BASELINE ENERGY AUDIT REPORT

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

HIRA INDUSTRIES

Industrial Area, Maksi Road
Ujjain
Madhya Pradesh

19-12-2015

Submitted to

ENERGY IS LIFE
BEE
CONSERVE IT

BUREAU OF ENERGY EFFICIENCY

4th Floor, Sewa Bhawan, R K Puram, Sector-I, New Delhi -110066

Submitted by

DESL

DEVELOPMENT ENVIRONERGY SERVICES LTD

819, Antriksh Bhawan, 22 Kasturba Gandhi Marg, New Delhi -110001
Tel.: +91 11 4079 1100 Fax : +91 11 4079 1101; www.deslenergy.com

DISCLAIMER

This report (including any enclosures and attachments) has been prepared for the exclusive use and benefit of the addressee(s) and solely for the purpose for which it is provided. Unless we provide express prior written consent, no part of this report should be reproduced, distributed or communicated to any third party. We do not accept any liability if this report is used for an alternative purpose from which it is intended, nor to any third party in respect of this report.

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 clusters” 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. Deepak Sanmukhani, Owner, for showing keen interest in the energy audit and also thankful to the management of M/s Hira Industries for their wholehearted support and cooperation for the preparation of this Base line 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. Mayank Patel, Secretary, Poha Parmal Nirmata Sangh, Ujjain, 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

Project Head	Mr. R. Rajmohan Chief Executive Officer
Team leader and co-coordinator	Mr. Suparno R. Majumdar Consultant
Team Members	Mr. Mithlesh Priya Analyst
	Mr. Prabhat Sharma Project Analyst
	Mr. B. Ram Suresh Project Analyst

CONTENTS

List of figures

List of Tables

ABBREVIATIONS

Abbreviations	Expansions
APFC	Automatic Power Factor Correction
BEE	Bureau of Energy Efficiency
CEA	Comprehensive Energy Audit
CFL	Compact Fluorescent Lamp
CRV	Chromium Vanadium
DESL	Development Environergy Services Limited
DG	Diesel Generator
EE	Energy Efficiency
EPIA	Energy Performance Improvement Action
FO	Furnace Oil
GEF	Global Environment Facility
HSD	High Speed Diesel
HVAC	Heating Ventilation and Air Conditioning
LED	Light Emitting Diode
LT	Low Tension
MD	Maximum Demand
MPPKVVCL	M.P. Paschim Kshetra Vidyut Vitaran Co. Ltd
MS	Mild Steel
MSME	Micro, Small and Medium Enterprises
MT	Metric Tons
MTOE	Million Tons of Oil Equivalent
MV	Mercury Vapour
No.	Number
PF	Power Factor
PID	Proportional-Integral-Derivative
PNG	Piped Natural Gas
R & C	Radiation & Convection
RE	Renewable Energy
SEC	Specific Energy Consumption
SEGR	Specific Energy Generation Ratio
SLD	Single Line Diagram
SME	Small and Medium Enterprises
VFD	Variable Frequency Drives

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.

As part of this project, DESL has been engaged to implement the project in the SME 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 industries 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 within 5 selected units of the cluster
- Identifying and proposing two energy efficient process technologies to BEE
- Identifying at least 5 local technology/service providers for 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 audit 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 Hira Industries
Constitution	Private Limited
MSME Classification	Small
No. of years in operation	NA
Address: Registered Office	Plot No:6/7,6/9,6/11,Industrial area Maksi road,Ujjain
Administrative Office	Plot No:6/7,6/9,6/11,Industrial area Maksi road,Ujjain
Factory	Plot No:6/7,6/9,6/11,Industrial area Maksi road,Ujjain
Industry-sector	Food
Products Manufactured	Poha (Rice flakes)
Name(s) of the Promoters / Directors	Mr. Deepak Sanmukhani

Baseline Energy Audit

The study was conducted in 3 stages:

- **Stage 1:** Walk through 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

The production process description is as follows:

Paddy used as raw material for production of poha is purchased from nearby food grains markets. The purchased paddy is cleaned in mega and vibro cleaners to remove the large sized and small sized sand particles which come along with the paddy. The cleaned paddy is then soaked in water for 1 day. The soaked paddy is roasted in rotating tunnel roaster for moisture reduction and to soften it. The softened paddy is then manually fed into the poha (press) machines where it is flattened and the husk cover of the paddy is removed by machining. The flattened raw poha is then conveyed to flaker machines for processing poha (rice) flakes. These rice flakes are then cleaned in cleaners and finally packed and dispatched.

Identified Energy Performance Improvement Actions (EPIAs)

The baseline energy audit covered all the equipment which were in operation during the time of field study. These processes require electrical and thermal energy. Saw dust (thermal energy) is used in roaster for roasting of paddy and constitutes 48% of the total energy cost of the unit. Major areas of electrical energy consumption in the unit are poha (press) machines. Measures proposed for reduction of electrical energy consumption include replacement of main motor of poha machine by smaller motors or retrofitting VFD on the poha motor. Measures proposed for reduction of thermal energy consumption (in rotating tunnel roaster for poha drying) includes reduction in dry flue gas loss, reduction in radiation and convection loss due to damaged insulation and from ash removal openings and reduction in losses due to un-burnts in ash due to incomplete combustion of fuel.

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

Table 2: Summary of EPIA

Sl. No.	Energy Performance Improvement Action (EPIA)	Annual energy savings	Annual energy savings	Investment cost	Monetary energy cost savings	Payback period
		kWh/y	Saw dust (kg/y)	Rs. Lakh	Rs. Lakh	y
	Press machine and flaker machine					
1	Installation of VFD and replacement with new EE motor for press machine	30,805	-	10.10	2.56	3.94
2	Installation of VFD and replacement with new EE motor for flaker machine	6,267	-	1.89	0.54	3.47
3	Installation of geared box and replacement with new EE motor for conveyor motor	2,480	-	0.49	0.22	2.25
4	Replacement of existing compressor with energy efficient compressor system	3,375	-	1.62	0.29	5.54
5	Replacement of existing FSS unit with servo driven FSS unit	3,133	-	0.58	0.27	2.14
6	EE in roaster process: (VFD on feed role & vibro motor, temperature sensor in roaster, moisture sensor for paddy, handheld meter for process calibration, and replacement of FD fan motor with EE motor)	467	17,235	2.16	0.90	2.39
7	Installation of VFD on roaster motor	1,762	-	0.51	0.15	3.32
8	Installation of EE motor on chalani machine	522	-	0.13	0.05	2.97
9	Refurbishing the insulation with glass wool and MS sheet of rotating tunnel roaster		13,367	1.92	0.67	2.87
10	Cover the ash removal gate with MS sheet insulated door		6,138	0.13	0.31	0.44
11	Fuel shift from saw dust based to gas based in roaster		-	7.00	1.98	3.54
	Total	**48,813**	**36,740**	**19.53**	**5.96**	**3.28**

- Energy cost savings from fuel shift has not been considered in total values
- With the implementation of these EPIAs, overall cost savings of Rs. 5.96 Lakh 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 for Baseline Energy Audit (BEA)

The general scope of work for base line 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 equipments 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
- Classification of parameters related to EE enhancements such as estimated quantum of energy savings, investment required, time frame for implementation, payback period, re-skilling of existing manpower.

1.3 Methodology

1.3.1 Boundary parameters

Following boundary parameters were set for the baseline 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:

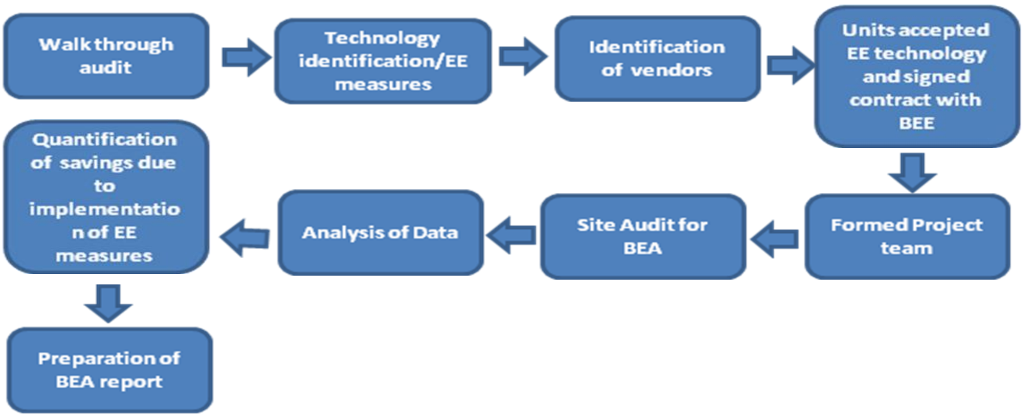

Figure 1: General Methodology

The study was conducted in following 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 MuUs 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 Base line energy audit – field assessment

A walk around was carried out before the baseline 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 unit'' 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:

- Main motors of poha machines
- Rotating tunnel (poha) roaster

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 equipment
- Conducting field testing and measurement
- Data analysis for preliminary estimation of savings potential at thesite
- 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
1	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
2	Power Analyzer – 3 Phase (for balance load) with 1 CT and 2 PT	Elcontrol Energy	Nanovip plus mem	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 2 sec interval
3	Flue Gas Analyzer	Kane-May	KM-900	O2%, CO2%, CO in ppm and Flue gas

				temperature, Ambient temperature
4	Digital Temp. & Humidity meter	Testo	610	Temp. & Humidity
5	Vane Type Anemometer	Testo	410	Air velocity
6	Digital Infrared Temperature meter	Raytek	Minitemp	Distant Surface Temperature

1.3.4 Baseline energy audit – desk work

Post audit off-site work carried out included:

- Re-validation 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 Hira industries
2	Constitution	Private Limited
3	Date of incorporation / commencement of business	NA
4	Name of the contact person Mobile/Phone No. E-mail ID	Mr. Deepak Sanmukhani +91 – 9425092919 Hiraindustries.ujjain@gmail.com
5	Address of the unit	Plot No:6/7,6/9,6/11,Industrial area Maksi road,Ujjain
6	Industry / sector	Food
7	Products manufactured	Poha (Rice flakes)
8	No. of operational hours	10
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

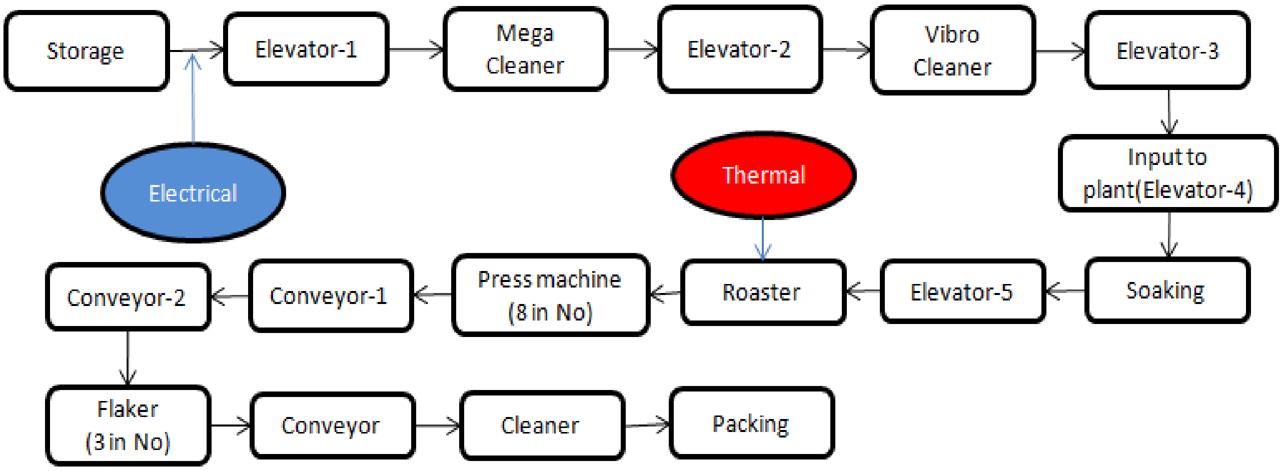

Figure 2: Production flow diagram

3.1.2 Process description

M/s Hira Industries, Ujjain is a poha manufacturing unit. The process description is as follows:

Paddy is used as raw material for production of poha. Raw material is purchased from nearby food-grain markets. Purchased raw material is conveyed to mega cleaner to remove huge sand particles which come along with the paddy from fields. After removal of larger sized sand particles in the mega cleaner, the smaller sized sand particles are removed from the paddy in a vibro cleaner. Post cleaning, the paddy is soaked in water for 24 hours. The soaked paddy is heated in a roaster for removal of moisture and to soften it. The roasted paddy is transferred manually to the poha machines where the paddy is flattened and the husk is removed from the softened paddy. Then the material is processed in the flaker followed by cleaner to produce poha (rice flakes) which is then packed and dispatched.

3.2 Inventory of process machines / equipment and utilities

Major energy consuming equipments in the plant are:

- **Mega cleaner:** Mega cleaner is used for removing sand particles present in the Raw paddy
- **Vibro Cleaner:** Vibro cleaner is used for removing tiny sand particles present in the Raw paddy
- **Roaster:** The roaster is used for roasting of paddy in which the moisture content in the paddy is reduced from about 45% to approximately 35%.
- **Poha Machine:** The poha machine is used to flatten the paddy and remove the husk from the paddy.

- **Flaker:** Flaker machine is used for further pressing of grains.
- **Cleaner:** This machine is used to remove dust particles in the poha produced.
- **Compressor:** It is used to supply compressed for packing machine.

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 usage pattern in the unit is as follows:

- Electricity is obtained from one source:
  - From the utility, M.P. Paschim Kshetra Vidyut Vitaran Co. Ltd
- Thermal energy is used for following applications:
  - Saw dust in roaster

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

Table 5: Energy cost distribution

Particulars	Energy cost distribution		Energy use distribution	
	Rs. Lakh	% of Total	MTOE	% of Total
Grid –electricity	24.0	52	24	14
Thermal – Saw dust	22.2	48	146	86
Total	**46.2**	**100**	**169.6**	**100**

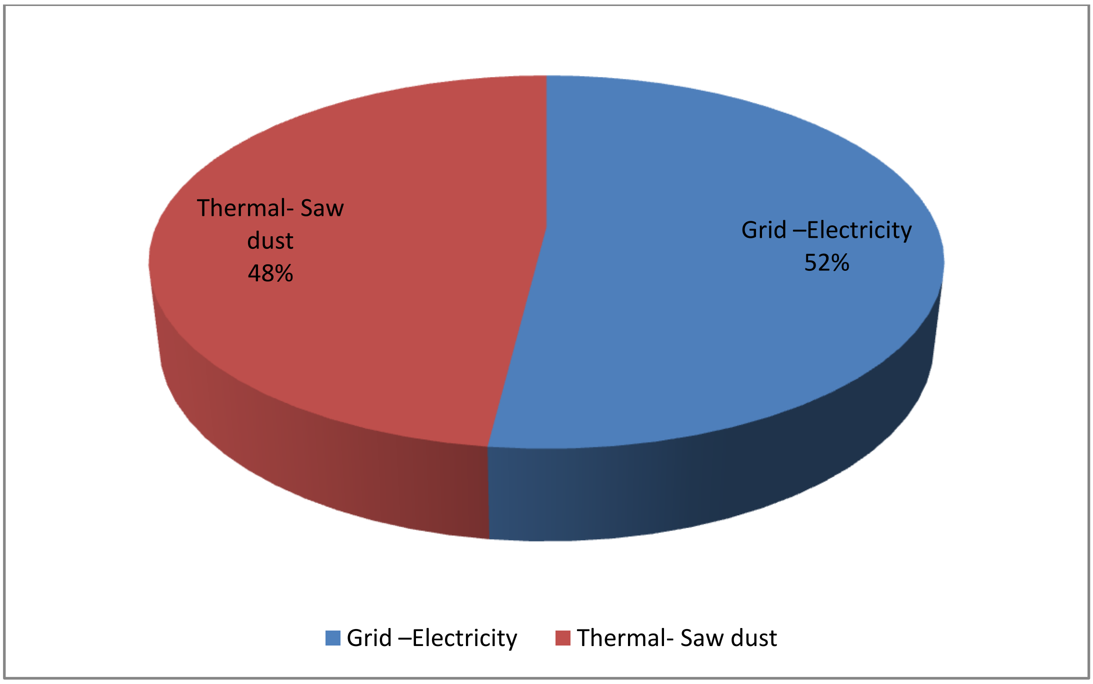

Figure 3: Energy cost share

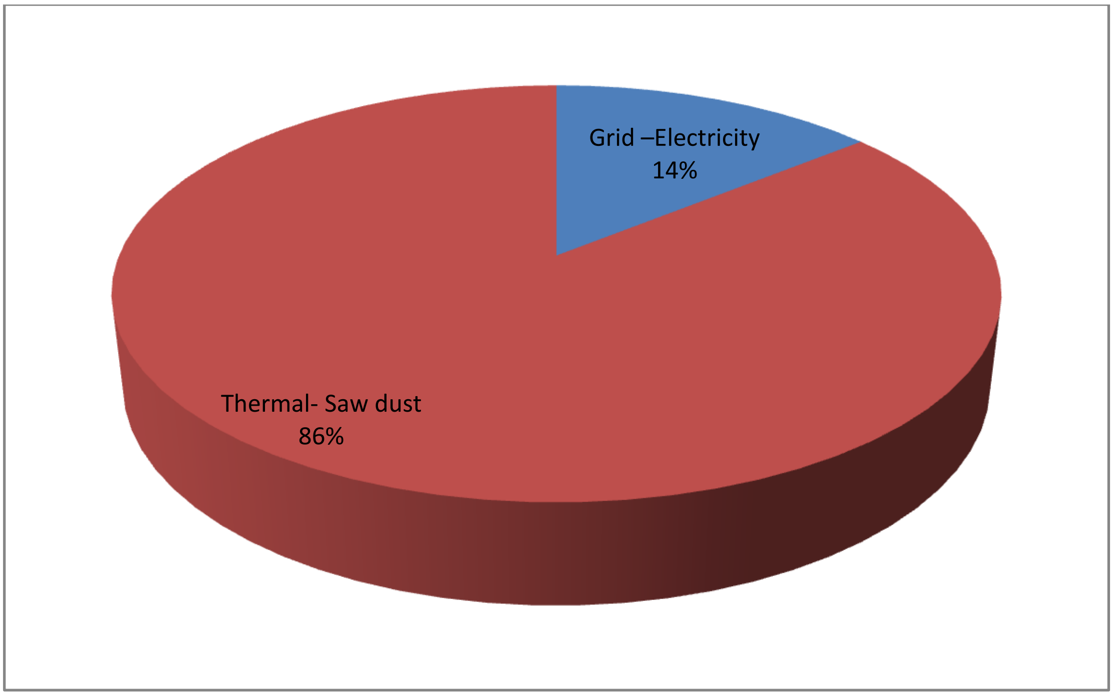

Figure 4: Energy use share

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 the form of saw dust, which is used for roasting process.
- Saw dust used in roaster accounts for 48% of the total energy cost and 86% of overall energy consumption.
- Electricity used in the process accounts for 52% of the energy cost and 14% of overall energy consumption.

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 102 kW
- The utility load is about 11.23 kW and the single phase load (lighting) is about 2 kW

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

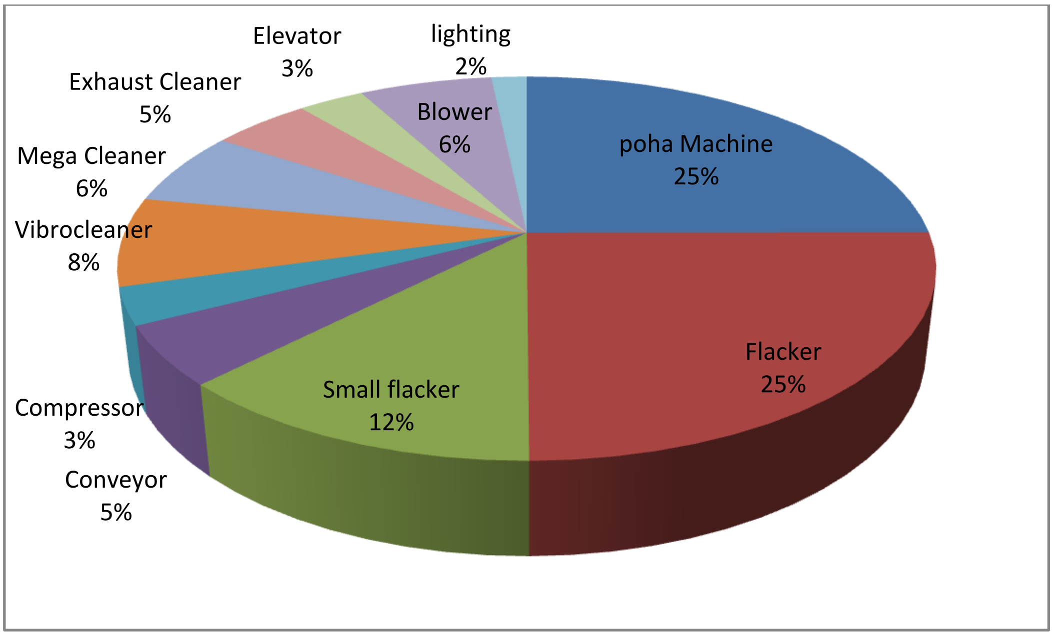

Figure 5: Details of connected load

As shown in the above pie chart, the connected load is divided between poha machine – 25%, flaker– 25%, small flaker– 12%, conveyor-5%, compressor – 3%, vibro cleaner – 8%, mega cleaner-6%, exhaust cleaner-5%, blower-6% and elevators contribute around 3% of the connected load.

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 Sharing
Poha machine	34%
Flaker	9%
Small flaker	11%
Conveyor	6%
Compressor	4%
Vibro cleaner	10%
Mega cleaner	8%
Exhaust cleaner	7%
Elevator	4%
Blower	5%
Lighting	2%
Total	**100%**

This is represented graphically in the figure below:

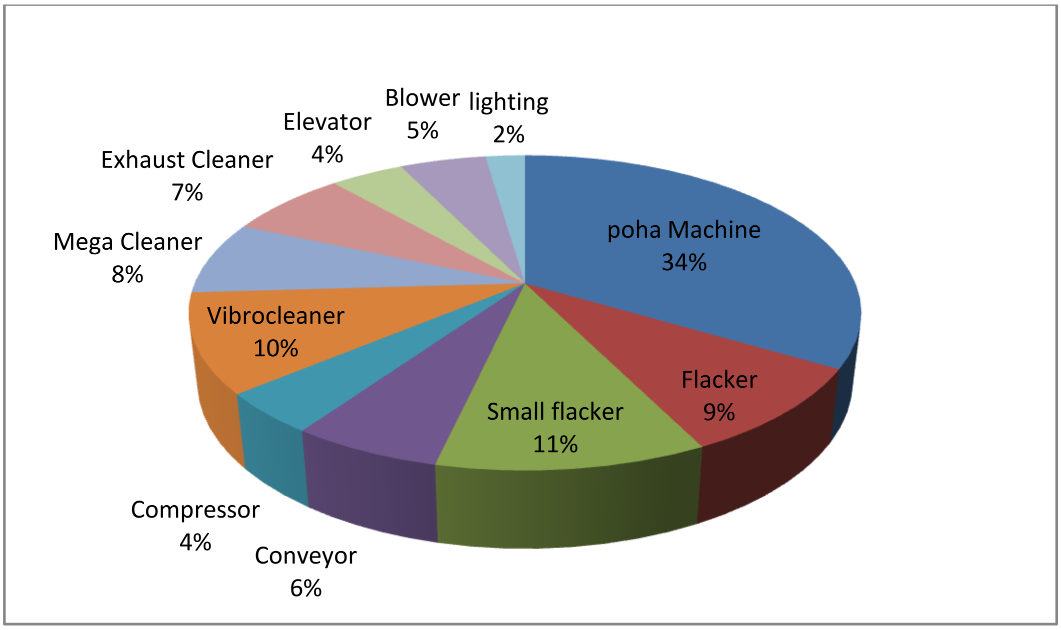

Figure 6: Area wise electricity consumption

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:

- 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 about Rs. 24 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 HT energy meter provided by the distribution company within its premises. Details of the supply are as follows:

a) Power Supply : 11 kV line
b) Contract Demand : 150 kVA
c) Nature of Industry : LT – G

The tariff structure is as follows:

Table 7: Tariff structure

Particulars	Tariff Structure	
Present energy charge	5.75	Rs./kWh
Electricity duty	0.87	Rs./kWh

TOD rebate	0.87	Rs./kWh
TOD surcharge	2.9	Rs./kWh
FCA Charge	0.04	Rs./kWh

(As per Nov-2015 bill)

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

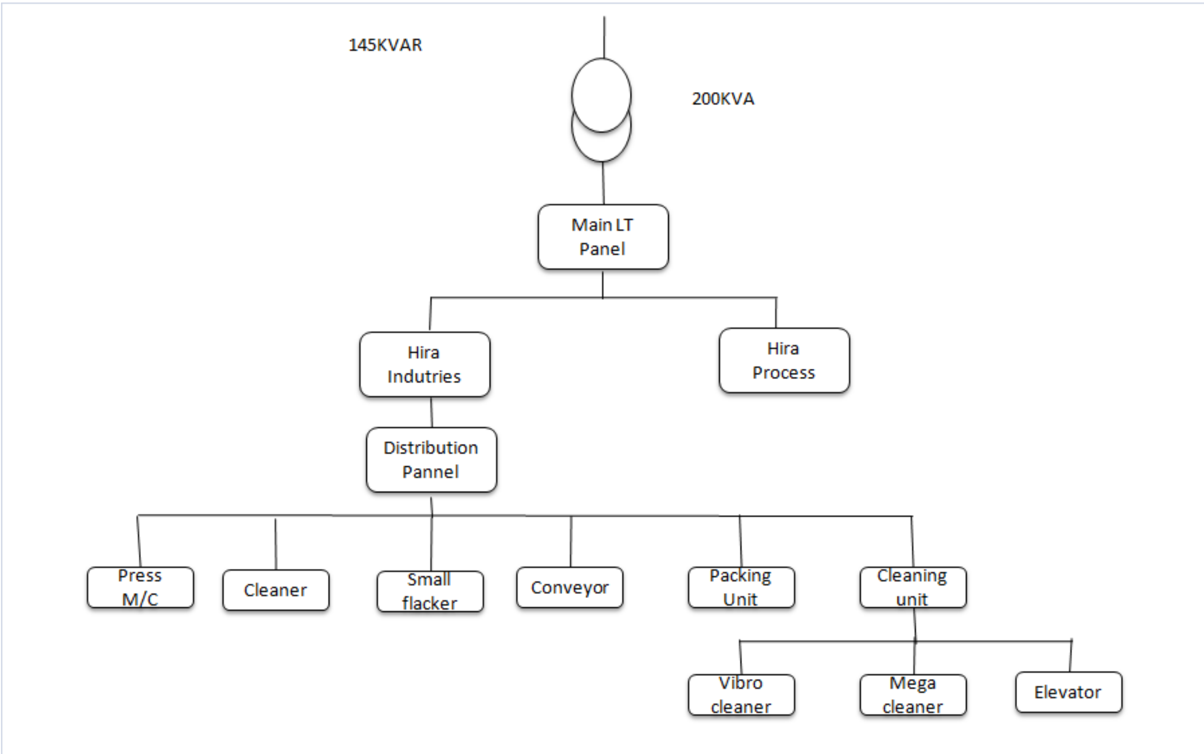

Figure 7: SLD of electrical load

Power factor

The power factor of the unit varies from 0.87 to 0.99 according to electricity bill. However, during the energy audit study, measurement of the power factor was done by logging the main incomer. The average power factor measured was found to be 0.96 with the maximum being 1.

3.3.4 Month wise electricity consumption and poha production

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

Table 8: Electricity consumption & cost

Months	Electricity	Cost
	Grid (kWh)	**Grid (Rs.)**
Jan-15	15,038	248,501
Feb-15	14,819	129,248
Mar-15	15,228	128,990
Apr-15	33,906	236,444
May-15	45,680	319,018

Jun-15	38,921	286,622
Jul-15	18,513	178,083
Aug-15	18,323	168,463
Sep-15	17,613	170,899
Oct-15	19,406	171,892
Nov-15	18,396	161,866
Dec-15	23,258	200,002
Total	**279,098**	**2,400,028**

The month wise poha production for the year 2015 is given in the figure below.

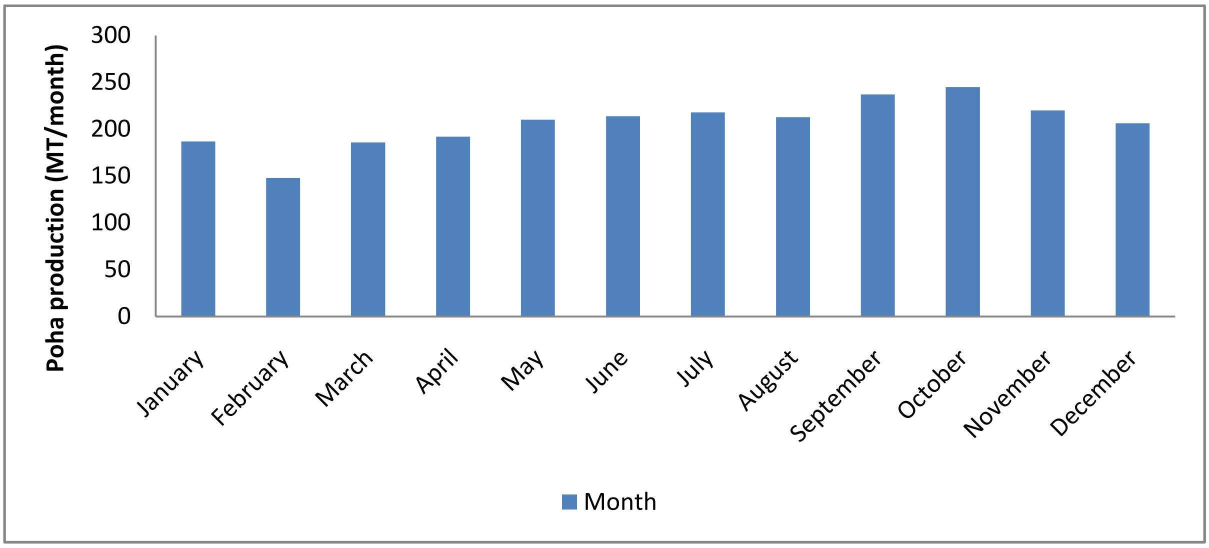

Figure 8 : Month wise poha production for 2015

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

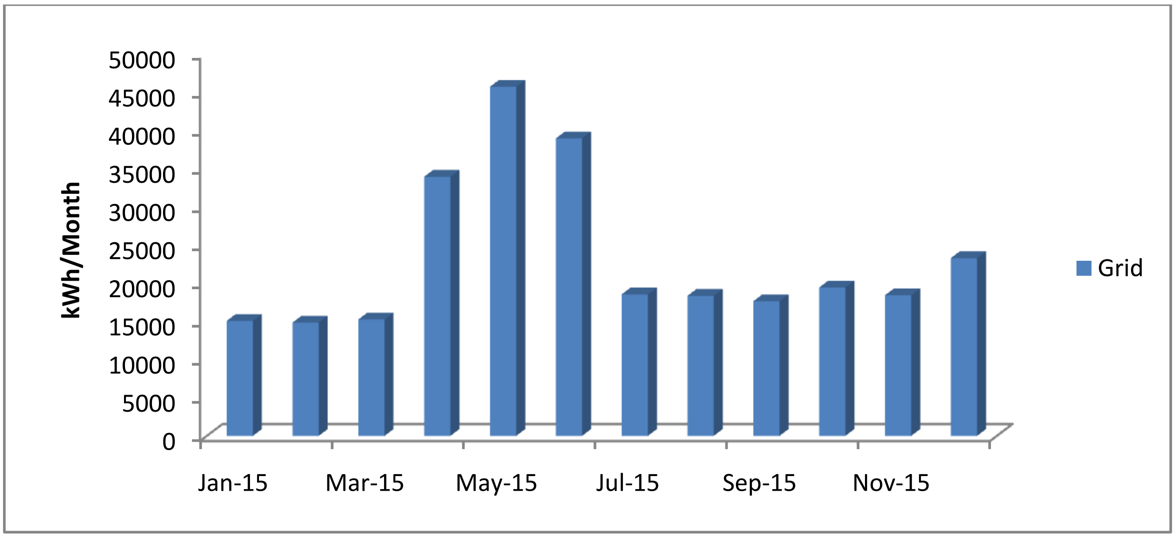

Figure 9: Month wise variation in electricity consumption from different sources

As shown in figure above, the consumption of electrical energy was on the higher side during the months of May and June 2015. However, the electricity consumption during the month of Feb- 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:

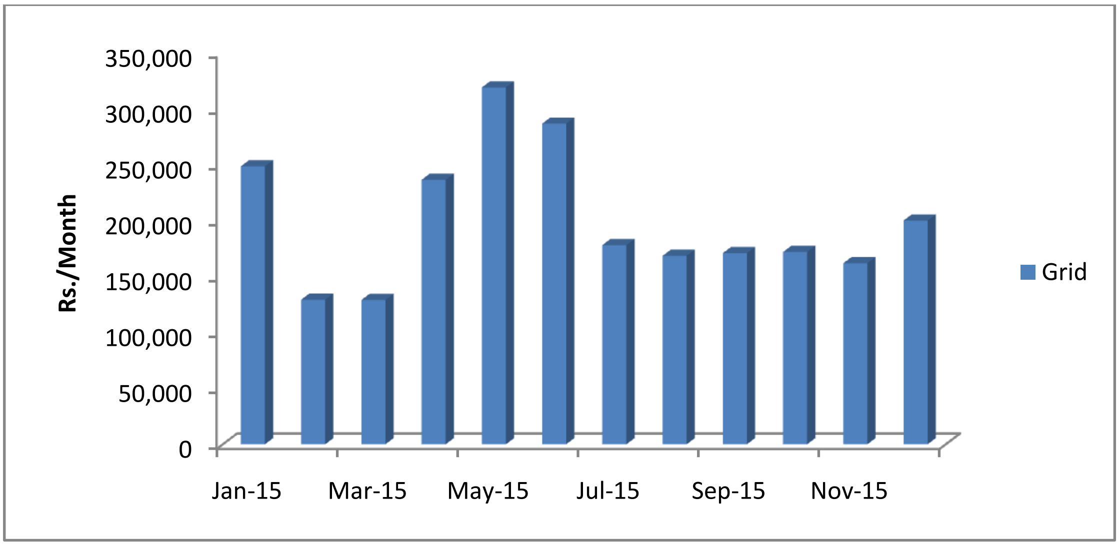

Figure 10: Month wise variation in electricity cost from different sources

3.4 Analysis of thermal consumption by the unit

Fuel used for roaster is saw dust which is bought at the rate of Rs. 5/kg. There is no provision for measurement of Saw dust consumption in the Roaster. Annual saw dust consumption is 431 MT costing Rs. 2,219069.45.

3.5 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. ***It is to be noted here that though annual production value was provided, the monthly data for the same was not provided by the unit.***

Table 9: Overall specific energy consumption

Parameters	Unit	Value
Annual grid electricity consumption	kWh	279,098
Annual DG generation unit	kWh	0
Annual total electricity consumption	kWh	279,098
Annual thermal energy(saw dust) consumption	MT	431
Annual Energy Consumption; MTOE	MTOE	170
Annual energy cost	Lakh Rs.	46.2
Annual production	MT	2,476
SEC; Electrical	kWh/MT	112.7
SEC; Thermal	MT/MT	0.17
SEC; Overall	MTOE/MT	0.07
SEC; Cost Based	Rs./MT	1,865

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
  - 1koe : 10,000 kCal
- GCV of saw dust : 3,380 kCal/ kg
- GCV of LPG : 12,500 kCal/kg
- CO_2 Conversion factor
  - Grid : 0.89 kg/kWh
  - Saw dust : 1.64 tons/ ton

3.6 Baseline parameters

Following are the general baseline parameters, which have been considered for the 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	5.75
Weighted average electricity cost	Rs./ kWh	8.68
Annual operating days	days	300
Operating hours per day	h	10
Production	MT/Y	2,476
GCV of grid electricity	kCal/kWh	860
GCV of grid electricity	kCal/kWh	860
Saw dust cost	Rs. /kg	5
GCV of saw dust	kCal/kg	3,380
Cost of LPG	Rs./kg	51
GCV of LPG	kCal/kg	12,500
CO_2 emission factor - grid	kg/kWh	0.89
CO_2 emission factor - saw dust	tons/ton	1.64

3.7 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 / equipments were recorded, and energy efficiency improvement actions proposed after the WTA was substantiated with measured data. Summary of key observations is as follows:

3.7.1 Electricity supply from grid

The electrical parameters at the main electrical incomer feeder from M.P. Paschim Kshetra Vidyut Vitaran Co. Ltd that supplies power to the unit were recorded by using the portable power analyzer instrument.

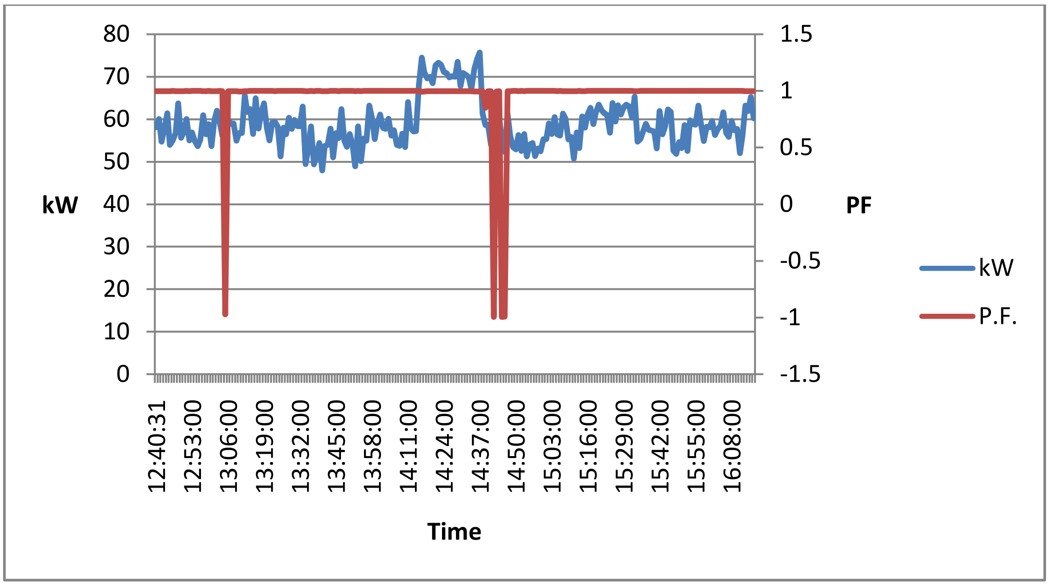

Figure 11: Load (kWh) and PF profile

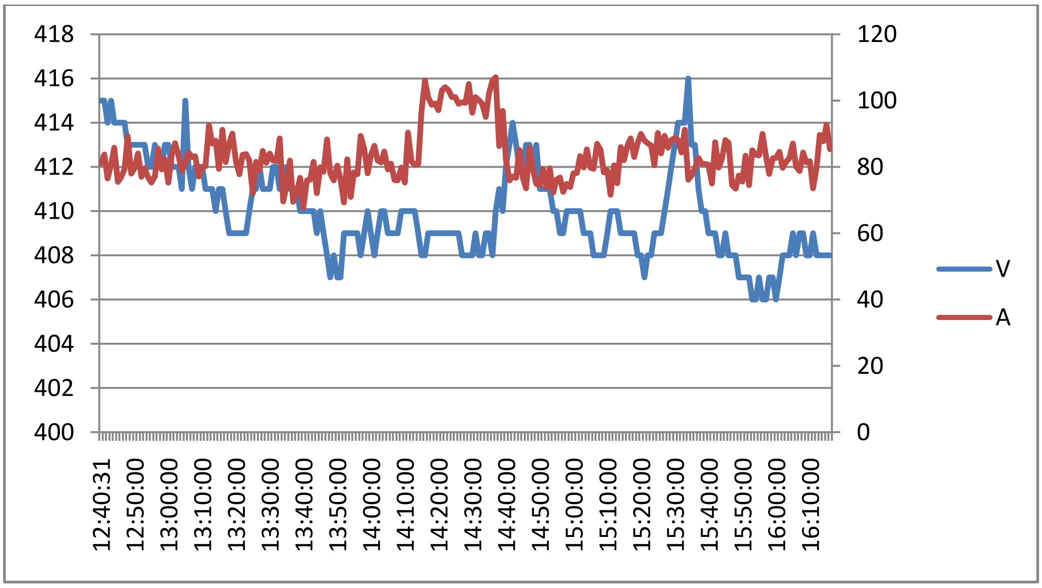

Figure 12: Voltage and current profile

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 HT connection. The contract demand of the unit is 150 kVA and sanctioned load is 143 kW.	As per the electricity bill analysis, it was found that the electricity tariff was Rs. 5.75/kWh, Weighted average electricity cost was Rs. 8.68/kWh and the PF according to the electricity bill was about 0.944.	No EPIAs suggested.
Power	Unit has an HT connection (11 kV –	The average PF found during the	No EPIAs suggested.

Factor	440 V) and billing is in kWh. PF paid by the unit is as per the utility bill.	measurement was 0.96 and maximum was measured as 1.	
Voltage variation	The unit has no separate lighting feeder and no servo stabilizer for the same.	The voltage profile of the unit was satisfactory and it is about 410V	No EPIAs suggested.

3.7.2 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 98% of energy consumption is for carrying out production operations and about 2% is for the lighting.

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

<table>
<tr><th>Name of Area</th><th>Present Set-up</th><th>Observations during field Study & measurements</th><th>Proposed Energy performance improvement actions</th></tr>
<tr><td>Poha machines</td><td>There are 8 poha machines. Machines 1,2,3 and 4 are operated by motor-1 and machines 5,6,7 and 8 are run by motor-2</td><td>Study was conducted on both of the poha machines.
The results of the study are as below:
<table>
<tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr>
<tr><td>Motor-1 (Poha M/C-1,2,3&4)</td><td>14.69</td><td>0.77</td></tr>
<tr><td>Motor-2 (poha M/C-5,6,7&8)</td><td>16.43</td><td>0.8</td></tr>
</table></td><td>Replacement of existing common motors of poha machines with EE motors of same rating and installation of VFD is recommended</td></tr>
<tr><td>Flaker</td><td>There are three flaker machines. They constitute 20% of total energy consumption.</td><td>The study was conducted on all 3 machines.
The results of the study are as below:
<table>
<tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr>
<tr><td>Big flaker</td><td>8</td><td>0.84</td></tr>
<tr><td>Small Flacker-1</td><td>5.19</td><td>0.69</td></tr>
<tr><td>Lathe m/c #3</td><td>4.43</td><td>0.70</td></tr>
</table></td><td>Replacement of flaker motors with EE motors of same size and retrofitting VFDs with them is proposed</td></tr>
<tr><td>FD fan for roaster</td><td>There is a FD fan for supplying air for combustion of saw dust in roaster</td><td>The study was conducted on FD fan.
The results of the study are as below:
<table>
<tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr>
<tr><td>FD fan</td><td>1</td><td>0.57</td></tr>
</table></td><td>Replacement of FD fan motor with EE motor of same size and VFD.</td></tr>
<tr><td>Conveyors</td><td>There unit has 5 conveyors, each rated for 1 HP.</td><td>The study was conducted on one conveyor motor. The results of the study are as below:
<table>
<tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr>
<tr><td>Conveyor</td><td>0.62</td><td>0.92</td></tr>
</table></td><td>Replacement of present conveyor motors with EE motors of same size and coupled with gearbox is suggested</td></tr>
</table>

3.7.3 Thermal consumption areas

As discussed in earlier sections, about 89% of total energy cost of the plant and 89% of the total energy usage is in the roaster. 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
Roaster	The fuel used for roasting the paddy in Roaster is saw dust. The air supplied for combustion of saw dust in roaster is supplied by electrical driven blower (FD fan).	There was no metering system available for - measuring saw dust consumption, combustion air flow and pressure, flue gas parameters. The O_2 level in flue gases coming out of the roaster was about 11%. 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. The surface temperature of the roaster was very high varying from 68 to 148°C. This results in high heat loss from surface of the roaster. There were 2 ash removal holes which also doubled up as inspection holes for the roaster. Both the holes were of dimensions of 90 cm x 60 cm. It was observed that the holes were open throughout the operation of the roaster and resulted in high amount of heat loss due to radiation. High levels of un-burnt were found in ash and also color of flue gas was black. This reflects incomplete combustion of fuel.	Excess air control with PID controller is proposed Insulation of the Roaster skin is proposed It is suggested to close the ash removal holes for some periods of time using doors, when ash is not being removed. To improve the combustion efficiency shifting to FBC is proposed

4 EE TECHNOLOGY OPTIONS AND TECHNO–ECONOMIC FEASIBILITY

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 earlier sections of this report.

Based on the analysis, Energy Performance Improvement Actions (EPIAs) have been identified and are discussed below:

4.1 EPIA 1: Installation of VFD with new EE motor on press machine-1 &2

Technology description

Installation of VFD on a motor reduces the total power consumption of the motor to about 10% by reducing the power consumption while unloading. The installation of energy efficient motor instead low efficiency motor will increase the utilization of electrical energy.

Study and investigation

The unit has 8 poha/press machines and two motors run 4 machines each which were running at partial loading conditions during the study. The loading pattern of each of the poha machine depends on operator efficiency and output from the roaster. The energy efficiency rating of installed motor in press machine is very low and installed with re-wound coil. The energy consumption by the motor is very high and utilization of input electrical energy is very low because of low efficiency rating of motor.

Recommended action

It is recommended to install VFD on all poha machine motors to decrease their power consumption during unloading periods and for reduction of annual power consumption of the motors. It is also recommended to install energy efficient motor instead of existing motor.

The cost benefit analysis for this energy conservation measure is given below:

Table 12: Cost benefit analysis - retrofit VFD with poha machine motors (EPIA 1.1)

Parameters	Unit	Motor-1		Motor-2	
		As Is	To Be	As Is	To Be
Motor Rating	kW	30	30	30	30
Average power consumption during loading	kW	18	-	18	-
Average power consumption during unloading	kW	11	-	11	-
On Load time in percentage	%	50	-	74	-
Off Load time in percentage	%	50	-	26	-
Average power consumption	kW	15	12	16	14
No of operating hours per day	h/d	10	10	10	10
Operating days per year	day/y	300	300	330	330
Average electricity consumption per year	kWh/y	44,055	37,447	54,233	46,098
Annual electricity saving per year	kWh/y	6,608		8,135	
W. Average Electricity Tariff	Rs./kWh	8.68		8.68	

Annual monetary savings	Lakh Rs./y	0.57	0.71
Estimate investment for the VFD on motor	Lakh Rs.	2.71	2.71
Simple Payback	Y	4.72	3.84

Table 13: Cost benefit analysis - replace existing poha machine motors with EE motors (EPIA 1.2)

Parameters	UOM	Motor-1		Motor-2	
		As is	To be	As is	To be
Rated power given on poha machine motor	kW	29.80	29.8	29.80	29.8
Efficiency of motor	%	79.00	90	79	90
Average Load	kW	20.86	18	21	18
Net Power Saving	kW	2.55		2.55	
Running Hours	h/y	3000		3300	
Annual energy savings	kWh/y	7649		8414	
Avg. weighted cost	Rs./kWh	8.68		8.68	
Investment	Lakh Rs.	2.34		2.34	
Monetary savings	Lakh Rs.	0.66		0.73	
Simple payback	Y	3.52		3.20	

4.2 EPIA 2: Replace existing big flaker machine motor with EE motor and retrofit with VFD

Technology description

Installation of VFD on a motor reduces the total power consumption of the motor to about 10% by reducing the power consumption while unloading. The installation of energy efficient motor instead low efficiency motor will increase the utilization of electrical energy.

Study and investigation

The unit has two flaker machines, one small and one big. The capacity of motor of big flaker machine is 15 HP which was running at partial loading conditions during the study. The loading pattern of each of the flaker machines depends on operator’s efficiency and output from the roaster. The energy efficiency rating of installed motor in press machine is very low and installed with re-wounded coil. The energy consumption by the motor is very high and utilization of input electrical energy is very low because of low efficiency rating of motor.

Recommended action

It is recommended to install VFD on motors of the flaker machines to decrease their power consumption during unloading periods and for reduction of annual power consumption of the motors. It is also recommended to install energy efficient motor instead of existing motor.

The cost benefit analysis for this energy conservation measure is given below:

Table 14: Cost benefit analysis – retrofit VFD with big flaker machine motor (EPIA 2.1)

Parameters	Unit	As Is	To Be
Motor rating for flaker machine	kW	11	11
Average power consumption	kW	8	6.8
No of operating hrs per day	h/day	10	10
Operating days per year	days/y	300	300
Average electricity consumption per year	kWh/y	24,000	20,400
Annual electricity saving per year	kWh/y	3,600	
W. average electricity tariff	Rs/kWh	8.68	
Annual monetary savings	Lakh Rs./y	0.31	
Estimate of investment for VFD	Lakh Rs.	1.02	
Simple Payback	Y	3.25	

Table 15: Cost benefit analysis – replace existing flaker machine motor with EE motor(EPIA 2.2)

Parameters	UOM	As Is	To be
Rated power given on flaker machine motor	kW	11	11
Efficiency of motor	%	80.00	90
Average load	kW	8.00	7
Net power savings	kW	0.89	
Running Hours	h/y	3000	
Annual energy savings	kWh/y	2667	
Avg. weighted cost	Rs./kWh	8.68	
Estimated investment for EE motor	Lakh Rs.	0.87	
Monetary savings	Lakh Rs.	0.23	
Simple payback	Y	3.75	

4.3 EPIA 3: Replace existing conveyor motors with EE motors and retrofit with gear box

Technology description

Installation of gear box on a motor reduces the total power consumption of the motor to about 10% by reducing the power consumption while lower loading periods. The installation of energy efficient motor instead low efficiency motor will increase the utilization of electrical energy.

Study and investigation

The unit has 5 conveyor motors installed for conveying the raw material. During the study, it was found that motors were running at partial loading. The loading pattern of each of the conveyor motor depends on operator efficiency and amount of material conveying from the conveyors. The energy efficiency rating of installed motor in conveyor motor is very low and installed with re-wounded coil. The energy consumption by the motor is very high and utilization of input electrical energy is very low because of low efficiency rating of motor.

Recommended action

It is recommended to install VFD on each conveyor motor to decrease their power consumption during unloading periods and for reduction of annual power consumption of the motors. It is also recommended to install energy efficient motor instead of existing motor.

The cost benefit analysis for this energy conservation measure is given below:

Table 16: Cost benefit analysis – replace existing conveyor motors with EE motors (EPIA 3.1)

Parameters	UOM	As is	To be
Total number of motors	kW	5	5
Capacity of each motor	kW	0.746	0.46
Rated power given on conveyor motor	kW	4	4
Efficiency of motor	%	75.00	90
Average Load	kW	2.61	2
Net Power Saving	kW	0.44	
Running Hours	hours/y	3000	
Annual energy savings	kWh/y	1306	
Avg. weighted cost	Rs./kWh	8.68	
Estimated investment for EE motor	Lakh Rs.	0.29	
Monetary savings	Lakh Rs.	0.11	
Simple payback	Y	2.58	

Table 17: Cost benefit analysis – Retrofit gear box with existing conveyor motors (EPIA 3.2)

Parameters	Unit	As Is	To Be
Total number of motor	kW	5	5
Capacity of each motor	kW	0.746	0.46
Motor rating for conveyor motor	kW	4	4
Average power consumption	kW	3	2.22
No of operating hours per day	Hrs/d	10	10
Operating days per year	Days/Y	300	300
Average electricity consumption per year	kWh/Y	7,833	6,658
Annual electricity savings per year	kWh/Y	1,175	
W. average electricity tariff	Rs/kWh	8.68	
Annual monetary savings	lakh Rs/y	0.10	
Estimate of investment	Lakh Rs	0.19	
Simple Payback	Y	1.90	

4.4 EPIA 4: Replacement of old reciprocating compressor with new EE screw compressor

Technology description

Replacement of old reciprocating compressor with new compressor. The compressor has been installed for the packaging section and higher un-loading period for a cycle.

Study and investigation

The unit has compressed air application in FFS unit for packaging the final material into bags. There is requirement of continuous application of compressed air for packaging. The compressor unloading period and the power consumption were very high for small period of time or a cycle. The leakage in compressed air network near the machine was high.

Recommended action

It is recommended to replace the existing compressor with new energy efficient screw compressor. The new screw compressor will have better specific energy consumption (SEC) of 0.18 kW / CFM whereas the present reciprocating type compressor had a SEC of over 0.24 kW / CFM. Further, the new screw compressor is sufficient for delivering the sufficient air application in to process with lower power consumption. The cost benefit analysis for this energy conservation measure is given below:

Table 18: Cost benefit analysis (EPIA 4)

Particulars	UOM	As Is	To be
Type of compressor	Type	Reciprocating	Screw Compressor
Installed motor capacity	kW	5.00	5.00
Average power consumption	kW	4.50	3.38
Saving in power consumption	kW	1.1	
Running hours	h/day	10	
Running days per year	days/y	300	
Annual monetary savings in terms of power	kWh/y	3,375.0	
Electricity tariff	Rs./kWh	8.7	
Savings in terms of cost	Lakh Rs.	0.29	
Estimated investment	Lakh Rs.	1.6	
Payback period	Y	5.54	

4.5 EPIA 5: Installation energy efficient servo motor for FSS unit

Technology description

The new EE motors are more efficient than the old several times re-wounded motors. They consume less power than the old motors resulting in energy savings. The servo motor has inherent technical properties of shutdown or stop in unloading period of the machines.

Study and investigation

The unit has two lower energy efficiency rating motors of 10 H.P for FFS unit. The installed motor is squirrel cage induction motor which has property of consuming power during unloading period.

Recommended action

It is recommended to replace these motors with new energy efficient motors. The servo motor has inherent properties to stop itself during unloading period. The duty cycle for the servo motor is very high in comparison with other squirrel cage induction motor. The cost benefit analysis for this energy conservation measure is given below:

Table 19: Cost benefit analysis (EPIA 5)

Parameters	UOM	AS IS	TO BE
Number of motor installed in FSS unit	Nos.	2.00	2
Capacity of motor	kW	3.73	4
Total capacity of motor	kW	7.46	7.46
Type of motor installed	Squirrel cage induction motor/Servo Motor	Squirrel cage induction motor	Servo motor
Average power consumption	kW	5.222	4.1776
Operating hours per day	h/day	10	
Operating days per year	days/y	300	
Electricity tariff	Rs./kWh	8.7	
Annual saving in terms of power consumption	kWh/y	3133.2	
Estimated investment	Lakh Rs.	0.58	
Monetary savings	Lakh Rs.	0.27	
Simple payback	Y	2.14	

4.6 EPIA 6: Energy efficiency in roaster process: (Installation of VFD on blower (FD fan), Installation of digital thermocouple for roaster, moisture sensor for the paddy, handheld meter for process calibration

Technology description

Energy efficiency technologies or package has suggested for roaster machine. Energy efficiency technologies included the VFD installation on blower/FD fan, installation of thermocouple to monitor the temperature of tunnel kiln, installation of moisture meter for monitoring moisture percentage of paddy, various type of handheld meter to know the thermal parameters of roaster.

Study and investigation

The efficiency of roaster machine was very poor because of various losses inside the fuel combustion chamber and due to un-monitorable parameters. The moisture percentage of poha should be monitored for quality control. The air fuel ratio should be maintained inside the combustion chamber for proper combustion. The blower was supplying constant combustion air for any amount of fuel firing and excess air was found very high during the study.

Recommended action

It is recommended to install VFD on blower to control the rpm as per fuel firing. The amount of fuel firing and combustion air will decide the temperature inside the tunnel kiln. The installation of thermocouple will monitor the temperature of the tunnel kiln. It is also recommended to install the moisture meter for monitor the quality of poha. The cost benefit analysis of energy conservation measure is given below:

Table 20: Cost benefit analysis (EPIA 6)

Parameters	Unit	As Is	To Be
Current drive system for the motor	DOL/Star-Delta/VSD	DOL	VSD
Installed capacity of motor for blower	kW	1	1
Average power consumption	kW	1	0.51
Savings in terms of power consumption	kW	0.1	
Practice of temperature monitoring	Thermocouple/Contact type portable	No monitoring	Thermocouple
Firing rate of fuel	kg/y	430887	417,961
Savings in terms of fuel	kg/y	12,927	
Practice of moisture monitoring	Digital/analogue portable instrument	No monitoring	Digital type
Practice of parameters monitoring and calibration	Digital/analogue portable instrument	No monitoring	Handheld meters
Firing rate of the fuel	kg/y	430887	426,578
Savings in terms of fuel	kg/y	4309	
Rated energy efficiency of the motor	%	80.00	90.00
Average power consumption	kW	0.60	0.53
Savings in terms of power consumption	kW	0.1	
Running hours per day	h/day	10.00	
Running days per year	days/y	300.00	
Electricity tariff	Rs./kWh	8.68	
Cost of fuel	Rs./kg	5.00	
Total power savings	kWh /Y	467	
Total fuel savings	kg/y	17,235	
Savings in terms of cost	Lakh Rs.	0.90	
Estimated investment for the VFD	Lakh Rs.	0.06	
Estimated investment for thermocouple with digital display system	Lakh Rs.	0.50	
Estimated investment for the moisture monitoring and process calibration	Lakh Rs.	0.30	
Estimated investment for the EE motor for blower	Lakh Rs.	0.05	
Total investment	Lakh Rs.	2.16	
Simple Payback	Y	2.39	

4.7 EPIA 7: Installation of VFD on roaster motor

Technology description

Installation of VFD on a motor reduces the total power consumption of the motor to about 10% by reducing the power consumption while unloading.

Study and investigation

The unit has one of roaster motor for roistering the material into tunnel kiln. The loading pattern of the roaster motor has observed and it was found the motor unloading period is very high which depends on operator efficiency and output from the roaster.

Recommended action

It is recommended to install VFD on roaster motors to decrease their power consumption during unloading periods and for reduction of annual power consumption of the motors.

The cost benefit analysis for this energy conservation measure is given below:

Table 21: Cost benefit analysis (EPIA 7)

Parameters	Unit	As Is	To Be
Motor rating for roaster machine motor	kW	6	6
Average power consumption	kW	4	3.33
No of operating hours per day	h/day	10	10
Operating days per year	Days/y	300	300
Average electricity consumption per year	kWh/y	11,750	9,987
Annual electricity savings per year	kWh/y	1,762	
W. average electricity tariff	Rs./kWh	8.68	
Annual monetary savings	Lakh Rs./y	0.15	
Estimate of investment	Lakh Rs.	0.51	
Simple payback	Y	3.32	

4.8 EPIA 8: Replacement of chalna machine motors with EE motor

Technology description

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

Study and investigation

The unit has a common motor of 1.5 HP for filtering the poha materials before roistering process.

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 22: Cost benefit analysis (EPIA 8)

Parameters	UOM	AS IS	TO BE
Rated power given on conveyor motor	kW	1	1
Efficiency of motor	%	75.00	90
Average Load	kW	1.04	1
Net power savings	kW	0.17	
Running hours	h/y	3000	
Annual energy savings	kWh/y	522	
Annual energy savings	kVAh/y	544	
Avg. weighted cost	Rs./kWh	8.68	
Estimated Investment for EE motor	Lakh Rs.	0.13	
Monetary avings	Lakh Rs.	0.05	
Simple Payback	Y	2.97	

4.9 EPIA 9: Refurbishing the insulation with glass wool and MS sheet of rotating tunnel roaster

Technology description

Insulating the surface of roaster reduces the skin losses from the roaster which in turn helps in savings of fuel fired in the roaster.

Study and investigation

The unit has a roaster for heating the moist paddy grains. The skin temperature of the roaster varies from 68 to 148°C at various locations.

Recommended action

It is recommended to adequately insulate the surface of the roaster by proper refractories and insulating material of adequate thickness to prevent heat loss due to radiation and convection.

The cost benefit analysis for this energy conservation measure is given below:

Table 23: Cost benefit analysis (EPIA 9.1)

Parameters	Units	Value	To Be
Length of Roaster	m	4.12	4.12
Width of Roaster	m	2.22	2.22
Height of Roaster	m	3.00	3.00
Average Temp of front surface(material outlet)	^{0}C	130.00	45.00
Average Temp of side surface(press-side)	^{0}C	66.19	45.00
Average Temp of side surface(Ash removal side)	^{0}C	82.05	45.00
Average Temp of Back Surface(fuel feeding side)	^{0}C	68.17	45.00
Ambient Temperature	^{0}C	29.40	30.00
Velocity of air	m / sec	1.00	1.00
Heat loss due to R&C - Front side	Watt / m^2	1,240.9	113
Heat loss due to R&C - Press machine side	Watt / m^2	349.3	113
Heat loss due to R&C - Ash removal side	Watt / m^2	547	113

Heat loss due to R&C - Back side	Watt / m^2	372	113
Heat loss due to R&C - Front side	kCal / m^2	1,067	97.7
Heat loss due to R&C - Press machine side	kCal / m^2	300	97.7
Heat loss due to R&C - Ash removal side	kCal / m^2	470	97.7
Heat loss due to R&C - Back side	kCal / m^2	320	97.7
Total area - Front side	m^2	6.66	6.66
Total area - Back side	m^2	6.66	6.66
Total area - Press machine side	m^2	12.36	12.36
Total area - Ash removal side	m^2	12.36	12.36
Heat loss due to R&C - Front side	kCal / h	7,107.45	650.92
Heat loss due to R&C - Press machine side	kCal / h	3,713.01	1,208.02
Heat loss due to R&C - Ash removal side	kCal / hr	5,821.32	1,208.02
Heat loss due to R&C - Back side	kCal / h	2,136.30	650.92
Total heat loss due to R&C from furnace surface	kCal / h	18,778.09	3,717.88
Efficiency of roaster-furnace	%	26.44	26.44
Calorific value of fuel - saw dust	kCal / kg	3,380.00	3,380.00
Total energy savings by insulating the roaster-furnace	kCal / h	15,060.21	
Total fuel savings per hour	kg / h	4.46	
Operating hours / day	h / day	10.00	
Running days per year	days / y	300.00	
Cost of saw dust	Rs. / kg	5.00	
Total fuel savings per year	kg / y	13,367.05	
Monitory savings per year	Rs Lakh / y	0.67	
Estimated investment	Rs. Lakh	1.92	
Simple payback period	Y	2.87	

4.10 EPIA 10: Reduction in radiation losses by covering the ash removal openings of roaster with insulated MS plate doors

Technology description

There are 2 ash removal openings in the roaster which also double up as inspection holes. Plant operator uses these doors to manually remove the bottom ash formed as a product of combustion. The operator also inspects the colour of the firing chamber during combustion to judge the temperature level of the roaster combustion zone.

These ash removal holes are kept always open that result in high amount of heat loss due to radiation from the roaster. It is very common these days to keep such openings of combustion zones closed when not in use, thereby preventing heat loss.

Figure 13: Ash removal opening in roaster

Study and investigation

At the time of BEA, it was found that the combined total area of both the ash chamber openings was 1.08 m^2. The average temperature inside the roaster was approximately 250^{0}C. Heat loss due to radiation from both these ash removal openings was estimated to be 7,173 kCal/h. A portion of this heat loss can be prevented by installing a well insulated metallic door on both the openings and covering the openings while ash is not removed or when operators are not inspecting the roaster internal temperature.

Recommended action

It is recommended to install 2 insulated metallic plate doors on both the openings and keeping the openings closed while ash is not being removed or when the operators are not checking the roaster internal temperature. This will help prevent heat loss during the time when the door is kept closed. The estimated savings due to this is shown in the table below.

Table 24: Cost benefit analysis (EPIA 10)

Particulars	Unit	As is	To be
Area of (ash removal) chamber opening	M^2	1.08	1.08
Average temperature	^oC	400.00	60.00
Ambient temperature	^oC	29.40	29.40
Velocity of air	m / sec	1.00	1.00
Heat loss from the ash chamber opening	Watts / m^2	7,723	277
	kCal / m^2	6,642	238
	kCal / h	7,173	258
Savings in thermal energy	kCal/h	6,915	
GCV of fuel	kCal / kg	3,380	3,380
Saving in fuel	kg / h		2.05
Operating hours / day	h / d	10	10
Running days per year	days / y	300	300
Cost of saw dust	Rs. / kg	5	5
Annual savings	kCal/y	20,746,091	
Annual savings in fuel	kg/y	6,138	
Annual monetary savings	Rs. Lakh / y	0.31	
Investment	Rs. Lakh	0.13	
Payback years	y	0.438	

4.11 EPIA 11: Fuel switching from saw dust to gas based system in the roaster

Technology description

The present system of fuel combustion in roaster-furnace using saw dust has lots of de-merits as below –

- It results in very dusty environment inside the plant causing health problems for workers.
- It results in release of high quantity of un-burnts (CO in ppm) in flue gas creating higher pollution levels due to high amount of suspended particles.

- It results in un-even heating in the roaster which hampers final poha quantity.
- There is lot of storage space required for storing saw dust.
- During rainy season the stored saw dust becomes wet thereby increasing its moisture contents.

As Avantika Gas Co. is in the process of laying PNG pipelines in the industrial area of Ujjain, the management of Hira industries is interested to change the roaster fuel system from saw dust to PNG. Further the calorific value of PNG (over 10,000 kCal / kg) is much higher than that of saw dust (3,500 to 4,000 kCal / kg).

Study and investigation

During the BEA, it was found that the air and fuel were supplied to the roaster together using the blower. The fuel was falling on the hearth of the roaster due to gravity and was in a suspended state for lesser time. Due to this and also due to high velocity of combustion air, the fuel gets lesser time for proper combustion. This results in formation of un-burnts in bottom and fly ash. The colour of flue gas observed was black indicating high level of carbon mono-oxide (CO) in the flue gas which was measured (by flue gas analyzer) to be over 6,000 ppm during BEA.

Apart from this, there are many demerits of using saw dust fuel when compared to PNG which is a much cleaner fuel as described earlier.

Recommended action

It is recommended to change the fuel system from saw dust to PNG based system thereby eliminating the demerits associated with saw dust based system (as discussed earlier) and also increasing the combustion efficiency of the roaster-furnace. It is recommended that till the unit does not receive PNG, they can operate the roaster-furnace with LPG by installation of duel fuel (LPG / PNG) burners. The cost benefit analysis of energy conservation measure is given below:

Table 25: Cost benefit analysis (EPIA 11)

Particulars	Units	Value
Roaster efficiency by using saw dust	#	26%
GCV of saw dust	kCal/kg	3,390
Present saw dust consumption	kg/y	430,887
Annual heat requirement	kCal/y	386,283,859
Annual heat supply cost (Saw Dust)	Rs. Lacs / y	21.54
Calculations		
Roaster efficiency by using gas based fuel	#	75%
GCV of LPG	kCal/kg	12,500
Mass of LPG required	kg / y	41,204
Annual cost of LPG	Rs. Lakh / y	26.78
Present energy consumption	MTOE	146.07
Post energy consumption	MTOE	51.50
Energy savings	MTOE	94.57

Production enhancement	%	1.50
Present Production	kg/h	572.83
Production enhancement	kg/h	8.59
Average selling price	Rs./kg	35.00
Cost benefit through production	Rs. Lakh / y	7.22
Total cost savings	Rs. Lakh / y	1.98
Estimated investment	Rs. Lakh	7.00
Simple payback period	Y	3.54

The following table gives the values used for estimating savings for the above EPIA.

Cost of saw dust	Rs./kg	5
Cost of LPG	Rs./kg	65
GCV of saw dust	kCal/kg	3,390.00
GCV of LPG	kCal/kg	12,500
Heat rate saw dust	Rs./kCal	0.0014749
Heat rate LPG	Rs./kCal	0.0052

5 ANNEXURE

Roaster efficiency calculations

Input parameters

Input Data Sheet		
Type of Fuel	Saw Dust	
Source of fuel	Local Vendor	
Fuel Analysis	Value	**Units**
C	*48.98*	%
H	*4.89*	%
N	*0.32*	%
O	*36.01*	%
S	*0.18*	%
Moisture	*6.40*	%
Ash	*3.30*	%
GCV of fuel	*3380*	kcal/kg
Flue Gas Details		
Flue gas temp	458	*deg C*
O2 in flue gas	11.0	*%*
CO2 in flue gas	5.3	*%*
CO in flue gas	6065.8	*ppm*
Specific heat of flue gas	0.26	*Kcal/kgdegC*
Ash Analysis		
bottom ash	*75.00*	%
fly ash	*25.00*	%
GCV of bottom ash	*1800*	kCal/kg
GCV of fly ash	*1200*	kCal/kg
Atmospheric Air		
Ambient Temp.	29.4	*Deg C*
Relative Humidity	48	*%*
Humidity in ambient air	0.0120	*kg/kgdry air*
Mass flow rate of fuel	130	*kg/hr*
Production of Roasted Paddy	1333	*kg/hr*

Efficiency calculations

Calculations	Values	Unit
Theoretical air required	5.82	*kg/kg of fuel*
Excess air supplied	109.65	*%*
Actual mass of supplied air	12.21	*kg/kg of fuel*
Mass of dry flue gas	12.67	*kg/kg of fuel*

Amount of water vapour in flue gas	-	*Kg of H2O/kg of fuel*
Specific fuel consumption	0.10	*kg of fuel/kg of Paddy*
Heat loss in dry flue gas	183,615.01	*kcal/h*
Heat loss due to formation of water from H2 in fuel	44,447.06	*kcal/h*
Heat loss due to moisture in fuel	6,463.56	*kcal/h*
Heat loss due to moisture in air	3,674.23	*kcal/h*
Heat loss due to partial conversion of C to CO	36,764.00	*kcal/h*
Heat loss due to radiation and Convection losses	41,158.42	*kcal/h*
Heat loss from Unburnt in fly ash	1,287.00	*kcal/h*
Heat loss from bottom ash	5,791.50	*kcal/h*
Roaster Efficiency by indirect Method	26%	

6 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 26 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