BASELINE ENERGY AUDIT REPORT

"SUPPORTING NATIONAL PROGRAM ON ENERGY EFFICIENCY IN SMES FOR INDORE (FOOD) CLUSTER"

NANAK OVERSEAS

Udyog Nagar, Indore

15-12-2015

Submitted to

ENERGY IS LIFE
BEE
CONSERVE IT

BUREAU OF ENERGY EFFICIENCY

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Submitted by

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ACKNOWLEDGEMENT

DESL places on record its sincere thanks to Bureau of Energy Efficiency (BEE) for vesting confidence in DESL to carry out the assignment "Conducting baseline energy audit in Indore SME food cluster" under their national project *"Supporting National Program on Energy Efficiency in SMEs for Indore (Food) cluster".*

As a part of this assignment, work in Indore and Ujjain food cluster was awarded to DESL, and DESL is grateful to BEE for their full-fledged coordination and support throughout the study.

The study team is indebted to Mr. Mayur Kukreja, Partner and Mr. Rakesh Kanjani for showing keen interest in the energy audit and also thankful to the management of M/s Nanak overseas for their wholehearted support and cooperation for the preparation of this baseline energy audit report, without which the study would not have steered to its successful completion. Special thanks to other members of the unit for their diligent involvement and cooperation.

It is well worthy to mention that the efforts being taken and the enthusiasm shown by all the plant personnel towards energy conservation and sustainable growth are really admirable.

Last but not the least, the interaction and deliberation with Mr. Suresh Agrawal, President, Association of pulses Manufacturers (APM) Indore, technology providers and all those who were directly or indirectly involved throughout the study were exemplary. The entire exercise was thoroughly a rewarding experience for DESL.

DESL Team

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ABBREVIATIONS

Abbreviations	Expansions
BEE	Bureau of Energy Efficiency
DESL	Development Environergy Services Limited
DG	Diesel Generator
EE	Energy Efficiency
EPIA	Energy Performance Improvement Action
HSD	High Speed Diesel
LT	Low Tension
MD	Maximum Demand
MSME	Micro, Small and Medium Enterprises
MT	Metric Tons
MTOE	Million Tons of Oil Equivalent
No.	Number
PF	Power Factor
SEC	Specific Energy Consumption
SLD	Single Line Diagram
SME	Small and Medium Enterprises

EXECUTIVE SUMMARY

Bureau of Energy Efficiency (BEE) is implementing a project titled "Supporting National Program on Energy Efficiency in SMEs for Indore (Food) cluster" The objective of the project is to provide impetus to energy efficiency initiatives in small and medium enterprises (SMEs) of Indore food Cluster in India.

DESL has been engaged to implement the project in the MSME food cluster at Indore and Ujjain in Madhya Pradesh. There are about 200 units scattered over Indore and Ujjain. The major products processed in these food industrie includes Poha (rice flakes) and various types of Pulses – toor, masoor, chana, arahar, moong, etc.

The project awarded to DESL consists of 18 major tasks:

- Conducting pre–activity cluster workshop defining the agenda of this engagement
- Conducting initial walk through energy audits with in 5 selected units of the cluster
- Identifying and proposing two energy efficient process technologies to BEE
- Identifying at least 5 local technology/service providers of the above technologies in the cluster
- Identifying 20 SME units willing to implement and demonstrate the above two technologies
- Assistance to BEE for entering into contract with each of the 20 shortlisted SME units
- Conducting Comprehensive Energy Audits in 20 SME units
- Development of technology specific case studies (Audio, Visual and Print) for each technology
- Developing best operating practices(BOP) document for the top 5 energy equipment/processes in the industry cluster
- Enumeration of common regularly monitorable parameters at the process level which have impact on energy performance and listing of appropriate instrumentation for the same
- Conducting post energy audits in each of the above 20 units to verify energy savings
- Verification and submission of relevant documents (Evidence of implementation and commissioning of EE technology) to the BEE
- Assisting BEE in conducting five post energy audits
- Submission of progress report in hard and soft versions (Word, presentation) to BEE
- Submission of Draft document to BEE within seven days from issue of LOI by BEE

Brief Introduction of the Unit

Table 1: Details of Unit

Name of the Unit	**M/s Nanak Overses**
Constitution	Partnership
MSME classification	Small
No. of years in operation	NA
Address: Registered office	30, A Udhyog Nagar, Indore, Madhya Pradesh
Administrative office	30, A Udhyog Nagar, Indore, Madhya Pradesh
Factory	30, A Udhyog Nagar, Indore, Madhya Pradesh
Industry-sector	Food
Products manufactured	Pulses

Name(s) of the promoters / directors	Mayur Kukreja

Baseline Energy Audit

The study was conducted in 3 stages:

- **Stage 1:** Walk through the plant for assessment of the measurement system and accessibility of measurement points.
- **Stage 2:** Baseline energy audit, data collection and field measurements for performance evaluation of equipment/ systems, estimation of savings potential, technology assessment and understanding of project constraints
- **Stage 3**: Data analysis, configuration of projects, savings quantification and preparation of baseline energy audit report

The production process of the unit

Production process description is as follows:

The unit purchases raw pulses from nearby located agricultural markets, and in some cases also imports them from abroad. The pulses are cleaned in vibrating cleaners to remove dust and sand particles which come along with the raw pulses from agricultural fields. The outer cover from the cleaned pulses is removed in a rotary shaft covered with emery rolls. The pulses are again cleaned in a vibrating cleaner (Chalne machine) to separate the removed husk from the pulses (dal). The dal (without the husk) is then passed over a screw conveyer where water is sprayed on it. The wet dal is then heated in a dryer to reduce its moisture content and also to soften it. From the drier, the dal is conveyed to grinder machine (Chakki) where it is broken down into 2 parts as per requirements. Post breaking, the dal is finally cleaned in cleaner machines, packed and dispatched.

It was observed that the unit had 2 sections – raw material (kaccha) and post finishing (pakka). In both these sections, there was one main motor (and one standby) which was operating most of the machines like fadfadiya, chalne, grinder, elevators, screw conveyer, etc through a common shaft and flat-belt-pulley drives. When a machine was not in operation, the operator just de-coupled the pulley connected to that machine from the common shaft.

Identified Energy Performance Improvement Actions (EPIA)

The baseline energy audit covered all the equipment which were in operation during the time of field study. The dal milling process requires both electrical and thermal energy. Wood is used for generating hot air in a hot air generator and constitutes approximately 8% of the total energy cost of the unit. The balance energy cost is for electrical usage.

Major areas of electrical energy consumption in the unit are raw material section common main motor (kacha counter) and finished material section common main motor (pakka counter), polisher and roll. Measures proposed for reduction of electrical energy consumption include replacement of common motors of both pakka and kacha counters and emery roll motor with energy efficient (EE) motors.

Measures proposed for reduction of thermal energy consumption include excess air control and skin loss reduction by repairing insulation in hot air generator and dryer.

The identified energy performance improvement actions are given in the table below.

Table 2: Summary of EPIA

Sl. No.	Energy Performance Improvement Action (EPIA)	Annual electricity savings	Annual fuel savings	Investment cost	Monetary energy cost saving	Simple payback period
		kWh / y	kg/y	Rs. Lakh	Rs. Lakh / y	y
1	Replacing old and inefficient motors with EE motors - (Pakka counter motor, 10 HP X 1 number + Kaccha counter motor, 10 HP X 1 number + Emery Roll motor, 15 HP X 4 numbers + Polisher motors, 15 HP X 2 numbers + FD fan of dryer motor, 10 HP X 2 numbers + Dust collector motor, 15 HP X 2 numbers)	21,668		4.02	1.53	2.62
2	Controlling excess air supplied for combustion in hot air generator of dryer by installing O2 sensor, fuel control and damper control	492	3,090	0.85	0.25	3.39
3	Refurbishing the damaged insulation of surface of hot air generator thereby reducing heat loss due to radiation and convection		2,669	0.55	0.19	2.94
	Total	22,160	5,759	5.42	1.97	2.75

- With the implementation of these EPIAs, overall cost savings of Rs. 1.97 Lakh per year can be achieved.

1 INTRODUCTION

1.1 Background and Project objective

Bureau of Energy Efficiency (BEE) is implementing a project titled "Supporting National Program on Energy Efficiency in SMEs for Indore (Food) cluster". The objective of the project is to provide impetus to energy efficiency initiatives in small and medium enterprises (SMEs) sector in Indore and Ujjain food cluster in India.

The objectives of this project are as under:

- Identifying Energy efficient process and technologies that can be implemented by units in the Indore food cluster;
- Identifying 20 SME units within the cluster that are willing to implement and demonstrate the above technologies in their units;
- Facilitating Bureau of Energy Efficiency (BEE), New Delhi to sign tri-partite Memorandum of Understanding (MoUs) with the 20 SME units of Indore food cluster (that are willing to implement the energy efficient technologies) and their cluster association
- Conducting Baseline Energy Audits in 20 SME food units of the Indore food cluster who have signed MoUs with BEE;
- Establishing baseline energy efficiency scenario for the 20 units against which energy savings will be computed post implementation;
- Facilitating the 20 SME units in implementing the proposed energy efficient technologies in their units;
- Conducting post implementation energy audits in the 20 SME units to establish the actual energy savings in those units;
- Development of technology specific case studies (audio-visual and print) for each technology (during pre-implementation, implementation and post implementation stages).

1.2 Scope of work of Baseline Energy Audit

The general scope of work for baseline energy audits is as follows:

- Data Collection
    - Current energy usage (month wise) for all forms of energy from Jan-2015 to Nov-2015 (quantity and cost)
    - Data on production for corresponding period (quantity)
    - Mapping of process
    - List of major equipment and specifications
    - Baseline energy measurements for the processes / equipment for which energy efficient measures were proposed
- Analysis:
    - Energy cost and trend analysis
    - Energy quantities and trend analysis
    - Specific consumption and trend analysis

- Performance evaluation of identified energy consuming equipment / systems
- Quantification of energy cost savings by implementing EE measures / technologies
- Classify parameters related to EE enhancements such as estimated quantum of energy savings, investment required, timeframe for implementation, payback period, re-skilling of existing manpower.

1.3 Methodology

1.3.1 Boundary parameters

Following boundary parameters were set for coverage of the audit:

- Audit covered all the identified energy intensive areas and equipment for which energy efficiency improvement measures were proposed
- All appropriate measuring systems including portable instruments were used
- The identified measures normally fall under short, medium and long-term measures

1.3.2 General methodology

Following flow chart illustrates the methodology followed for carrying out the project:

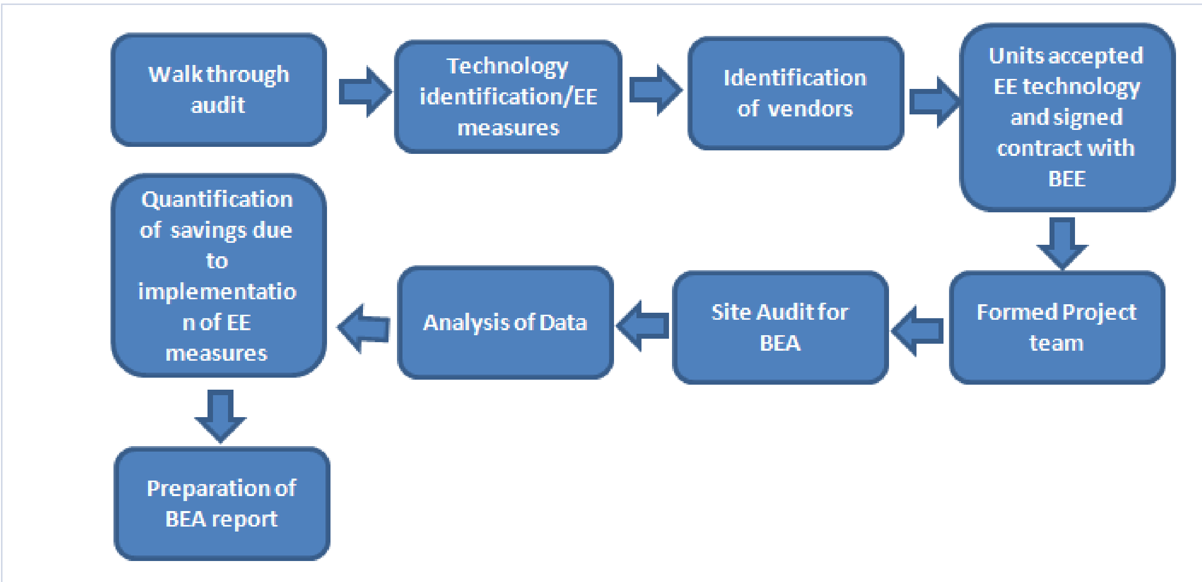

Figure 1: General methodology

The study was conducted in fallowing stages:

Stage 1: Identification of units and conducting walk through energy audits in 5 units to understand the process and its energy intensiveness, identification of energy saving technologies, assessment of the measurement system, proposing energy efficient technologies to BEE and units for acceptance, Stage 2: Identification of vendors for implementation of energy efficient technologies and facilitating BEE to sign tripartite MoUs with the units that are willing to implement the EE technology and their cluster association

Stage 3: Formation of project team for conducting baseline energy audits (BEA) in the units that have signed MOUs with BEE; and conducting BEA in those units – carrying out on-site measurement of energy parameters, collection of historical energy use data for analysis.

Stage 4: Data analysis, quantification of energy savings (in the processes / equipment) post measurements, and preparation of baseline energy audit report.

1.3.3 Baseline energy audit – field assessment

A walk around was carried out before the base line energy audit with a view to:

- Collect historical energy consumption data
- Obtain cost and other operational data for understanding the impact of energy cost on the units' financial performance
- Assess the energy conservation potential for the identified EE measures.
- Check for accessibility of measurement points for measurement of energy parameters

The equipment and technologies identified for study are as follows:

- Common main motors of raw material and finished material sections
- Hot air generator and dryer

Further activities carried out by the team during BEA study included:

- Preparation of the process and energy flow diagrams
- Study of the system and associated equipments
- Conducting field testing and measurement
- Data analysis for preliminary estimation of savings potential at site
- Discussion with the unit on the summary of findings and energy efficiency measures identified

Baseline audit methodology involved system study to identify the energy losses (thermal / electrical) and proposing solutions to minimize the same. This entailed data collection, measurements / testing of the system using calibrated, portable instruments, analyzing the data / test results and identifying the approach to improve the efficiency. The various instruments used for energy audit are as following:

Table 3 Energy audit instruments

Sl. No.	Instruments	Make	Model	Parameters Measured
01	Power Analyzer – 3 Phase (for un balanced Load) with 3 CT and 3 PT	Enercon and Circutor	AR-5	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 1 sec interval
02	Power Analyzer – 3 Phase (for balance load) with 1 CT and 2 PT	Elcontrol Energy	Nanovip	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 2 sec interval
03	Flue Gas Analyzer	Kane-May	KM-900	O_2%, CO_2%, CO in ppm and Flue gas temperature, Ambient temperature
04	Digital Temp. & Humidity meter	Testo	610	Temp. & Humidity
05	Vane Type Anemometer	Testo	410	Air velocity
06	Digital Infrared Temperature Gun	Raytek	Mini temp	Distant Surface Temperature

1.3.4 Base line energy audit – desk work

Post audit off-site work carried out included:

- Revalidation of all the calculations for arriving at the savings potential
- Quick costing based on DESL's database or through vendor interactions as required
- Configuration of individual energy performance improvement actions
- Preparation of draft audit report

2 ABOUT THE MSME UNIT

2.1 Particulars of the unit

Table 4: General particulars of the unit

Sl. No	Particulars	Details
1	Name of the unit	M/s Nanak overseas
2	Constitution	Partnership
3	Date of incorporation / commencement of business	NA
4	Name of the contact person	Mr. Mayur Kukreja
	Mobile/Phone No.	+91 – 9893533030
	E-mail ID	Rakesh.kanjani@mayurglobal.com
5	Address of the unit	30, A Udyog Nagar, Indore, Madhya Pradesh
6	Industry / sector	Food
7	Products manufactured	Pulses
8	No. of operational hours	12
9	No. of shifts / day	1
10	No. of days of operation / year	330

3 DETAILED TECHNICAL FEASIBILITY ASSESSMENT OF THE UNIT

3.1 Description of manufacturing process

3.1.1 Process & energy flow diagram

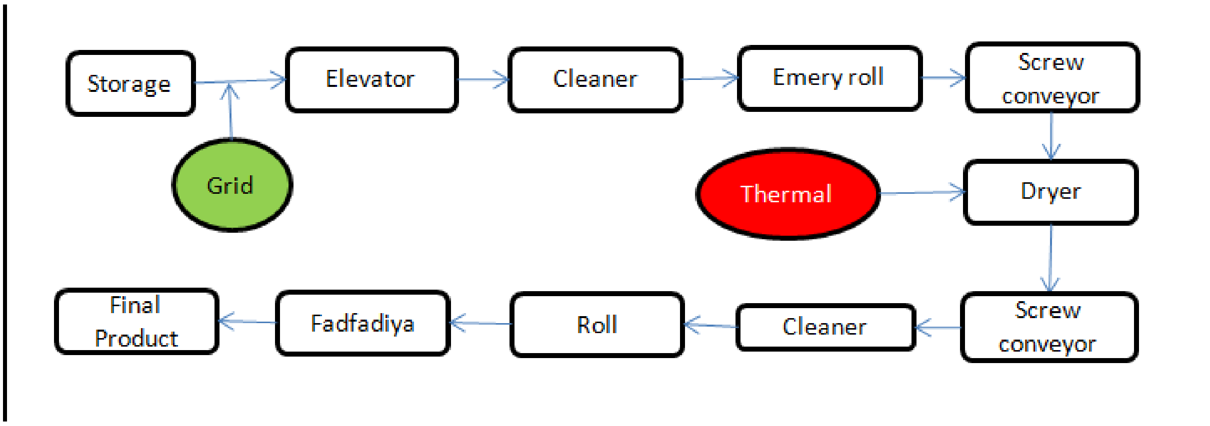

Figure 2: Process flow diagram

3.1.2 Process description

M/s Nanak overseas Industries is a pulses (dal) milling unit. The process description is as follows:

The unit purchases raw pulses from nearby agricultural markets, and in some cases also imports them from abroad. The pulses are cleaned in vibrating cleaners to remove dust and sand particles which come along with the raw pulses from agricultural fields. The outer cover from the cleaned pulses is removed in a rotary shaft covered with emery rolls. The pulses are again cleaned in a vibrating cleaner (Chalne machine) to separate the removed husk from the pulses (dal). The dal (without the husk) is then passed over a screw conveyer where water is sprayed on it. The wet dal is then heated in a dryer to reduce its moisture content and also soften it. From the drier, the dal is conveyed to grinder machine (Chakki) where it is broken down into 2 parts as per requirements. Post breaking, the dal is finally cleaned in cleaner machines, packed and dispatched. It was observed that the unit has 2 sections – raw material (kaccha) and post finishing (pakka). In both these sections, there were one main motor (and one standby) which was operating most of the machines like fadfadiya, chalne, grinder, elevators, screw conveyer, etc through a common shaft and flat-belt-pulley drives. When a machine was not running, the operator just de-coupled the pulley connected to that machine from the common shaft.

3.2 Inventory of process machines / equipment and utilities

Major energy consuming equipment in the plant are:

- **Main common motor of raw material section (Kacha counter):** A common motor operates the raw material common shaft to which most of the machines are coupled through flat belts and pulley drives. Various machines connected to this common shaft are 5 elevators, 3 cleaners with fans.

- **Roll:** The emery rolls are used for removing the outer cover of the dal. It has separate motor.
- **Main common motor of finished material section (Pakka counter):** A common motor operates the finished material common shaft to which most of the machines are coupled through flat belts and pulley drives. Various machines connected to this common shaft include 8 elevators, 5 cleaners with fans, and fadfadiya.
- **Polisher:** Polisher is used for polishing the dal at final stage. It has a separate motor.
- **Blower:** Blower is used for collection of dust from various machines**.**
- **De-stoner:** Used for removing small sand particles from the dal. It has a separate motor.

3.2.1 Types of energy used and description of usage pattern

Both electricity and thermal energy are used in different processes. The overall energy use pattern in the unit is as follows:

- Electricity is obtained from only one source-grid:
  - From the Utility, M.P. Paschim Kshetra Vidyut Vitaran Co. Ltd
- Thermal energy is used for following applications:
  - Wood in hot air generator of dryer.

Total energy consumption pattern for the period Jan-15 to Nov-15, from different sources are as follows:

Table 5: Energy cost distribution

Particular	Rs.(Lakh)	% of Total	MTOE	% of Total
Grid –Electricity	8.6	91%	9.82	74%
Thermal- Wood	0.81	9%	3.36	26%
Total	**9.4**	**100%**	**13.18**	**100%**

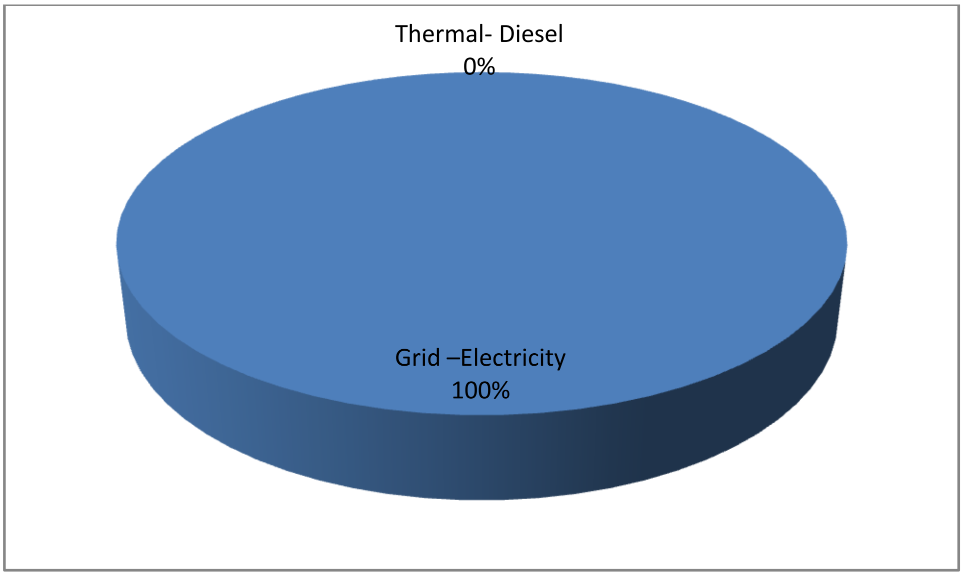

Figure 3: Energy cost share

Figure 4: Energy consumption share

Major observations are as under:

- The unit uses both thermal and electrical energy for production. Electricity is sourced from the grid. Thermal energy consumption is in hot air generator for generation of hot air which is used for drying the dal in dryer.
- Wood is used in hot air generator which accounts for 9% of the total energy cost and 26% of overall energy consumption.

- Electricity used in the process is about Rs. 8.58 Lakh per year.

3.3 Analysis of electricity consumption by the unit

3.3.1 Electricity load profile

Following observations have been made from the utility inventory:

- The plant and machinery load is 120 kW
- The single phase load is about 1.25 kW (for lighting and office equipment like ceiling fans, computer, etc)

A pie chart of the entire connected load is shown in the figure below:

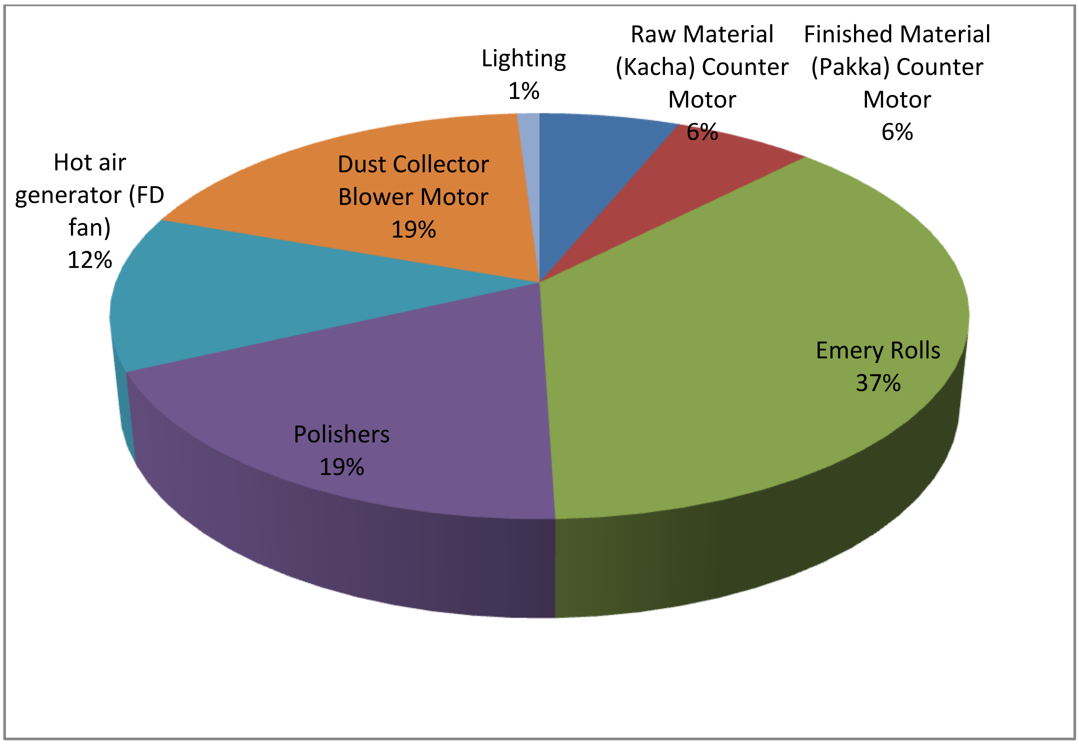

Figure 4: Details of connected load

As shown in the pie chart of connected load, the emery rolls accounts for 37%. Dust collector blower motor, polishers, FD fans of hot air generators, raw material counter motor, and finished material counter motor and lighting account for 19%, 19%, 12%, 6%, 6% and 1% respectively.

An analysis of area wise electricity consumption has been computed to quantify the electricity consumption in the individual processes. The area wise energy consumption details are shown as under:

Table 6: Area wise electricity consumption (estimated)

Machine	Percentage

Raw material (kacha) counter motor	2%
Finished material (pakka) counter motor	6%
Emery rolls	28%
Polishers	21%
Hot air generator (FD fan)	16%
Dust collector blower motor	23%
Lighting	3%
Total	**100%**

This is represented graphically in the figure below:

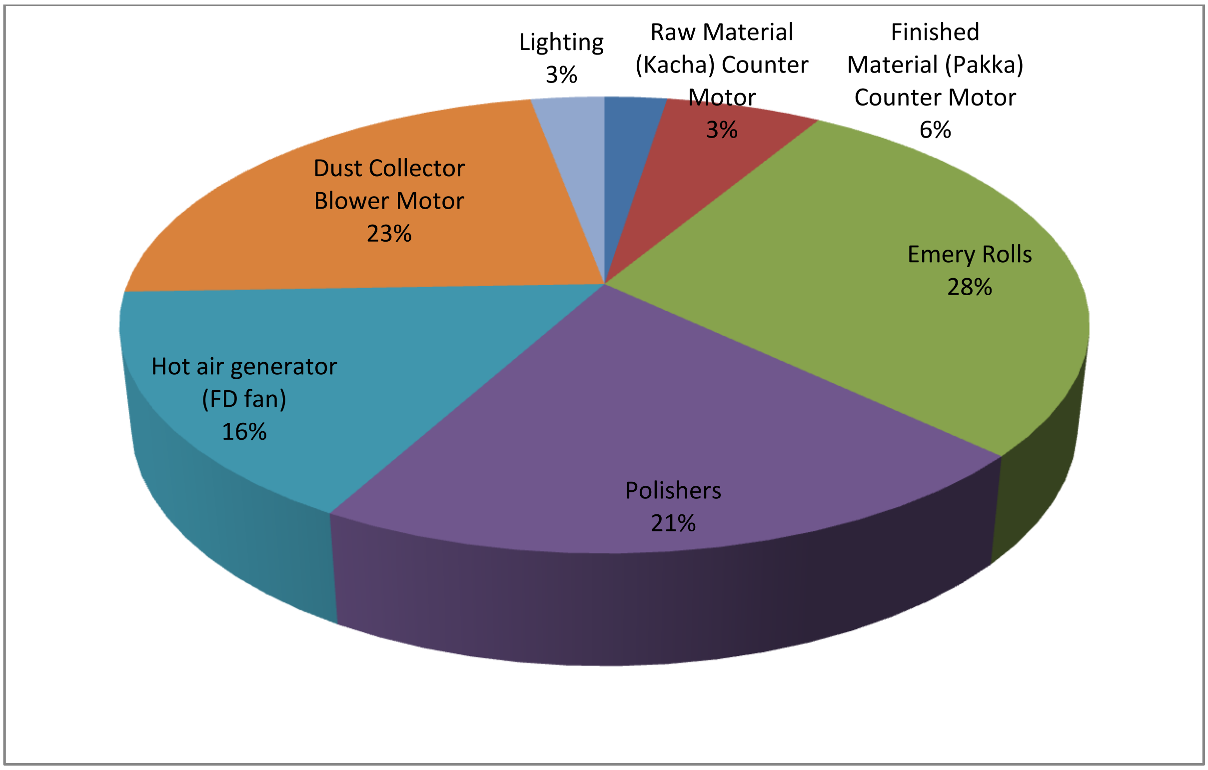

Figure 5: Area wise electricity consumption (estimated)

There is a small difference between the estimated energy consumption and actual consumption recorded (<1%). This is attributed to assumptions made on operating load (based on measurement), diversity factor and hours of operation (based on discussion with plant maintenance).

3.3.2 Sourcing of electricity

The unit is drawing electricity from one source-grid:

- Utility (M.P. Paschim Kshetra Vidyut Vitaran Co. Ltd) through regulated tariff
- There is no DG in the unit

As there is no DG in the unit, the share of grid is 100% in electricity cost. It is approximately Rs. 8.58 Lakh per annum.

3.3.3 Supply from utility

Electricity is supplied by M.P. Paschim Kshetra Vidyut Vitaran Co. LTd. The unit has one LT energy meter provided by the distribution company within its premises. Details of the supply are as follows:

a)	Power Supply	:	440 V line
b)	Contract Demand	:	150 HP
c)	Nature of Industry	:	LT – G

The tariff structure is as follows:

Table 7: Tariff structure

Particulars	Tariff Structure	
Present energy charge	5.74	Rs./kWh
Electricity duty	0.5	Rs./kWh
TOD rebate	0	Rs./kWh
TOD surcharge	0.24	Rs./kWh
Power factor surcharge	0.57	Rs./kWh

(As per Nov-bill)

The single line diagram of electrical distribution system is shown in the figure below:

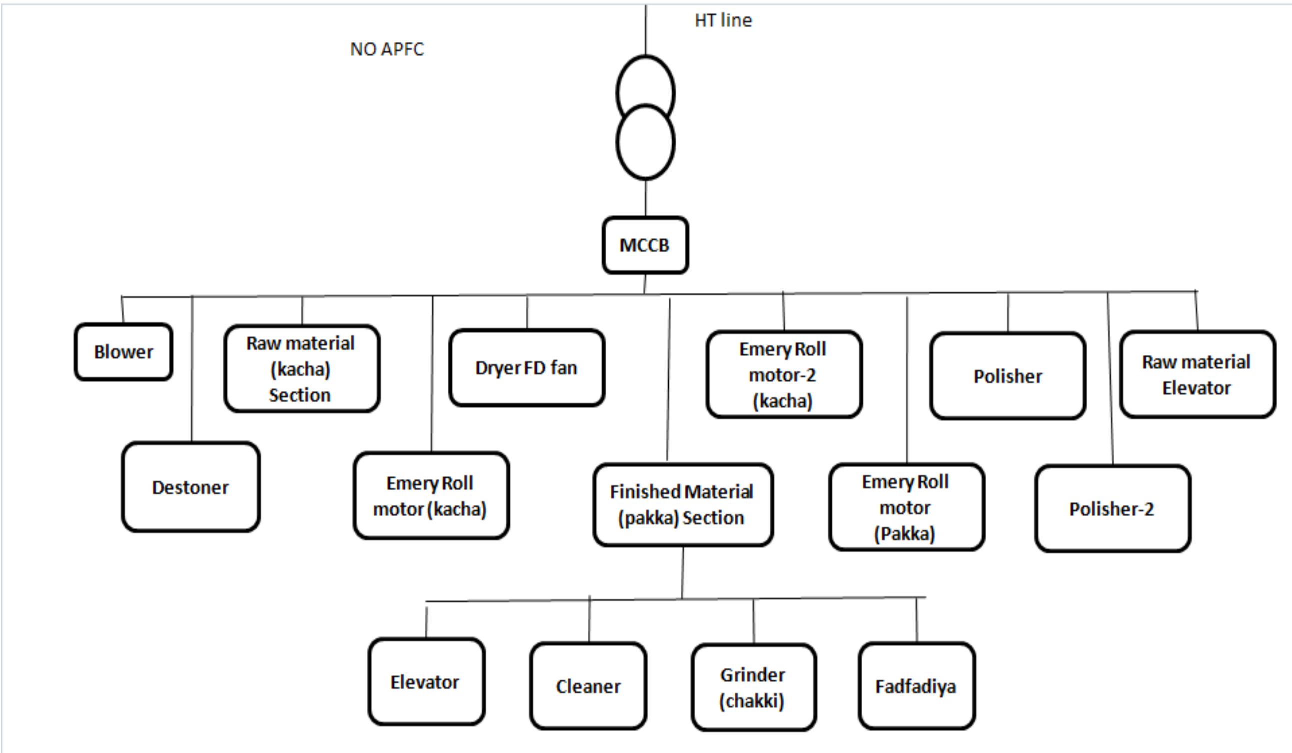

Figure 6: SLD of electrical load

Power factor

The power factor of the unit varied from 0.63 to 0.68 according to electricity bill. During the energy audit study, measurement of the power factor was done by logging on the main incomer. The average power factor measured was found to be 0.67.

3.3.5 Month wise electricity consumption

Month wise total electrical energy consumption from different sources is shown as under:

Table 8: Grid electricity consumption & cost

Months	kWh	Rs.
Jan-15	6886	59,475
Feb-15	8,260	68,411
Mar-15	6,702	28,269
Apr-15	9,514	71,503
May-15	7,260	64,812
Jun-15	8,288	73,536
Jul-15	8,712	79,751
Aug-15	10,942	95,522
Sep-15	9,898	85,965

Oct-15	20,582	90,139
Nov-15	7,610	69,154
Dec-15	9,514	71,503
Total	**114,168**	**858,040**

The month wise variation in electricity consumption is shown graphically in the figure below:

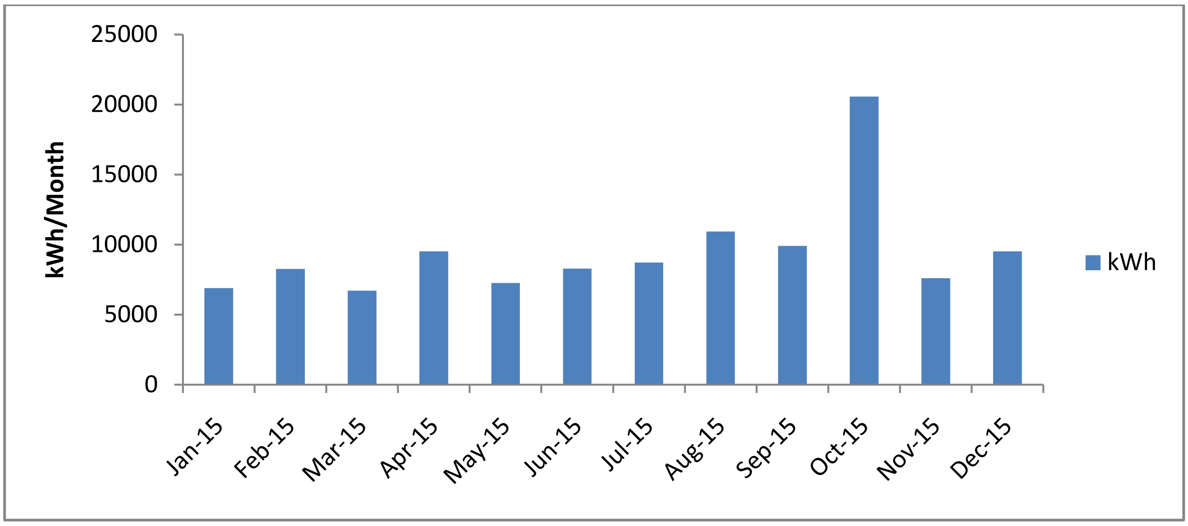

Figure 7: Month wise variation in electricity consumption

As shown in figure above, the consumption of electrical energy was on the higher side during the months of Aug-15 and Oct-2015. However, the electricity consumption during the month of Mar-2015 was less because the production during that month was low. The corresponding month wise variation in electricity cost is shown graphically in the figure below:

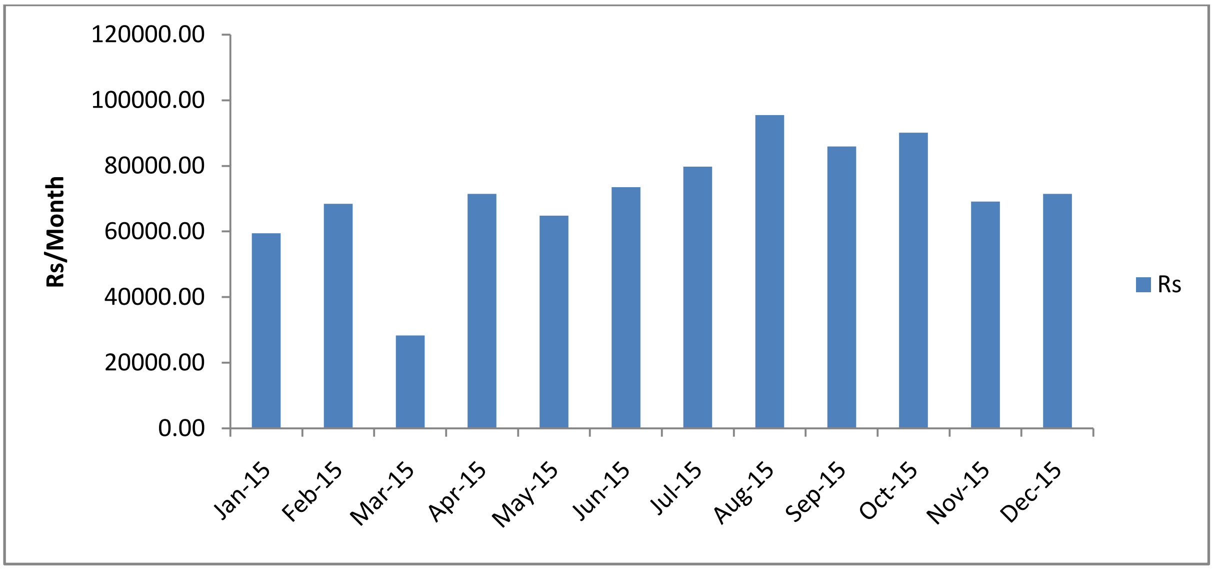

Figure 8: Month wise variation in electricity cost from different sources

3.3 Analysis of thermal consumption by the unit

Fuel used for hot air generator is wood which is bought at the rate of Rs. 7/kg. Average annual wood consumption is 11.6 MT costing Rs. 0.81 Lakh as per data provided by the unit.

3.4 Specific energy consumption

Annual production data was provided by the unit. Based on the available information, various specific energy consumption parameters have been estimated as shown in the following table.

Table 9: Overall specific energy consumption

Parameters	Unit	Value
Annual grid electricity consumption	kWh	114,168
Annual wood consumption	kg	11,594.68
Annual energy consumption; MTOE	kgOE	13,180.9
Annual energy cost	Lakh Rs.	9.4
Annual production	MT	3,312.77
SEC; Electrical	kWh/MT	34.5
SEC; Thermal	kg/MT	3.50
SEC; Overall	kgOE/MT	3.98
SEC; Cost Based	Rs./MT	284

Basis for estimation of energy consumption in terms of tons of oil equivalent are as follows:

- Conversion Factors
  - Electricity from the grid : 860 kCal/KWh
  - 1 kgOE : 10,000 kCal
- GCV of wood : 2900 kCal/kg
- CO_2 Conversion factor
  - Grid : 0.89 kg/kWh
  - Wood : 1.12 t/t

3.5 Baseline parameters

Following are the general baseline parameters, which have been considered for techno-economic evaluation of various identified energy cost reduction projects, as well as for the purpose of comparison after implementation of the projects. The rates shown are the landed rates.

Table 10: Baseline parameters

Parameters	Unit	Value
Electricity rate	Rs./ kWh	5.74
Weighted average electricity cost	Rs./ kWh	7.074
Annual operating days	days	330
Operating hours per day	h	12
Production	MT/yr	3,312.765

GCV of grid electricity	kCal/kWh	860
GCV of wood	kCal/kg	2,900
Cost of wood	Rs./kg	7
CO2 emission factor - grid	kg/kWh	0.89
CO2 emission factor - wood	tons/ton	1.12

3.6 Identified energy conservation measures in the plant

Diagnostic Study

A detailed study was conducted during BEA in the unit. Observations regarding energy performance of various processes / equipment were recorded, and a few ideas of EPIAs were developed. Summary of the key observations is as follows:

3.6.1 Electricity supply from grid

The electrical parameters at the main electrical incomer feeder from the supplier- M.P. Paschim Kshetra Vidyut Vitaran Co. Ltd- was recorded by using the portable power analyzer instrument.

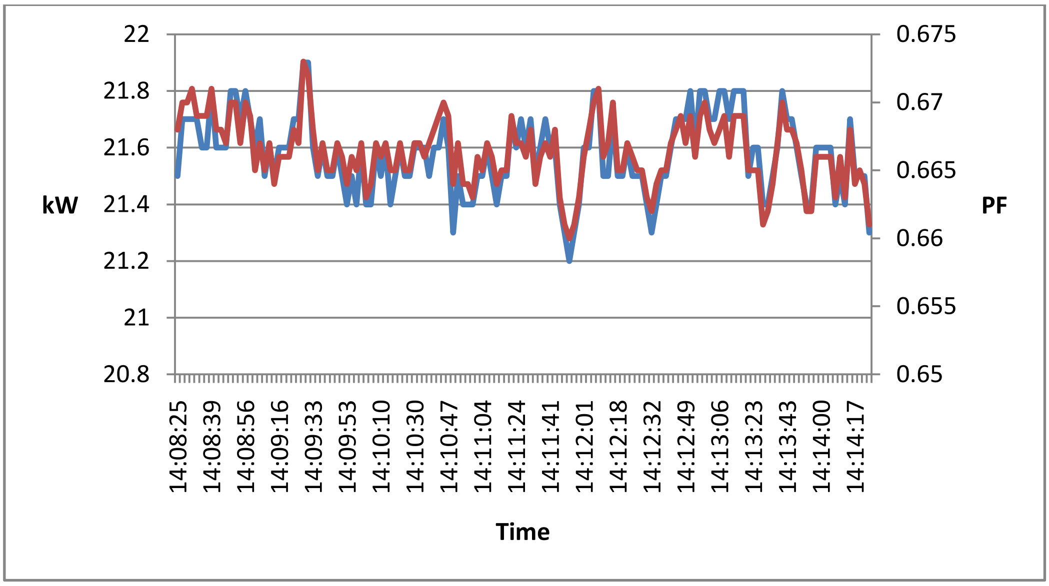

Figure 9: Load (kWh) and PF profile

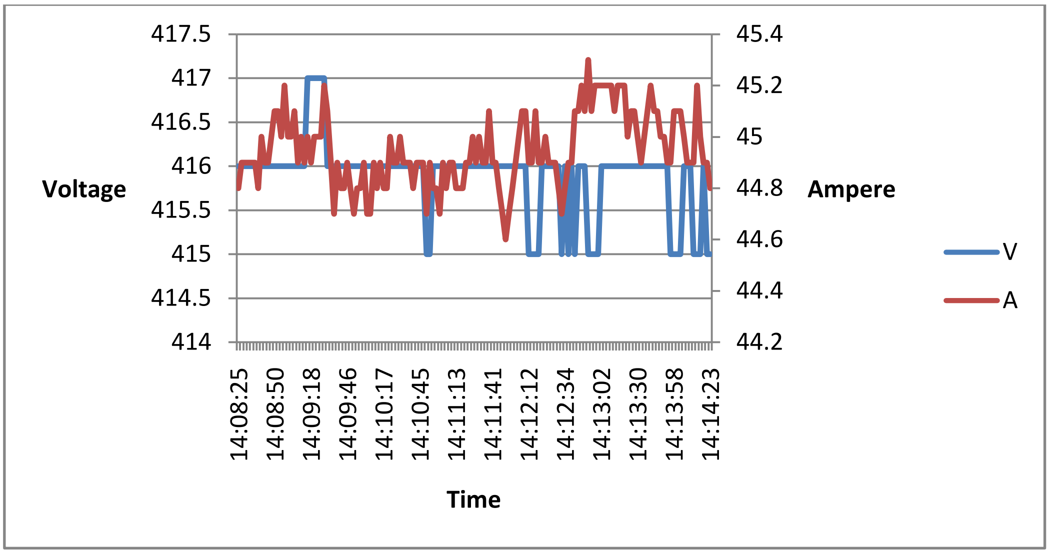

Figure 10: Voltage and Current profile

Following observations have been made:

Table 11: Diagnosis of electric supply

Name of Area	Present set-up	Observations during field study & measurements	Ideas for energy performance improvement actions
Electricity Demand	M.P. Paschim Kshetra Vidyut Vitaran supplies the required power to the unit through a transformer. The unit has a LT connection. The contract demand of the unit is 150 H.P	As per the electricity bill analysis, it was found that the electricity tariff was Rs. 7.1 / kWh and the PF according to the electricity bill was about 0.64.	No EPIAs suggested.
Power Factor	Unit has an LT connection and billing is in kWh. PF paid by the unit is as per the utility bill.	The average PF found during the measurement was 0.67 and maximum was measured as 0.67.	No EPIAs suggested.
Voltage variation	The unit has no separate lighting feeder and no servo stabilizer for the same.	The average voltage level of the unit was 416 V	No EPIAs suggested.

3.6.2 Electrical consumption areas

The equipment-wise consumption of electrical energy was measured in consultation with the unit. This is indicated in Table 6 of this report. Around 99% of energy consumption is for carrying out production operations and about 1 % is for the lighting.

Details of the observations, measurements conducted and ideas generated for energy conservation measures are as follows:

Name of Area	Present Set-up	Observations during field Study & measurements	Proposed Energy performance improvement actions

<table>
<tr><td>Main common motor of Raw material counter (kacha counter)</td><td>The main common motor for raw material section is of 10 H.P and there are 5 elevators, and 3 cleaners with fans connected to this motor through a common shaft and flat belts and pulleys.</td><td>Study was conducted on raw material main common motor during BEA.
The results of the study are as below:<table><tr><th>Machine</th><th>Avg. Volt</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Raw material motor</td><td>412</td><td>3.35</td><td>0.3</td></tr></table></td><td>Replacement of existing main common motor with EE motor is recommended</td></tr>
<tr><td>Finished material main common motor (pakka motor)</td><td>The main common motor for the finished material section is of 10 H.P and there are 8 elevators, 5 cleaners with fans and one fadfadiya machine connected to this motor.</td><td>Study was conducted on finished material main common motor during BEA.
The results of the study are as below:<table><tr><th>Machine</th><th>Avg. Volt</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Finished material motor</td><td>413</td><td>6.71</td><td>0.74</td></tr></table></td><td>Replacement of existing motor with EE motors is recommended</td></tr>
<tr><td>Emery Roll machines</td><td>There are 4 emery roll machines. They constitute 36% of total energy consumption. Each emery roll motor is rated for 15 HP.</td><td>At the time of BEA only one roll was in operation. The power analysis of this roll was done.
The results of the study are as below:<table><tr><th>Machine</th><th>Avg. Volt</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Emery roll</td><td>416</td><td>4.5</td><td>0.92</td></tr></table></td><td>Replacement of motor of all the 4 roll machines (rated for 15 H.P) with EE motors is recommended</td></tr>
<tr><td>Polisher machine</td><td>There are 2 polisher machines. During BEA, 1 machine was in operation. Each machine is rated for 15 HP each</td><td>During BEA, 1 machine was in operation. Power measurements of this machine was done as given in the table below:<table><tr><th>Machine</th><th>Avg. Volt</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Polisher</td><td>409</td><td>8.6</td><td>0.91</td></tr></table></td><td>Replacement of polisher machine motors (2 numbers) with EE motors is recommended.</td></tr>
<tr><td>FD fan of hot air generator –dryer. (dryer motors)</td><td>There is a FD fan (1 running and 1 standby) for supplying combustion air to the hot air generator of the dryer. It is rated for 10 H.P</td><td>During BEA, a power measurement of the running FD fan was done. The results of the study are as below:<table><tr><th>Machine</th><th>Avg. Volt</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>FD fan (hot air generator)</td><td>413</td><td>7.81</td><td>0.78</td></tr></table></td><td>It is recommended to replace both the fan motors with EE motors.</td></tr>
<tr><td>Dust collecting blower</td><td>There are two dust collecting blowers of 15 H.P rated power (each) for collecting dust from various machines</td><td>At the time of BEA. The power analysis of one blower was done. The second blower was not running. The results of the study are as below:<table><tr><th>Machine</th><th>Avg. Volt</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Dust collecting blower</td><td>413</td><td>8.10</td><td>0.74</td></tr></table></td><td>Replacement of both the blower motors with EE motors of same size is recommended.</td></tr>
</table>

3.6.3 Thermal consumption areas

As discussed in earlier sections, about 9% of total energy cost of the plant and 26% of the total energy usage was in the hot air generator of the dryer. The details of present set-up, key observations made and potential areas for energy cost reduction have been mentioned in the table below:

Name of Area	Present set-up	Observations during field study & measurements	Proposed Energy performance improvement actions
Hot air Generator	The fuel used for heating the air in the hot air generator is wood. The air required for combustion of wood in hot air generator was supplied by using the ID fan which was also performing the function of a FD fan	The amount of wood required for generating the requisite hot air for drying the dal was measured during BEA. The O_2 level in flue gases coming out of the hot air generator was about 15.7%. This reflects high amount of excess air supplied than required for efficient combustion. This also results in high heat loss due to dry flue gases. During the field study the surface temperature of the dryer was found to be 99.5°C which is high. This results loss of heat from surface of dryer due to radiation and convection.	Control of excess air supplied for combustion in hot air generator Insulation of flue gas duct is proposed

4 EE TECHNOLOGY OPTIONS AND TECHNO – ECONOMIC FEASIBILTY

During BEA of the plant, all energy consuming equipment and processes were studied. The analysis of all major energy consuming equipment and appliances were carried out, which have been already discussed in the earlier sections of this report. Based on the analysis, Energy Performance Improvement Actions (EPIAs) have been identified below:

4.1 EPIA 1: Replacement of old and inefficient motors with EE motors

Technology description

The new EE motors are more efficient than the old several times re-wound motors. They consume less power than the old motors resulting in energy savings.

Study and investigation

The unit has old and inefficient motors like 10 HP motors at raw material counter and finished material counter, 15 HP motors with emery rolls, 15 HP motors with polishers, 10 HP motors with dust collecting blowers.

Recommended action

It is recommended to replace these motors with new energy efficient motors. The cost benefit analysis for this energy conservation measure is given below:

Table 12: Cost benefit analysis (EPIA 1)

Particulars	Units	As Is	To Be
Rated capacity of main motor – Finished Material (Pakka) counter (1 number, 10 HP)	HP	10.00	10.00
Rated capacity of main motor – Raw Material (Kaccha) counter (1 number, 10 HP)	HP	10.00	10.00
Rated capacities of Emery Roll motors (4 numbers, 15 HP each)	HP	60.00	60.00
Rated capacities of Polisher motors (2 numbers, 15 HP each)	HP	30.00	30.00
Rated capacities of FD fan of hot-air-generator motor (Dryer motor); (2 numbers, 10 HP each)	HP	20.00	20.00
Rated capacities of dust collecting blower motor (2 numbers, 15 HP each)	HP	30.00	30.00
Total Rated kW of all motors	kW	119.36	119.36
Total power consumption by all the running motors	kW	39.08	33.61
Running hours per day	h / day	12	12
Running days per year	days / y	330	330
Total energy consumption	kWh / y	154,773	133,104
Total energy savings per year	kWh / y		21,668
Cost of electricity	Rs. / kWh	7.07	7.07
Total monetary savings per year	Rs / y		153,194
	Rs. Lakh / y		1.53

Estimated Investment for new EE motors (30 HP X 2 numbers + 20 HP X 1 number + 10 HP X 2 numbers + 1 HP X 2 numbers + 2 HP X 2 numbers); Total 9 number of motors	Rs. Lakh	4.02
Simple payback period	y	2.62

4.2 EPIA 2: Control of excess air supplied for combustion in hot air generator

Technology description

It is necessary to maintain optimum excess air levels in combustion air supplied for complete combustion of the fuel in hot air generator of dryer. The excess air levels are calculated based on oxygen content in the flue gases. The theoretical air required for combustion of any fuel can be estimated from the ultimate analysis of the fuel. All combustion processes require a certain amount of excess air in addition to the theoretical air supplied. Excess air supplied needs to be maintained at optimum levels, as too much of excess air results in excessive heat loss through the flue gases. Similarly, too little excess air results in incomplete combustion of fuel and formation of black colored smoke in flue gases.

In the wood fired hot air generator, fuel is fired with too much of excess air as can be estimated from the high amount of oxygen percentage in the flue gases. This result in formation of excess flue gases, taking away the heat produced from the combustion and increasing fuel consumption. This also results in formation of excess GHG emissions. It is suggested to control the combustion air being supplied by the induced draft fan (common ID and FD fan) by installing a flue gas analyzer on the flue gas duct and setting the oxygen content in flue gas to 5% by fixing the air-fuel ratio by manually adjusting the combustion air suction damper and maintaining fixed damper positions for different quantities of hot air generation requirements.

Study and investigation

At the time of BEA, it was found that there was no proper measurement and control system installed to maintain the optimum excess air levels. Fuel was fired by the existing combustion system on the hot air generator and no combustion air flow control mechanism was in place for maintaining proper combustion of the fuel. It was found that the oxygen level in the flue gases of the hot air generator was 15.67% which indicates very high excess air levels resulting in high heat loss due to dry flue gas from the hot air generator.

Recommended action

Since the unit is using wood fired hot air generator, the control of excess air is recommended by installing on-line flue gas (oxygen) level indicator on the flue gas duct and setting the oxygen content in flue gas to 5% by fixing the air-fuel ratio by manually adjusting the combustion air suction damper and maintaining fixed damper positions for different quantities of hot air generation requirements.

The cost benefit analysis of energy conservation measure is given below:

Table 13: Cost benefit analysis (EPIA 2)

Parameters	UOM	Present	Proposed
Oxygen level in flue gas	%	15.67	4.50
Excess air control	%	293.75	27.27
Flue gas temperature	^{0}C	118.00	118.00
Saving in fuel	With every 10% reduction in excess air leads to savings in fuel consumption by 1%		
fuel consumption per year	kg / y	11,595	8,505
Saving in fuel consumption per year	kg / y		3,090
Cost of fuel	Rs. / kg	7.00	7.00
Savings in fuel cost per year	Rs. Lakh / y		0.22
Running load of blower	kW	1.49	1.34
Operating hours per year	h / y	3,300.00	3,300.00
Electrical energy consumed per year	kWh / y	4,917	4,425
Savings in electrical energy per year	kWh / y		492
Savings in terms of cost of electrical energy per year	Rs. Lakh / y		0.03
Total savings per year	Rs. Lakh / y		0.25
Estimated investment	Rs. Lakh		0.85
Simple payback Period	y		3.39

4.3 EPIA 3: Refurbishing damaged insulation of flue gas ducts between hot air generator and air pre-heater

Technology description

Insulating the surface of flue gas ducts reduces the radiation and convection losses from its surface which in turn helps in savings of fuel fired in the hot air generator.

Study and investigation

The flue gas duct between hot air generator and air pre-heater (APH) has the average skin temperature of 99.5^{o}C

Recommended action

It is recommended to repair and re-insulate the damaged insulation portions of the flue gas duct surface to prevent convection and radiation losses. The cost benefit analysis for this energy conservation measure is given below:

Table 14: Cost benefit analysis (EPIA 4)

Particulars	Unit	As Is	To Be
Length of hot air generator surface	m	2.00	2.00
Width of hot air generator surface	m	0.20	0.20
Height of hot air generator surface	m	0.20	0.20
Average surface temperature of hot air	^{0}C	99.50	33.40

generator surface			
Ambient temperature	^0C	22.40	22.40
Total surface area of hot air generator (to be insulated)	m^2	1.68	1.68
Heat loss per hour from surface of hot air generator	kCal / h	1,795	195
Energy savings per hour by limiting heat loss from surface of hot air generator by refurbishing the damaged insulation	kCal / h	1,600	
Energy savings per year by limiting heat loss from surface of hot air generator by refurbishing the damaged insulation	kCal / y	5,374,812	
Annual Savings in fuel	kg / y	2,669	
Annual monetary savings	Rs. Lakh / y	0.19	
Estimated Investment	Rs. Lakh	0.55	
Pay Back	y	2.94	

5 LIST OF VENDORS

The details of empanelled local service providers with Bureau of Energy Efficiency, Ministry of Power, GoI for energy equipments are given in the table below:

Table 15 List of empanelled local service providers

S.No.	Name of Agency	Address	Name of Contact Person	Contact Number & Email ID	Technology Supplied
1	Bharmal Traders	20, Udhyog Puri, Nemawar Road, Indore, MP	Mr. Hatim Ali	9827023499; sales@bharmaltraders.com	Electrical & Thermal Engineering (Installation and commissioning)
2	V K Four Agencies Pvt. Ltd	9, Mangal Compound, MR-11, Near BMW / Jaguar Showroom, Dewas Naka, A.B.Road, Indore - 452010. MP	Mr. Kayton Thakkar / Mr. P.K.Jakhetia / Mr. Yogesh Jog	0731 - 4064919, 4065918, 4041603; Vk4apl@gmail.com, vkfourapl@airtelmail.in	ABB make motors, VFDs, Starters, Air compressors (Indo-air make), Pumps (KSB), spares
3	Prithvi Power Engineers Pvt. Ltd.	19/4, West Patel Nagar, New Delhi - 110008	Mr. Abhishek Vigh	0120-425688; prithvipowers@yahoo.com	O2 analyzers, VFDs (Yaskawa make), Control systems
4	Lloyd Insulations (India) Ltd.	Punjstar Premises, 2 Kalkaji Industrial Area, New Delhi - 110019	Mr. K.K.Mitra	011-30882874, 30882877; kk.mitra@lloydinsulation.com, lloyd@del2.vsnl.net.in	Insulation and Refractories
5	Wesman Thermal Engineering Processes Pvt. Ltd.	Wesman Centre, 8 Mayfair Road, Kolkata - 700019	Mr. Malay Ghosh	033-22908050; malay-ghosh@wesman.com	Gas burners, PLC based combustion control system, waste heat recovery, VFDs, Electrical Panels
6	Automation & general electric co.	Plot no. 151, A/B Scm, No. 94, Piplayahna Square (near ocean motor), Indore-452001; MP	Mr. Ashish Patidar	08458860001; 0731-8963996399; patidar@ageco.in	Electric motors - Havells and other makes

7	Yash Engineering & Services	151, Nyay Nagar, Sukhliya, Indore, MP	Mr. Yatendra Hande	0731-4032731; yashenggservices@gmail.com	Air compressor, VFD on air compressors
8	Patel Brothers	97, Ninas Choraha, Ujjain, MP	Mr. Khushwant Patel	0734-2551135; patelbrosujn@yahoo.co.in	Engineering, Installation and commissioning
9	Digital Marketing Systems Pvt. Ltd.	122, Kanchan Bagh, Indore - 452001, MP	Mr. Prafulla Jain	0731-3046800; prafulla@digitalcontrols.org	VFDs, PID controllers
10	PM Projects & Services Pvt. Ltd.	14-B, Ratlam Kothi, Near Hotel Omni Palace, Indore - 452001, MP	Mr. Milind Hardikar	09826052924; 0731-4046265; info@pmprojectsindia.com	Engineering, Design, Installation and commissioning; Thermal heating system, Automation
11	Emerald Infrastructure	76/24, Maksi Road Industrial Area, Behind R.C.Tiles, Ujjain - 456010, MP	Mr. Dharmendra Sharma	0734-2525896; 09926067886; dharm.sharmaa@gmail.com	Engineering, Fabricator, Installation & commissioning