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A Study to Assess the Energy Saving Potential and Economic Analysis of an Agro Based Industry in Karnataka, India

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***Abstract*—**Agro based industries in India are considered as the micro, small and medium enterprises (MSME). In India, MSMEs contribute approximately 8 percent of the country's GDP, 42 percent of the manufacturing output and 40 percent of exports. The toor dal (scientific name *Cajanus cajan*, commonly known as yellow gram, pigeon pea) is the second largest pulse crop in India accounting for about 20% of total pulse production. The toor dal milling industry in India is one of the major agro-processing industries in the country. Most of the dal mills are concentrated in pulse producing areas, which are spread all over the country. In Karnataka state, Gulbarga is a district, where toor dal is the main crop and is grown extensively. There are more than 500 dal mills in and around the Gulbarga district to process dal. However, the majority of these dal milling units use traditional methods of processing which are energy and capital intensive. There exists a huge energy saving potential in these mills. An energy audit is conducted on a dal mill in Gulbarga to understand the energy consumption pattern to assess the energy saving potential, and an economic analysis is conducted to identify energy conservation opportunities.

***Keywords*—**Conservation, demand side management, load curve, toor dal.

I. Introduction

IN India, the majority of manufacturing industries lack competitiveness; the two main attributes for enhancing competitiveness are the upgrading of technology and quality. Energy is a critical input to any modern manufacturing, processing unit, and the cost of energy forms the major constituent in the overall cost structure. As the cost of energy is increasing day by day and there is uncertainty looming over its uninterrupted availability, MSMEs need to focus on reducing their energy consumption. Up until now these entities had no compulsion to conserve the energy or use it efficiently. The Energy Conservation Act 2001 emphasized this neglected aspect and therefore, the approach suggested is demand side management (DSM). DSM refers to cooperative activities between the utility and its customers (sometimes with the assistance of third parties, such as energy services companies and various trade allies) to implement options for increasing the efficiency of energy utilization, with resulting benefits to the customer, producers, and society as a whole [1].

DSM has a clear role and there is a huge potential for utility driven DSM programs in India. It is estimated that the end-use efficiency improvement potential in industry and the building sector alone is in the order of Rs. 14,000 Crores (1Rs. = 0.02 US$) and a saving of 54 billion units of electricity. In view of these facts, to realise some of this potential, the Government of India has targeted 15 % improvement in energy efficiency per year [2]. Also, the new Energy Conservation legislation seeks to implement energy efficiency policies that lead to widespread market development though better standards for appliances and equipment, energy efficiency labeling, rational cost-of-service based tariffs, mandatory energy audits, awareness and training, financial and fiscal incentives.

In India, the dal (pulses) milling industry is one of the major agro processing industries in the country, which is an MSME. The annual production of pulses in the country is approximately 13.19 million tons and 75% of this output is processed by dal mills. The growth rate of dal mills in India is at a steady pace, in 1972 there were only 2,000 mills and in 2013-14, this number reached approximately 25,000 [3].

The use of electricity as a source of energy in these dal mills is found to be on the higher side and the machines are generally oversized. Much of the time the machines are not optimally loaded and are underutilized with respect to processes. For these reasons, their electricity consumption is also quite high. Because of the prevailing power situation in the country, there is a need to manage the power consumption occurring in these mills. In this regard, to encourage and implement energy saving measures, the Energy Conservation Act 2001 has many provisions. The energy audit is one of the provisions considered for the study. An energy audit is a means to assess and monitor the energy saving potential in any establishment. The energy audit is carried out in a dal mill of medium capacity in Gulbarga, Karnataka to identify and suggest practical energy saving measures. This paper studies the energy audit recommendations and economic analysis for such an industry.

The arrangement of the paper is as following; Section II discusses the energy audit methodology, in Section III, the data of audit measurement and data acquisition is considered. Section IV gives detailed analysis of energy saving measures suggested for the industry, along with the economic analysis; and finally in Section V, the conclusions are drawn.

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II. Energy Audit

By definition, Energy Audit is the verification, monitoring and analysis of use of energy, including submission of technical reports containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption [4]. It also helps in calculating the cost of energy used to manufacture a product and the suggested conservation can advocate how this can be reduced by curtailing the various losses in the whole system.

The energy audit is an important step in energy management. It gives complete information about how and where energy is being used in the establishment/organization. This in turn helps us to recognize the areas of energy wastage and step up practical goals for obtaining savings. Hence an energy audit is an activity to identify ways to lessen energy consumption and end wasteful energy spending.

Many steps are involved in an energy audit, which mainly include measurement, tabulation, techno-economic analysis and energy saving opportunities. The measurement includes the data concerning different types of energy and raw material inputs, basic data relating to energy consumption, and the cost and production figures of the sector under audit. These measurements are carried out for a certain period of time.

The measured data, taken during the audit, is suitably tabulated for further reference and analysis. The progress of the plant is measured by the programs drawn for this purpose, which may include/consider the management philosophy, culture and history of the plant/organisation/sector taken up for audit, type of plant and machinery, technological and process intricacies. It also considers economical evaluation of energy consumption in the plant/organization/sector considered for the audit, study of the past and the present measured data, also its differences, and finally the load behavior and its impact on the organisation's health.

Many solutions are indicated in techno-economic analysis, mainly for the following technical issues: process complexities, data acquirement and measurements, along with alternatives for reducing the possibility of energy losses in a system. Suggested solutions for the economic issues that include steps for reducing energy consumption, without compromising on productivity, required investments and the economic benefits, as well as the calculation of payback periods by simple payback period analysis (SPP).

Energy saving opportunities (ESO) are also included in the energy audit, such as employing automatically controlled power supply for the improvement in efficiency, switching off lights when not required, techno-economic information/guide lines with regards to suggested energy saving methods that lead to optimal energy utilisation [5].

III. Measurements and Data Acquisition

Major motive power required for the mill is developed using electricity. The electricity consumed by the dal mill for the year 2014 (past data), is considered and tabulated as shown in Table I. The data provides an insight into the electricity consumption pattern of the mill. The mill is supplied by the local electricity supply company (GESCOM, the Gulbarga Electricity Supply Company) through HT (High Tension) lines. The contracted demand is 150 kVA and the billing demand in all these months is given. Considering the monthly useage of the mill, consumption during the month of January is high compared to other months [6].

The mill undertakes the following production processes: cleaning, soaking, conditioning, de-husking and splitting, and grading, as shown in Fig. 1. A picture of the dal mill is shown in Fig. 2. The various operations involve many electric motors. Table II shows the various motors used in the mill along with their ratings. These are 3-phase induction motors working at 400 V, 50 Hz supply. Many of these machines are rewound, which means their windings are wound once again after they are shorted, which normally affects their efficiency drastically.

The rewinding is done locally by technicians who have little or no expertise in the field. Measurements were carried out in the whole plant for all these motors and the data collected is given in Table III. The measuring instruments used were calibrated properly and experienced technicians wre involved during the measurement. The plant was running at full capacity when the measurements were taken.

TABLE I
Electricity Bill Data of the Dal Mill

Sl.No.	Billing Month	Energy Charges			Recorded Demand (kVA)	Tax (Rs)	Bill Amount (Rs)
		Units (kWh)	Rate (Rs)	Amount (Rs)			
01	Jan-2014	5558	5.35	29735.3	45	1873.24	31608.54
02	Feb-2014	4651	5.35	24882.85	57	1511.97	26394.82
03	Mar-2014	4741	5.35	25364.35	42	1541.71	26906.06
04	Apr-2014	4652	5.35	24888.2	47	1512.71	26400.91
05	May-2014	4578	5.35	24492.3	41	1488.65	25980.95
06	Jun-2014	4867	5.35	26038.45	49	1582.62	27621.07
07	Jul-2014	4584	5.35	24524.4	52	1490.59	26014.99
08	Aug-2014	4849	5.35	25942.15	48	1576.76	27518.91
09	Sep-2014	4647	5.35	24861.45	47	1511.08	26372.53
10	Oct-2014	4223	5.35	22593.05	43	1373.20	23966.25
11	Nov-2014	4992	5.35	26707.2	53	1623.26	28330.46
12	Dec-2014	5480	5.35	29318.0	58	1781.95	31099.95

Fig. 1 Stages of Toor Dal Processing

Fig. 2 View of a Toor Dal Mill in Gulbarga, India

IV. Energy Saving Opportunities and Economic Analysis

The analysis of measured data of the energy audit is carried out to indentify energy conservation opportunities. In this section, the calculation for the annual energy saving potential is done, and considering capital investments, a simple payback period is also calculated. For this calculation, the energy charges are considered as Rs. 5.35/kWh as per the April 2014 electricity bill. The investment required for each of these options includes equipment supply, associated accessories, installation and commissioning, energy base lining, project monitoring, post-implementation energy monitoring and O&M support for one year. As the mill has old and rewound motors that are less efficient, these motors are replaced with IE2 Series Motors [7]. A sample calculation is shown below, for the replacement of existing low efficient motors with the IE2 Series SCR motor. Details of the technical economic analysis are given below.

A. Cost Analysis of Replacing the in-Efficient Motors

1. Dal Cleaning Motor (Existing) 5HP (η=70%)

Power input to the motor at full load = (5×746) ÷ 0.70 = 5328.571 W

Annual electricity consumption, when operated for 08 hours per day for 300 days per year. = 5328.571 × 8 × 300 = 12788.4 kWh

The annual energy cost in Rs. = 5.35 ×12788.4 = 68417.95

2. IE2 Series SCR Motor 5HP (η=86.3%)

Power input to the motor at full load = (5×746) ÷ 0.863 = 4322.13 W

Annual electricity consumption, when operated for 08 hours per day for 300 days per year = 4322.13 × 08 × 300 = 10373.116 kWh.

Annual energy cost in Rs. = 5.35 × 10373.116 = 55496.20

Saving in energy cost = 68417.95 – 55496.20 = 12921.75 Rs/year

Cost of the IE2 Series motor in Rs. = 27410.00

Simple payback period for this option = 27410 ÷ 12921.75 = 2.12 years

TABLE II
Details of the Motors Used for Various Processes

Sl. No.	Motor Application	Motor Rating in HP	Rewound Yes /No	Rated Efficiency
01	Dall cleaning	5.00	Yes	70 %
02	De husk	7.5	Yes	70 %
03	Single Role	30	Yes	75 %
04	Double Role	20	Yes	75 %
05	Tri Role	15	Yes	70 %
06	Polishing	20	Yes	75 %
07	Water Mixing	3	Yes	65 %
08	Boiler	7.5	No	70 %
09	Compressors (2Nos)	3	No	65 %
10	Drier lighting	1.5	No	65 %
11	Counter	20	Yes	75 %
12	Elevator	5	Yes	70 %
13	Chenni Warm	3	Yes	65 %

TABLE III
Measured Data of All the Motors in the Mill

Sl. No.	Motor work	Rating in HP	Voltage in Volts	Current in Amps	Power factor	Power input Watts
01	Dall cleaning	5.00	440	7.76	0.9	5328.27
02	De husk	7.5	440	10.52	0.9	7460
03	Single Role	30	440	41.21	0.95	29840
04	Double Role	20	440	27.47	0.95	19893.33
05	Tri Role	15	440	23.30	0.9	15985.71
06	Polishing	20	440	27.48	0.95	19895.33
07	Water Mixing	3	440	5.02	0.9	3443.076
08	Boiler	7.5	440	10.52	0.9	7460
09	Compressors	3	440	5.02	0.9	3443.076
10	Counter	20	440	27.48	0.95	19893.33
11	Elevator	5	440	7.36	0.9	5328.54
12	Chenni Warm	3	440	4.42	0.9	3197.142

Similarly, calculations for all the existing motor replacements, by the IE2 Series motors are carried out and the results are tabulated in Table IV. The economic analysis has revealed that there is huge energy saving potential available in the dal mill, which is using the old, inefficient motors.

V. Conclusion

In India, dal mills constitute a major share of the total MSMEs; hence, these have considerable energy saving

potential for the country. The energy audit conducted at a dal mill in Gulbarga has revealed that an energy saving of 62.040 MWh is possible, which translates into a monetary benefit of Rs. 3,31,915.59 annually. The payback period is calculated to be between two and three years, which is a very good period for this kind of investment. Hence, the study has shown that an energy audit should be conducted for similar MSMEs to assess their energy saving potential, as the number of such mills is extensive. Based on the study, a plan has to be developed to replace the old, existing motors by phasing in new, efficient motors. An incentive scheme can be devised to motivate mill owners to actively participate in replacing inefficient, outdated equipment with efficient machines. This is essential in the interest of the country, as the prevailing electricity crisis needs such initiatives to alleviate the problem.

TABLE IV
ECONOMIC ANALYSIS OF THE MOTORS USED IN DAL MILL

Sl. No.	Motor rating in HP	Existing motor efficiency	IE2 motor efficiency	Energy saving in kWh/year	Cost saving in Rs/year	SPP (year)
01	5	70 %	86.3 %	2415.28	12,921.18	2.12
02	7.5	70 %	87.7 %	3871.56	20,713.9	1.83
03	30	75 %	91.6 %	12978.44	69,434.65	1.86
04	20	75 %	90.6 %	8220.82	43,981.38	2.04
05	15	70 %	88.7 %	8088.37	43,272.77	2.13
06	20	75 %	90.6 %	8220.82	43,981.38	2.04
07	3	65 %	82 %	1713.14	9,165.30	2.33
08	7.5	70 %	87 %	2469.51	13,211.87	3.06
09	3	65 %	83.2 %	1713.14	9,165.30	2.08
10	20	75 %	90.6 %	8220.82	43,981.38	2.04
11	5	70 %	84.3 %	2415.28	12,921.18	3.48
12	3	65 %	82 %	1713.14	9,165.30	2.33
Total				62040.32	3,31,915.59	

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