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An unexplored sector for Energy Conservation - MSME of India

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Abstract

The International Energy Outlook 2021 forecasts that India will have the fastest growing rate of energy consumption globally through 2050. The major consumer of energy in India is the Industrial sector. The Micro Small and Medium Enterprises contribute to 33.4% output of the manufacturing sector and are not mandated for regular energy audits like Large Scale industries by Bureau of Energy Efficiency and hence, Energy Conservation in MSME becomes paramount. The importance of energy conservation in MSMEs is emphasized in our study. This research paper contains a case study done in small scale corrugated boxes manufacturing unit. The energy audit involved collection and analysis of the process and equipment data, energy bills data and electrical measurements data in order to identify major energy consumers in the plant area. The study then evaluated and quantified the possible reduction in energy consumption. Based on the evaluation, various suitable Energy Conservation measures and techniques are suggested to achieve the energy savings. The recommendations suggested could save around Rs. 132,343 annually. The annual energy cost savings are approximately 15.44% of the annual energy costs of the facility. The estimated implementation cost comes to Rs. 38,200 with an average simple payback period of around 4 months. This study strongly supports the estimated energy savings of 15% by BEE in MSMEs and concludes that there is a huge untapped energy conservation potential of 3.3 metric tonnes of oil equivalent or 38 GWh of electricity or 19,000 Crore Rupees (at energy rate of Rs.5/unit) per annum in this sector.

Keywords: *ECM measures; Energy Audit; Energy Conservation; Energy Savings; Energy Efficiency.*

1. Introduction

The International Energy Outlook 2021 forecasts that India will have the fastest growing rate of energy consumption globally through 2050 (IEO, 2021). Efficient use of Energy has become paramount for any developing country. This energy crisis can be addressed to some extent through saving energy by using energy efficient equipment (R. K. Gera yunus Parvej et. al., 2013). The micro, small, and medium enterprises (MSMEs) sector in India is heterogeneous in terms of products manufactured, firm size, processes and technological advancement, and volume and types of output. There are around 63.4 million units of MSMEs in the country which contribute about 6.11% of the national GDP in manufacturing and 24.63% of the GDP in service sector. MSMEs amount to 33.4% of India's manufacturing output (CII, 2022). MSME is the largest employer after agriculture employing more than 120 million people. Although the energy saving potential is immense in this sector which BEE intends to unlock, there are quite a challenge faced by Indian MSME entrepreneurs which are

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risk averseness, cumbersome documentation and lack of awareness/ motivation [1, 2]. This paper discusses a case study of energy saving potential in one of the MSME's through Energy Auditing. The major benefits a MSME can get by conducting energy audit are optimise the energy consumption and cut down energy related expenditure, reduce overall operating cost of the enterprise and prevent wastage of energy resources. This study involves energy auditing in a MSME providing recommendations to reduce energy consumption with potential cost savings if the recommendations are implemented [3].

2. Literature Survey

Research work done in the field of energy auditing which have rendered resourceful for our research is discussed below [4-10].

- The Energy and Resources Institute of Industrial Energy Efficiency Division of India has conducted a study (ERI, 2022) for Benchmarking and mapping Indian MSMEs energy consumption. The study provides the total aggregated energy consumption of 36 clusters including 4 sub-sectors at national level. The analysis shows that the majority of the MSME clusters use conventional and inefficient technologies and practices. The study identifies various sector-specific technologies (SST) and cross-cutting technologies (CCT) that would help in improving the Energy Efficiency considerably.

- Vyas Pareshkumar A and Bhale Purnanad V, in their research titled 'Experimental Investigation on Energy Efficiency of Electrical Utilities in Process Industries through Standard Energy Conservation' has focused on the energy uses and energy conservation opportunities for a process industry (Vyas P et al., 2013). The research paper consists of a brief description of MSME and energy consumption analysis. The paper provided deep insight on Energy auditing methodology, energy conservation analysis at micro scale processing industry and comparative study of systems before and after energy conservation measures were implemented.

- Ashwini B Bobade and M.G Walecha in their research paper titled 'Energy Audit in Small Scale Industry- A Review' provides a basic understanding about energy audit process in small scale industries and ways to improve energy efficiency (Ashwini B et.al., 2018). The study stresses on the current energy crisis and the lack of effective energy conservation practices in various industries in India. The authors throw light on the factors that forms the key decisive elements in selecting the energy audit methodology.

- R. H. Yadav describes that his study is to provide resources and methods to reduce energy use and energy related costs in dairy processing facilities (R. H. Yadav et. al. 2016). Using this study, dairy processing facility managers will learn how to manage energy in their facility and uncover opportunities to significantly reduce facility energy consumption. Energy audit is one of the most comprehensive methods to attain energy savings by dropping unnecessary energy consumption.

- D.A. Chaudhary, J.B. Upadhyay and Vivek Koshta describes electrical energy conservation in dairy industry. The focus point include use of the Soft starter to reduce starting current rushes and that can increase life span of compressor in the refrigeration plant; Variable frequency drive (VFD) to reduce maintenance and repair costs, and extend the life of the motor and the driven equipment; installing high efficiency motors that can reduce energy use, as pumps and aeration systems can contribute for 50-90% of the total energy consumption; capacitor can be connected across large motors to maintain healthy P.F. (between 0.9 to 0.98) correction. The improvement in load factor

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will help in accommodating more loads (D.A. Chaudhary et. al, 2014).

- Swapnil Ratnakar Mane tries to find the opportunity available in an industry to use its resources in a proper manner by energy management. The in-depth analysis of a dairy industry has been discussed (Swapnil Ratnakar Mane 2013). Soma Bhattacharya and Maureen L. Cropper have compared initiatives of energy efficiency in India with other countries and discussed about options and barriers of adopting energy efficiency in India (Soma Bhattacharya et. al. 2010). Biswajit Biswas, Aritra Ghosh and Sujoy Mukherjee, have discussed about a case study in an institution where energy savings is achieved by changing campus lighting (Biswajit Biswas et, al., 2013). Kongara Ajay, T.Guru Krishna, G.Sudhakar and K. Sasank, have dealt with energy audit technique for household application (Kongara Ajay et. al., 2014).

- Gousia Sultana and Harsha. H.U have discussed about the electrical energy audit methodology and its implementation in an institute (Gousia Sultana et. al., 2015).

The above discussed papers have looked at the overall energy consumption and conservation in industries and the current research is looking at the energy conservation in a MSME in depth with a case study.

3. Company General Information

To understand how the small-scale industries are run and whether sufficient measures are taken towards energy conservation, a pilot study is conducted in a company that manufactures corrugated boxes. The company considered under this study is located in Mysuru and manufactures a wide range of Corrugated Boxes. The work schedule of administrative office and production facility is 8 hours per day, 5 days a week and 50 weeks in a year that translates into 2,000 working hours in a year. The major energy consuming equipment identified during the energy audit process are tabulated in Table 1 [11, 12]. Table 2 shows the data from the electricity bills collected from the company and calculation of energy rates [13].

Table 1 Major Energy-Consuming Equipment

On site Equipment	Quantity	Rating in hp
Air Compressor	1	15
Fluting, pasting &	2	25
Conveyor motor	1	60
Die cutter & slotting m/c	2	10
Printing machine	1	5
Waste cutter	1	2
Reciprocating	1	15
Boiler induced draft	1	10
Boiler	1	3,000 kg

4. Energy Audit Methodology

Energy audit involves the following steps,

Step 1: Collect energy consumption data from energy bills, specific energy capacity data of the equipment used in the building and any other relevant information.

Step 2: Measure the energy consumption of all the machines and equipment using relevant measuring instruments.

Step 3: Calculate the energy consumption of machines and other equipment and analyse the results obtained.

Step 4: Identify the Energy Conservation Measures (ECMs) for the energy equipment and facilities and calculate the energy and cost savings.

Step 5: Device implementation plan of ECMs to reduce energy consumption and check for their feasibility. If feasible, calculate the payback period based on implementation cost and recommend their implementation plan to the company administration [14-17].

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Table 2 Tabulation of the Facility Electricity Bill for the Fiscal Year 2019-20

Month	Demand in kVA	Energy in kWH	Apparent energy in kVAH	Power factor	Demand cost[a]	Energy cost	PF surcharge	Interest charges	Other charges	Total charges	Tax	Total
Feb 20	71.18	6,825	8,408	0.81	19,740	47,433.75	1,842.75	335	614.25	69,965.75	4,269.04	74,234.79
Jan 20	75.6	7,223	8,873	0.81	19,740	50,199.85	1,950.21	330	650.07	72,870.13	4,517.99	77,388.12
Dec 19	69.53	6,368	7,875	0.81	19,740	44,257.60	1,719.36	365	573.12	66,655.08	3,983.18	70,638.26
Nov 19	65.7	6,570	8,175	0.8	19,740	45,661.50	1,971.00	303	1,116.90	68,792.40	4,109.54	72,901.94
Oct 19	66.68	5,393	6,795	0.79	19,740	37,481.35	1,779.69	650	1,994.81	61,645.85	3,373.32	65,019.17
Sep 19	66.45	6,038	7,485	0.81	19,740	41,964.10	1,630.26	307	1,026.46	64,667.82	3,776.77	68,444.59
Aug 19	71.18	6,825	8,408	0.81	19,740	47,433.75	1,842.75	335	614.25	69,965.75	4,269.04	74,234.79
Jul 19	75.6	7,223	8,873	0.81	19,740	50,199.85	1,950.21	330	650.07	72,870.13	4,517.99	77,388.12
Jun 19	69.53	6,368	7,875	0.81	19,740	44,257.60	1,719.36	365	573.12	66,655.08	3,983.18	70,638.26
May 19	65.7	6,570	8,175	0.8	19,740	45,661.50	1,971.00	303	1,116.90	68,792.40	4,109.54	72,901.94
Apr 19	66.68	5,393	6,795	0.79	19,740	37,481.35	1,779.69	650	1,994.81	61,645.85	3,373.32	65,019.17
Mar 19	66.45	6,038	7,485	0.81	19,740	41,964.10	1,630.26	307	1,026.46	64,667.82	3,776.77	68,444.59
	69.19	**76,834**	**95,222**	**0.805**	**2,36,880**	**5,33,996.30**	**21,786.54**	**4,580**	**11,951.22**	**8,09,194.86**	**48,059.68**	**8,57,253.74**

[a]If the metered demand is less than 85% of the contract demand, then demand charges are charged for 85% of the contract demand of 110 kVA, i.e., 0.85 x 110 = 94 kVA
Demand cost = 94 x Rs. 210 = Rs. 19,740 / month
Energy Cost per kWh = (Energy cost + PF Surcharge + Other charges) x (1+Tax %) / Total kWh
= (5,33,996.30 + 21,786.54 + 11,951.22) x (1+0.059392)/ 76,834 = Rs 7.83 / kWh

5. Results and Discussion

Recommendation 1: Reduce the contract demand from 110 kVA to 90 kVA

Currently, the company incorporates a low-tension power line for its operations with maximum demand provision for an LT connection of 110kVA. However, the company electricity bills show that the highest recorded demand as 75.6 kVA in the month of January and is shown in annual energy expenditure bill in Table 1. Now, since the highest recorded demand is just 75.6 kVA which is way below the purchased contract demand, lowering of

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contract demand to 90 kVA is proposed with a buffer of 15 kVA for any unforeseen demand increase. Based on the given parameters and the current contract demand, the monthly and yearly energy cost is calculated as shown below.

Calculations:
Given Demand Rate = Rs. 210 per month
Anticipated savings:
By reducing the Contract demand to 90kVA, monthly 20 kVA will be saved and 240 kVA yearly.
Calculations:
Demand cost per kVA = Rs.210/-.
Existing Contract Demand = 110 kVA.
Proposed Contract Demand = 90 kVA.
Difference in contract demand = (110 kVA - 90 kVA) x 0.85* = 17 kVA
(*only 85% of contracted demand is charged if the metered demand is below it)
Annual savings = 17 kVA × Rs. 210 × 12 months = Rs. 42,840
The calculations show an annual cost saving of Rs. 42,840/-
Approximate cost for paper work to change the contract demand = Rs. 4,000

Payback period = $\frac{Investment}{Savings} \times 12$ = (4,000/42,840) × 12 = 1.12 months
The pay-back period is calculated to be less than 2 months.

Recommendation 2: Replace drive belts on motors with Energy efficient Cog belts

Currently, facility employs motors that are driven by standard V-belts to transmit power which results in energy loss due to slippage. To overcome the problem of energy losses due to slippage, it is advisable to replace the standard V-belts with the cogged belts as shown in Figure 1. Belt replacement is done only for the motors whose horsepower (hp) rating is greater than or equal to 2 hp.

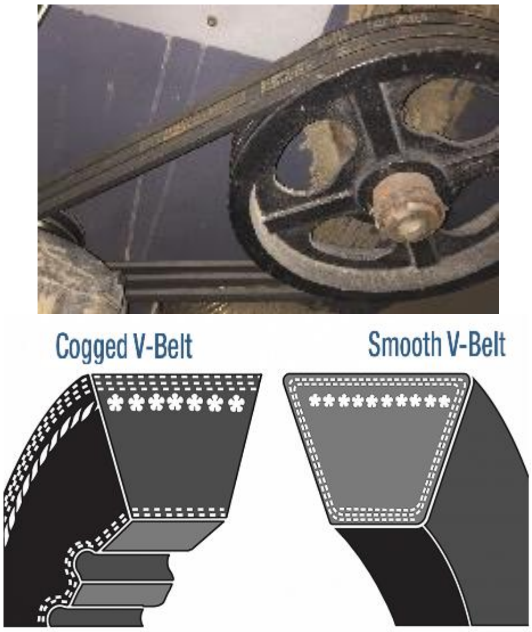

Figure 1 V-Belts used in the Facility and Cogged V Belts and Standard V Belts

Studies (Michael Brown, 1986) show that standard V-belts have a maximum efficiency of around 92%. On the other hand, cog belts reduce losses due to slippage and improve efficiency by 2% - 8%. For our calculations, we chose a median value of 5% increase in efficiency. We assume the average power requirement to be same even with the use of cog belt with efficiency of 97%. This results in lower load factor for the motor which is estimated below:

$HP \times \eta^{I} \times LF^{I} = HP \times \eta^{O} \times LF^{O} \rightarrow LF^{O} = LF^{I} \times (\eta^{I}/\eta^{O})$

Where,
HP =horsepower of the motors
η^{I}= Transmission efficiency of V belts = 92%
η^{O} = Transmission efficiency of cog belts = 97%
LF^{I} = load factor of the motor with V belts in % (estimated values given in the table)
LF^{O} = load factor of the motor with cog belt in %

The Current Energy Usage (CEU) and Proposed Energy Usage (PEU) for fluting machine (1st motor) in the Table 4 is calculated below

$$CEU = C \times N \times HP \times \frac{LF^{I}}{EFF^{I}} \times UF \times OH$$

$$PEU = C \times N \times HP \times \frac{LF^{O}}{EFF^{O}} \times UF \times OH$$

Where,

C = 0.746 kW / hp

N = number of motors

EFF^I = motor efficiency with current load factor in %

EFF^O = motor efficiency with new load factor in %

UF = average usage factor in % (estimated values given in the table)

OH = annual operating hours per year

New Load Factor for various machines is as shown below, Calculating Current Energy Usage (CEU), Proposed Energy Usage (PEU), Energy Saved and Cost of Energy Saved: $LF^O = LF^I \times (\eta^I/\eta^O) = 0.4 \times (0.92/0.97) = 0.38$

The new Load Factor (LF^O) after replacing standard V-belt with cog belt in fluting machine is found to be 0.38

i. CEU = 0.746 × 2 × 25 × (0.4/0.831) × 0.4 × 2000 = 14,364 kWh
   Current Energy Usage (CEU) for fluting machine is found to be 14,364 kWh
ii. PEU = 0.746 × 2 × 25 × (0.38/0.822) × 0.4 × 2000 = 13,795 kWh
   Proposed Energy Consumption (PEU) for fluting machine is found to be 13,795 kWh
iii. Energy Savings = CEU – PEU = 14,364 – 13,795 = 569 kWh
   Annual Energy Savings by replacing standard V-belt with Cog belt in the fluting machine is found to be 569 kWh
iv. Annual Energy Cost Savings = 569 kWh x Rs. 7.83/ kWh = 569 × 7.83 = Rs. 4,455/year
   Annual Energy Cost saving by replacing standard V-belt with Cog belt in the fluting machine is found to be Rs. 4,284/-.

Similarly, the total annual energy cost savings from all the motors in Table 3 is Rs. 16,019 /yr. The Cog belts are more expensive than V-belts. They cost 30% more than V-belts but they are 50% more durable than V-belts. Therefore, the higher purchase cost is compensated by the greater durability and hence this recommendation has immediate payback.

Recommendation 3: Install a Capacitor Bank to Lower the Energy Cost

Background: Power factor quantifies the reaction of alternating current (AC) electricity to various types of electrical loads. Inductive or capacitive loads cause the voltage and current to shift out of phase (Figure 2). Electrical utilities must then supply additional power, measured in kilovolt-amps (kVA), to compensate for phase shifting. Therefore, many plants try to achieve a power factor of 85% to 95% to reduce demand costs, penalty costs, reduce line losses and allow electrical equipment to run cooler.

Table 3 CEU, PEU, Energy and Cost Savings for replacing V-Belts with Cogged Belts

Motor type	#	V-belts Yes / No	Motor Size (kW)	Motor Size HP	Total Motor HP	LF^I (%)	LF^O (%)	UF (%)	EFF^I (%)	EFF^O (%)	CEU	PEU	Operating hours (Hr/yr)	Energy Saved (kWh)	Energy Cost Savings (Rs/yr)
Fluting,	2	Y	18.5	25	50	0.4	0.3	0.4	0.83	0.82	14,36	13,79	2,000	569	4,455
Convey	1	Y	45	60	60	0.4	0.4	0.4	0.91	0.91	17,63	16,88	2,000	747	5,846
Die	2	Y	7.5	10	20	0.4	0.4	0.5	0.80	0.79	8,372	8,070	2,000	302	2,362
Printin	1	Y	4	5	5	0.4	0.3	0.4	0.79	0.78	1,505	1,441	2,000	64	504
Waste	1	Y	1.5	2	2	0.4	0.4	0.5	0.71	0.71	934	904	2,000	30	236
Recp,	1	Y	11	15	15	0.4	0.4	0.5	0.86	0.85	5,821	5,608	2,000	213	1,670
Boiler	1	Y	7.5	10	10	0.4	0.4	0.4	0.80	0.79	3,349	3,228	2,000	121	945
Total											**51,975**	**49,928**		**2,046**	**16,019**

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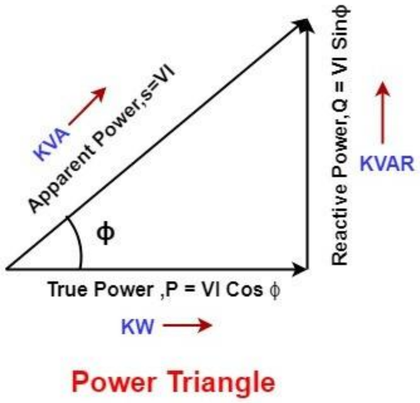

Figure 2 Power Components Relationship

Currently, the average power factor (PF) in the company between March 2019 and February 2020 is found to be around 0.81. It is possible to reach a PF of more than 0.95 without adverse effects by using capacitor banks to increase the mean power factor and thus decrease the kVA usage.

For example, the energy cost savings for the month of February 2020 are calculated as shown below,

- Amount of electric power consumed in the month of February 2020 = 6,825 kWh
- Demand used = 71.18 kVA
- Power factor = 0.81

Rate of Power Consumption for the month of February 2020 = Demand used × Power Factor = 71.18 × 0.81 = 57.66 kW

Rate of Power Consumption for the month of February 2020 is found to be 57.66 kW

Reactive Power supply = $Tan\ (Cos^{-1}(PF)) \times kW = Tan\left(Cos^{-1}(0.81)\right) \times 57.66$ = 41.74 kVAR

Calculation of Usage Charges:

For PF of 0.81, penalizing constant (PC) is 0.27

Power Factor Surcharge = Power consumption for the month x PC
= 6,825 x 0.27 = Rs. 1,842.75

Rate of Power Consumption for the month of February 2020 = 57.66 kW

Reactive Power Component after installing Capacitor Bank of 30 kVAR capacity as proposed
= 41.74 - 30 = 11.74 kVAR

Power factor achievable using Capacitor Bank= $Cos\ \{tan^{-1}(\frac{Proposed\ KVAR}{KW\ used})\}$
= Cos {tan-1(11.74/57.66)} ≅ 0.9997

Power Factor achievable by using a Capacitor Bank ≅ 0.99

Apparent Power consumption with both active and reactive component can be calculated using the formula,

$$Apparent\ Power\ = \frac{Actual\ Power}{Power\ Factor} = \frac{57.66}{0.99} =$$
57.67 kVA

Apparent Power consumption (with both active and reactive component) for the month of February 2020 is found to be 57.67 kVA

For Power Factor of 0.99 the value of the penalizing constant (PC) is 0.

Power Factor Surcharge for the month of February 2020 if the Capacitor Bank is installed as proposed is Rs. 0

Energy cost savings = Present PF surcharge cost – PF Surcharge cost reduction by installing Capacitor Bank = 1,842.75 - 0.0
= Rs. 1,842.75/-

Hence, the energy cost savings achievable by improving the power factor for February 2020 is Rs. 1,842.75/-. Similarly, for the fiscal year 2019-2020 the total savings that can be achieved from correcting the power factor is Rs. 21,787.

The implementation cost for the capacitor bank is approximately Rs. 1,000 per unit of kVAR correction. The Implementation cost is calculated as shown below,

Capacitor installation cost = Rs. 1,000/kVAR × 30 kVAR = Rs. 30,000

$$Payback\ Period = \frac{Investment}{Savings}\ x\ 12\ months$$

$$= \frac{30{,}000}{21{,}786.54}\ \text{x 12 = 16.52 months} \cong \text{17 months}$$

Recommendation 4: Switch off the boiler during non-working hours

The study advices the Company to switch off the Boiler for half an hour during the lunch break if possible to achieve the same throughput. Turning off the boiler will reduce the energy consumption, decreases the radiation heat losses and improves

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the life of the boiler.

The company has a single firewood fueled boiler of maximum rated steam capacity of 3,000 kg/hr.

Calculations:

Monthly average tonnage of firewood consumed = 30 ton/month.

Daily Consumption of firewood = 30,000/20 = 1,500 Kg/day (20 working days in a month)

Hourly Consumption of firewood = 1,500/8 = 187.5 Kg/hr (8 working hours daily)

Cost of firewood/kg = Rs.2 /-.

Firewood consumption in 30 minutes = 94 kgs

Cost of firewood consumed in half an hour = 94 x 2 = Rs. 188/-

Therefore, by switching off the boiler for half an hour during the lunch hours, it is possible to save Rs. 188/day

Energy cost saved per month = 188 x 20 = Rs. 3,760/-

Energy cost saved per year = 3,760 x 12 = Rs. 45,120/-

Firewood saved per year = 94 x 20 x 12 = 22,560 kgs

Thus, without any investment industry would be saving Rs. 45,120/- every year.

Recommendation 5: Replace the Florescent lights with LED Lights

Replace the existing twenty-one 40 W fluorescent bulbs with 20 W LED lights in the plant areas. LED lights consume less energy and produce the same or higher lumens compared to fluorescent lighting. Occupancy sensors can also be installed in the areas with less occupancy.

The energy savings, ES, due to replacing the existing fluorescent lamps with LED lamps are given by,

ES = CEU - PEU

Where,

CEU = current energy usage, kWh/yr

PEU = proposed energy usage, kWh/yr

The current and proposed energy usage can be calculated as follows:

CEU = N x CR x OH / K

PEU = N x PR x OH / K

Where,

N = Number of lamps in an area, no units

CR = Current rating of lamps with Ballast, watts

PR = Proposed rating of lamps with Ballast, watts

OH = Annual hours during which lights are on = 2,000 hrs per year

K = Conversion constant = 1,000 W/kW

CEU = 21 × 40 × 2000 / 1000 = 1,680 kWh/yr

PEU = 21 × 20 × 2000 / 1000) = 840 kWh/yr.

Energy Savings = 1,680 - 840 = 840 kWh/yr.

Cost of Energy Savings = 840 × 7.83 = Rs. 6,577.20/-

Investment = total number of lamps × cost of each lamp = 21 × 200 = 4,200/-

$$\text{Payback period} = \frac{investment}{savings} \times 12 = \frac{4200}{6{,}577.2} \times 12 = 7.66 \text{ months} \cong 8 \text{ months}$$

The pay-back period is calculated to be less than 8 months

Table 4 Summary of Energy Conservation Measures

Sl. No.	Description	Potential Conservation/yr	Potential Cost Savings (Rs./yr)	Type of resource	Estimated Cost (Rs.)	Simple Payback (months)
1	Reduce the contract demand	-	42,840	Electricity	4,000	2
2	Replace V Belts with Cog belts	2,046 kWh/yr	16,019	Electricity	-	Immediate
3	Install a Capacitor Bank to improve PF	-	21,787	Electricity	30,000	17
4	Switch off the boiler during lunch break	22,560 Kgs/yr	45,120	Firewood	-	N/A
5	Replace the Florescent lights with LED	840 kWh/yr	6,577	Electricity	4,200	8
	Total	**-**	**₹1,32,343**	**-**	**₹38,200**	**4**

Total energy usage for the fiscal year 2019-20 is found to be 76,834 kWh and the total energy cost comes up to Rs. 857,253.74 [18, 19]. The recommendations mentioned above could serve as Energy Conservation Measures and save around 2,886 kWh/yr of electricity, 22,560 kgs of firewood which is equivalent to reduction of CO_2 emission of 26,627 kgs or equal to planting 1,268 Trees. The annual energy cost savings is Rs. 1,32,343 and annual energy cost savings are approximately 15.44% of the annual energy costs in the facility. The estimated implementation cost comes up to Rs. 38,200 with an average simple payback period of around 4 months. Table 4 shows summary of energy conservation measures [20].

Conclusion

The study shows that the facility has a potential of significant energy savings. The outcome of the pilot study was presented before the top management and the management was suggested to incorporate the recommendations of the study.

MSMEs are organised in clusters across the country, around 180 clusters within 18 energy intensive sectors. In the 180 energy intensive MSME clusters, overall energy consumption is estimated to be 22.5 Metric tonne of oil equivalent per annum (Sameer Pandita 2015). In 25 MSME cluster, studies have estimated potential of 15% reduction in energy consumption and our case study is also proving the same. This estimates a energy savings of 3.3 metric tonnes of oil equivalent or 38 GWh of electricity or 19,000 Crore Rupees, a large energy saving potential untapped in MSME sector. Hence, more importance should be given for energy conservation in the MSME sector by the stake holders of this sector. BEE should take more initiatives to help MSME sector to improve their energy efficiency. Initiatives like free Energy audits from energy auditors and financial support in the form of loans and rebates for energy efficient equipment can help to tap the untapped energy saving potential in MSME sector.

References

[1]. International Energy Agency - India Energy Outlook 2021. https://www.iea.org/reports/india-energy-outlook-2021, (accessed on 21/3/24)

[2]. R. K. Gera yunus Parvej and Himanshu soni "Renewable Energy Scenario in India: Opportunities Challenges",Indian Journal of Electrical and Biomedical Engineering Volume 1No.1 Jan-Jun 2013 PP.10-16@ Academic Research Journals(India)

[3]. About micro, medium & small scale industry in confederation of indian industries website, 2022.

[4]. https://www.cii.in/Sectors.aspx?enc=prvePUj2bdMtgTmvPwvisYH+5EnGjyGXO9hLECvTuNuXK6QP3tp4gPGuPr/xpT2f (accessed on 21/3/24)

[5]. Benchmarking and mapping Indian MSMEs energy consumption, The Energy and Resources Institute, 2022.

[6]. http://www.sameeeksha.org/brouchres/AFD_Brochure.pdf (accessed on 21/3/24)

[7]. Vyas Pareshkumar A, Bhale Purnanad V, 2013. 'Experimental investigation on energy efficiency of electrical utilities in process industries through standard energy conservation'. 4th International Conference on Advances in Energy Research 2013, ICAER 2013

[8]. Ashwini B Bobade, Prof. M.G Walecha, 'Energy Audit in Small Scale Industry- A Review', International Journal of Advance Research, Ideas and Innovations in Technology, (IJARIIT) Volume-4, Issue-2, 2018

[9]. R. H. Yadav, Mr. V. V. Jadhav, Mr. G. A. Chougule "Performance Analysis of a Dairy Plant through Electrical Energy Audit", International Journal of Engineering Science and Computing, Volume 6, Issue No. 6, DOI 10.4010/2016.1817, ISSN 2321 3361, June 2016.

[10]. D.A. Chaudhary, J.B. Upadhyay and Vivek Koshta, "Electrical energy conservation in dairy industry" International Journal of

e ISSN: 2584-2137
Vol. 02 Issue: 04 April 2024
Page No: 851 - 860
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0120

Agricultural Engineering, Vol. 7, Issue 1, April 2014.
[11]. Swapnil Ratnakar Mane "Energy Management in a Dairy Industry" International Journal of Mechanical and Production Engineering, ISSN: 2320-2092, Volume- 1, Issue- 4, Oct-2013.
[12]. Soma Bhattacharya and Maureen L. Cropper," Options for Energy Efficiency in India and Barriers to their Adoption: A Scoping Study", 2010 Resources for the Future.
[13]. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1590510 (accessed on 21/3/24)
[14]. Biswajit Biswas,Sujoy Mukherjee, Aritra Ghosh," Conservation Of Energy: A case study of energy conservation in campus lighting in an institution", International Journal of Modern Engineering Research, Vol.3, Issue.4, Jul - Aug. 2013 pp-1939-1941 ISSN: 2249-6645
[15]. www.ijmer.com
[16]. KongaraAjay, G.Sudhakar, K.Sasank, T.Guru Krishna, "A case study on Energy Conservation and audit for household Application", IJAREEIE vol 3 issue 3 April 2014
[17]. Gousia Sultana, Harsha. H.U," Electrical energy Audit a case study", IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) Volume 10, Issue 3 Ver. III (May – Jun. 2015), PP 01-06
[18]. Michael Brown, 'High Torque Drive Belts Reduce Energy Losses', Industrial Energy Conserver, Vol. 7, March, 1986.
[19]. Sameer Pandita, Energy Efficiency Programme for Small and Medium Enterprises (SMEs), Bureau of Energy Efficiency, 2015
[20]. https://iea.blob.core.windows.net/assets/imports/events/131/SameerPandita.pdf (accessed on 21/3/24)