/10.20319/Mijst.2017.31.1627

Soltan and Thorman, Building Energy Systems Operation Optimization With Ice Storage – A Real Time Approach, MATTER: International Journal of Science and

Technology, ISSN 2454-5880, Special Issue Volume 3 Issue 1, pp. 28- 44 *DOI-* https://dx.doi.org/10.20319/Mijst.2017.31.2844

Sugar Expertise, Indian Sugar Policy: Government role in production expansion and transition from importer to exporter Prepared By Antoine Meriot, Sugar Expertise LLC, for the American Sugar Alliance (ASA), August 2016. https://sugaralliance.org/wp-content/uploads/2013/10/Meriot-India-8-16.pdf

The Effect of Repair/Rewinding on Motor Efficiency, EASA/AEMT Rewind study and Good practice Guide to maintain Motor Efficiency. https://www.scribd.com/document/290868988/The-Effect-of-Repair-Rewinding-on-Motor-Efficiency-EASA-AEMT

The Indian Sugar Industry Sector Roadmap 2017, June 2007, KPMG in India. www.in.kpmg.com/pdf/indian_sugar_industry.pdf

Vision 2030, Compilation & Editing : S.K. Duttamajumder, A.K. Sharma, Brahm Prakash , Published by Dr. R.L. Yadav, Indian Institute of Sugarcane Research Lucknow - 226 002. www.iisr.nic.in/IISRVision2030.pdf