BASELINE ENERGY AUDIT REPORT

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

Abhishek Industries

71, Industrial Area, Maksi Road
Ujjain
Madhya Pradesh

April 2016

Submitted to

BUREAU OF ENERGY EFFICIENCY

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

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. Abhishek Jain, Owner, for showing keen interest in the energy audit and also thankful to the management of Abhishek 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

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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/ Energy efficient
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 8 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	Abhishek Industries
Constitution	Private Limited
MSME Classification	Small
No. of years in operation	NA
Address: Registered Office	Plot No:71, Industrial area Maksi road,Ujjain
Administrative Office Factory	Plot No:71, Industrial area Maksi road,Ujjain Plot No:71, Industrial area Maksi road,Ujjain
Industry-sector	Food
Products Manufactured	Poha (Rice flakes)
Name(s) of the Promoters / Directors	Mr. Abhishek Jain

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. After the husk is removed the rice is processed into flakers that produce 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 69% of the total energy cost of the unit. Major areas of electrical energy consumption in the unit are poha (press) machines.

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 electricity savings	Annual fuel savings	Investment cost	Monetary energy cost savings	Simple payback period
		kWh / y	Saw dust (kg / y)	Rs. Lakh	Rs. Lakh / y	y
1	Replacing Poha machine motors with smaller sized (7.5 HP X 5 numbers) EE motors with gear box	4,597		1.50	0.37	4.11
2	Replacing flaker machine motor (15 HP X 1 number) with EE motors with VFD	1,930		0.30	0.15	1.96
3	Replacing conveyor (1 HP X 2 numbers) and elevator (1 HP X 5 number) motors with EE motors with gear box	1,188		0.41	0.09	4.35
4	Replacing roaster (3 HP) motor with EE motor	317		0.10	0.03	3.98
5	Replacing other plant process motors with EE motors (Paddy cleaner blower motor, 10 HP X 1 number; Paddy cleaner motor, 2 HP X 1 number; Poha cleaner motors, 1 HP X 2 numbers; FD fan motor of roaster, 1 HP X 1 number)	1,620		0.49	0.13	3.81
6	Reducing heat loss by covering the roaster inspection door with insulated MS plates		2,951	0.10	0.18	0.56
7	Reduction in radiation and convection loss from roaster by refurbishing refractory and insulation of surface		6,298	1.00	0.38	2.65
8	Fuel savings by waste heat recovery from flue gases from roaster-furnace		12,428	5.09	0.75	6.83
9	Fuel savings by controlling excess air supplied for combustion in roaster and controlling fuel feed	360	31,910	2.55	1.94	1.31
10	Energy cost savings by switching from saw dust to gas based fuel for roaster[1]			7.00	3.43	2.04
	Total	**10,013**	**53,587**	**11.54**	**4.01**	**2.88**

- Note: Fuel switch savings not considered in total savings.
- With the implementation of these EPIAs, overall cost savings of Rs. 4.01 Lakh can be achieved.
- Total estimated investment of Rs. 11.54 Lakh can incur with simple payback in nearly 3 years.

[1] Fuel switch investment and savings has not been considered in total values

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.

Objectives of this project are as under:

- Identifying energy efficient process and technologies that can be implemented the 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;
- Facilitate the 20 SME units to implement the proposed energy efficient technologies in their units;
- Conduct 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:

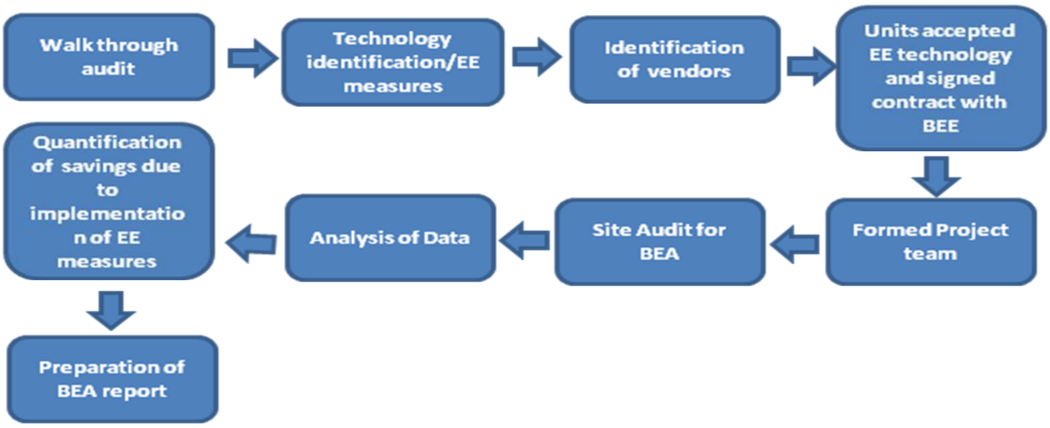

Figure 1: General Methodology

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 MuUs 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 the plant was carried out prior to 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's 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 follow:

- 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 equipments
- Field testing and measurement
- Data analysis for preliminary estimation of savings potential at the 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
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	O_2%, CO_2%, 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	Abhishek 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. Abhishek Jain +91 – 7342526249 Abhiayu2001@yahoo.com
5	Address of the unit	Plot No: 71, Industrial area Maksi road,Ujjain
6	Industry / sector	Food
7	Products manufactured	Poha (Rice flakes)
8	No. of operational hours	8
9	No. of shifts / day	1
10	No. of days of operation / year	300

3 DETAILED TECHNICAL FEASIBILITY ASSESSMENT OF THE UNIT

3.1 Description of manufacturing process

3.1.1 Process & Energy flow diagram

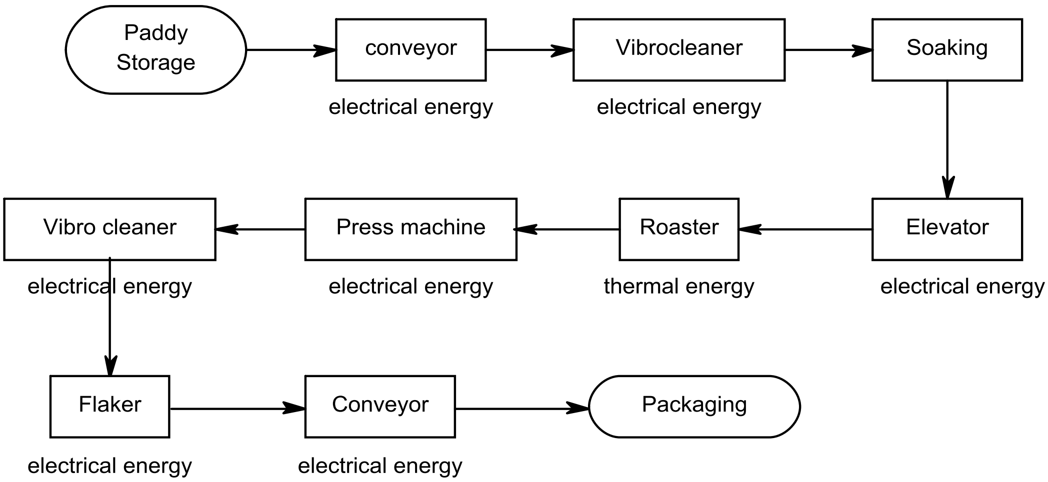

Figure 2: Production flow diagram

3.1.2 Process description

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. After the husk is removed the rice is processed into flakers that produce rice flakes. Then the material is processed cleaner to the cleaner to produce poha (rice flakes) which is then packed and dispatched.

3.2 Inventory of process machines / equipment and utilities

Major energy consuming equipment in the plant are:

- **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:** Processes the pressed rice into flakes.

- **Conveyor:** These belt type conveyors are used for transporting raw material and finished product within the plant.

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 only 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	5.5	31	6	8
Thermal – Saw dust	12.2	69	69	92
Total	**17.7**	**100**	**75.1**	**100**

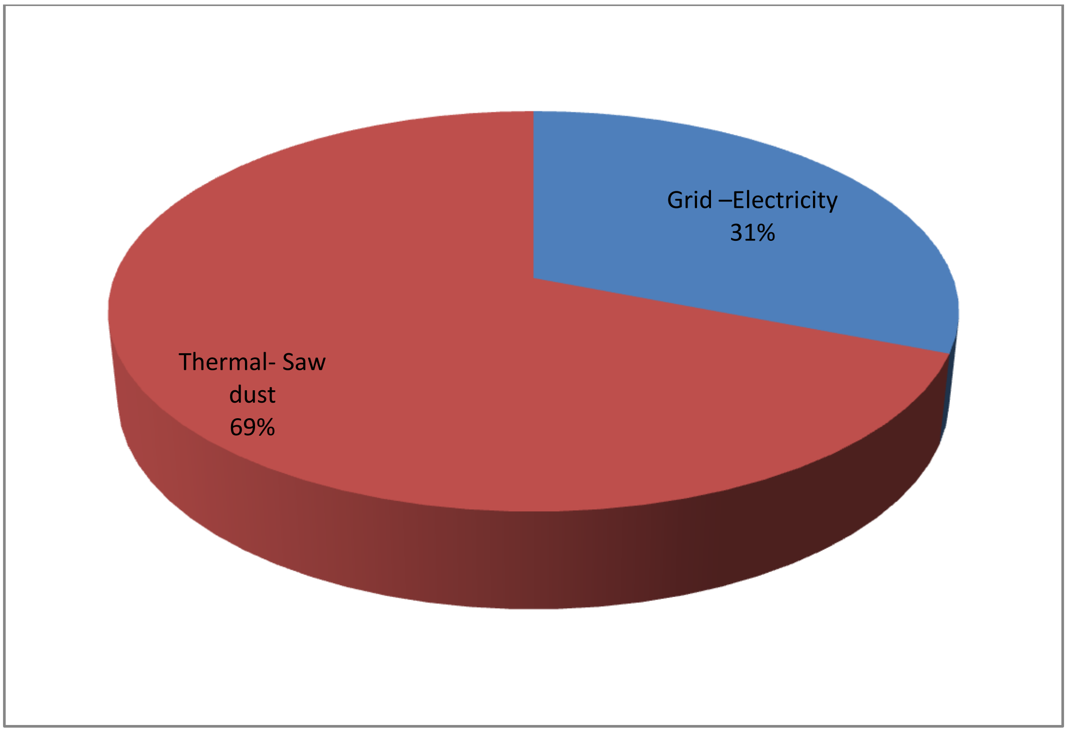

Figure 3: Energy cost share

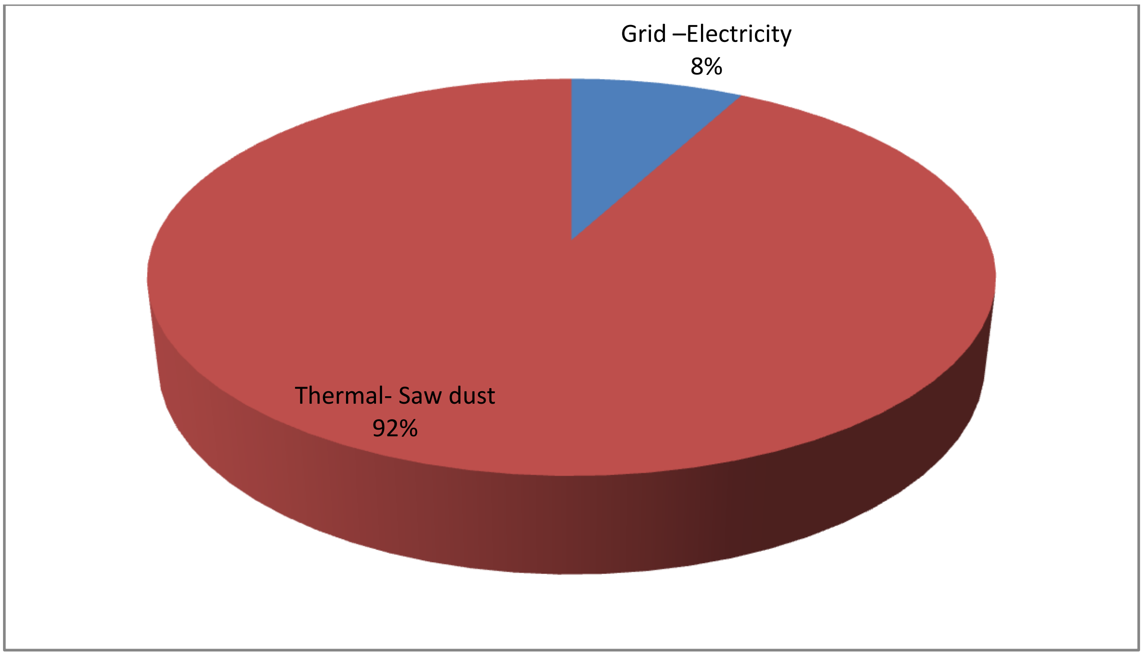

Figure 4: Energy use share

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 69% of the total energy cost and 92% of overall energy consumption.
- Electricity used in the process accounts for 31% of the energy cost and 8% 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 sanctioned electric load of plant is 60 HP

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

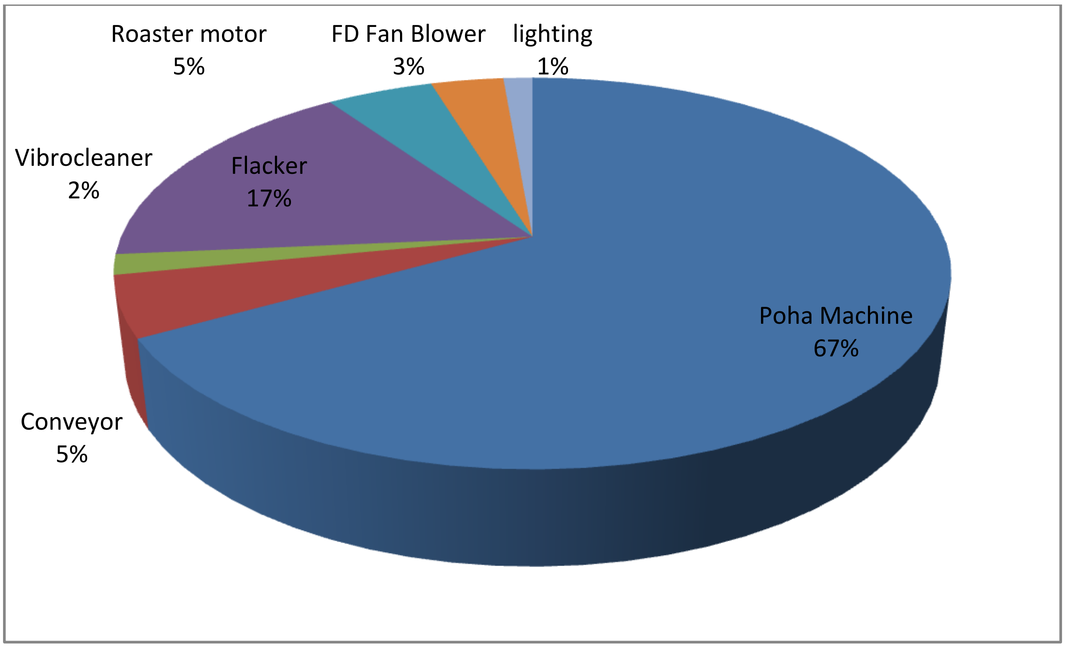

Figure 5: Details of connected load

As shown in the above pie chart, the connected load is divided between poha machine – 67%, flaker-17 %, conveyor-5%, roaster motor – 5%, FD fan blower – 3%, vibrocleaner-2%, while lighting contributes for about1 % of the connected load.

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 set in the unit

Unit is dependent fully on grid electricity, as there is no DG set for self generation. Cost of grid electricity is about Rs. 5.5 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) Sanctioned load : 60 HP
c) Nature of Industry : LT – G

The tariff structure is as follows:

Table 6: Tariff structure

Particulars	Tariff Structure	
Present energy charge	5.74	Rs./kWh
Electricity duty	0.52	Rs./kWh
TOD rebate	-	Rs./kWh

TOD surcharge	-	Rs./kWh
FCA Charge	1.69	Rs./kWh
Weighted Average	7.94	Rs/kWh

(As per Dec-2015 bill)

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

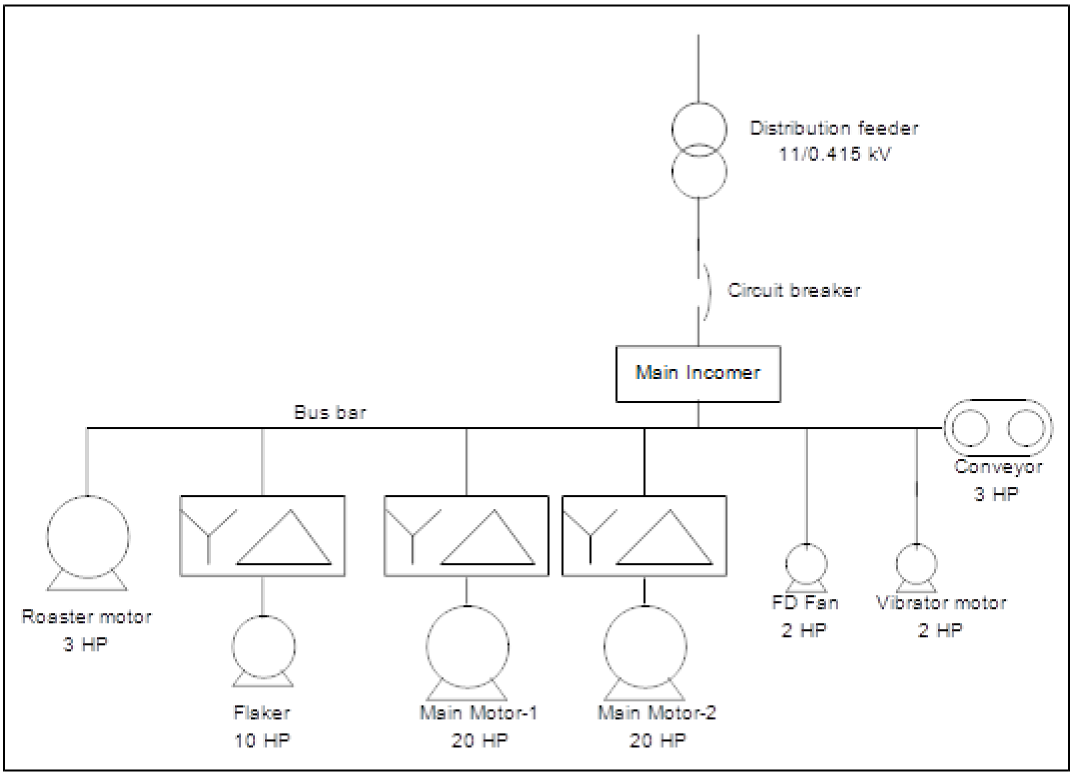

Figure 6: SLD of electrical load

Power factor

The power factor of the unit varies from 0.72 to 0.86 according to electricity bill. However, 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 0.96 with the maximum being 1.

3.3.4 Electricity consumption

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

Table 7: Electricity consumption & cost

Months	Electricity	Cost
	Grid (kWh)	**Grid (Rs.)**
Jan-15	8,140	56,825
Feb-15	5,140	39,581
Mar-15	6,620	48,255
Apr-15	5,520	40,769
May-15	4,940	39,887

Jun-15	6,060	46,755
Jul-15	4,420	38,161
Aug-15	4,920	45,649
Sep-15	6,150	51,699
Oct-15	5,060	43,863
Nov-15	5,300	46,184
Dec-15	6,480	51,033
Total	**68,750**	**548,661**

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

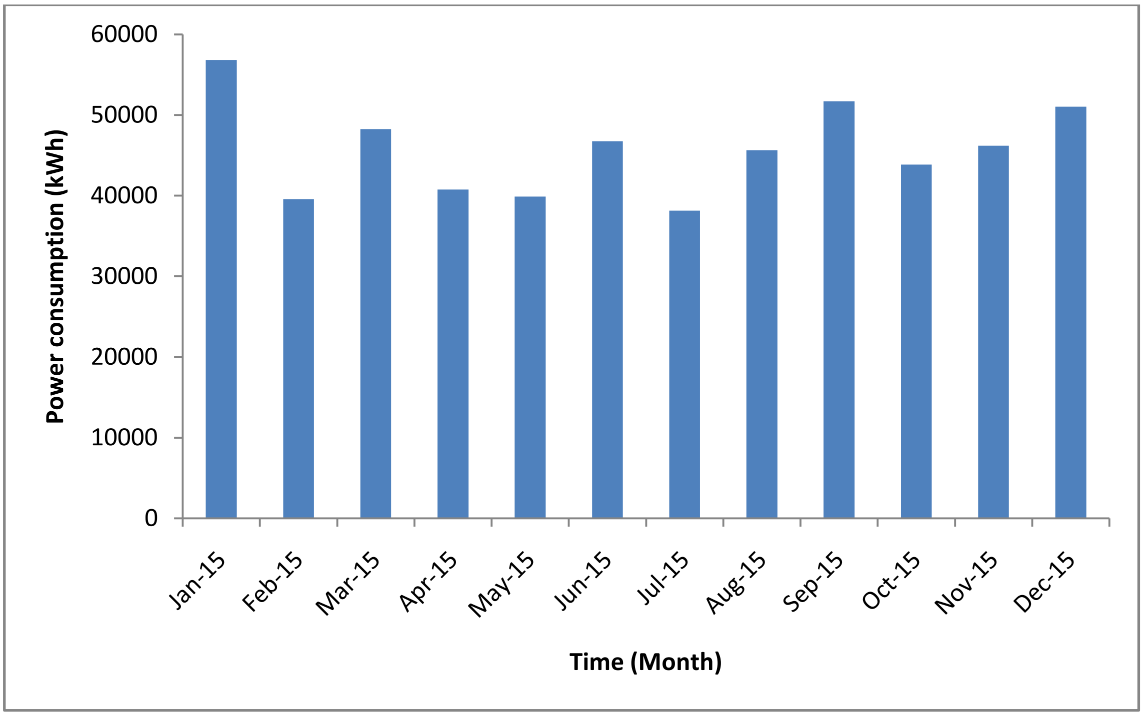

Figure 7: Month wise variation in electricity consumption from different sources

3.4 Analysis of thermal consumption by the unit

Fuel used for roaster is saw dust which is bought at the rate of Rs. 6/kg. There is no provision for measurement of saw dust consumption in the Roaster. Average annual saw dust consumption is 204 MT costing of Rs. 1,224,000.

3.5 Specific energy consumption

Annual production data was provided by the unit. Based on the available information, monthly specific electricity consumptions have been estimated as shown in the following table. ***It is to be noted here that though annual saw dust consumption value was provided, the monthly data for the same was not provided by the unit.***

Table 8: Specific electricity consumption

Month	Rice flakes (MT)	Units consumed (kWh)	SEC (kWh/MT)
Jan-15	124.4	8,140	65.43
Feb-15	118.9	5,140	43.23
Mar-15	116.4	6,620	56.87
Apr-15	114.2	5,520	48.34
May-15	112.6	4,940	43.87
Jun-15	115.6	6,060	52.42
Jul-15	104.9	4,420	42.14
Aug-15	96.8	4,920	50.83
Sep-15	113.8	6,150	54.04
Oct-15	116.8	5,060	43.32
Nov-15	110.5	5,300	47.96
Dec-15	129.9	6,480	49.88
Total	**1374.8**	**68,750**	**49.86**

Table 9: Overall specific energy consumption

Parameters	Unit	Value
Annual grid electricity consumption	kWh	68,750
Annual thermal energy(saw dust) consumption	MT	204
Annual energy consumption; MTOE	MTOE	75.1
Annual energy cost	Lakh Rs.	17.7
Annual production	MT	1,374.80
SEC; Electrical	kWh/MT	50.0
SEC; Thermal	MT of saw dust/MT	0.15
SEC; Overall	MTOE/MT	0.05
SEC; Cost based	Rs./MT	1289

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 saw dust : 3,390 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 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	7.94
Annual operating days	days	300
Operating hours per day	h	8
Production	MT/y	1,375
GCV of grid electricity	kCal/kWh	860
GCV of grid electricity	kCal/kWh	860
Saw dust cost	Rs. /kg	6
GCV of saw dust	kCal/kg	3,390
Cost of LPG	Rs./kg	51
GCV of LPG	kCal/kg	12,500
CO_2 emission factor - Grid	kg/kWh	0.89

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 / equipment 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 were recorded by using portable power analyzer instrument.

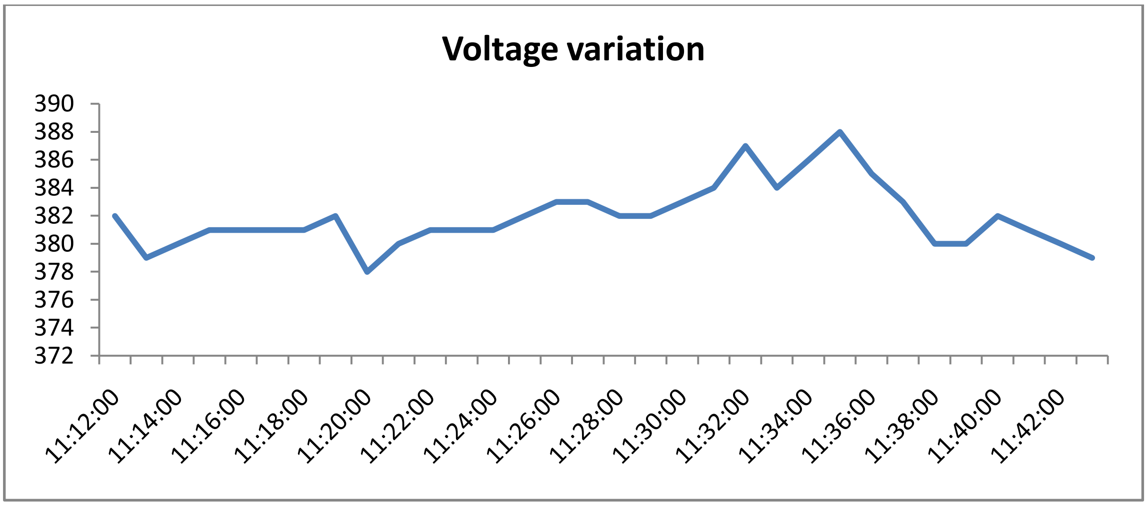

Figure 8: Variation in voltage at main incomer of plant during BEA

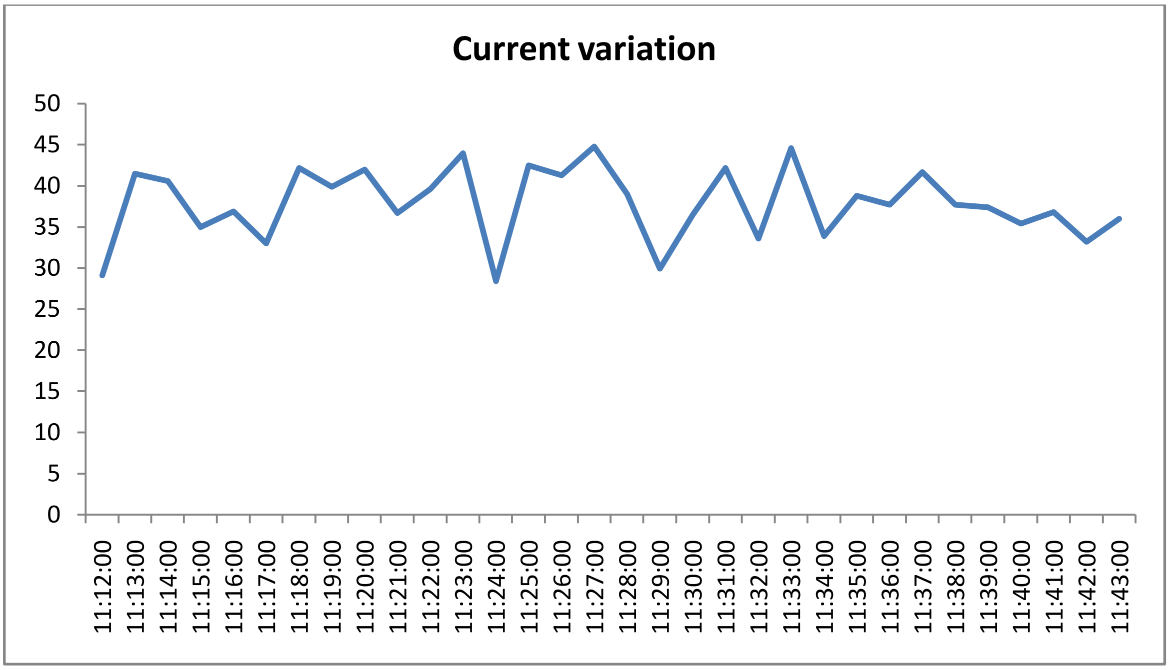

Figure 9 Variation in current at main incomer of plant during BEA

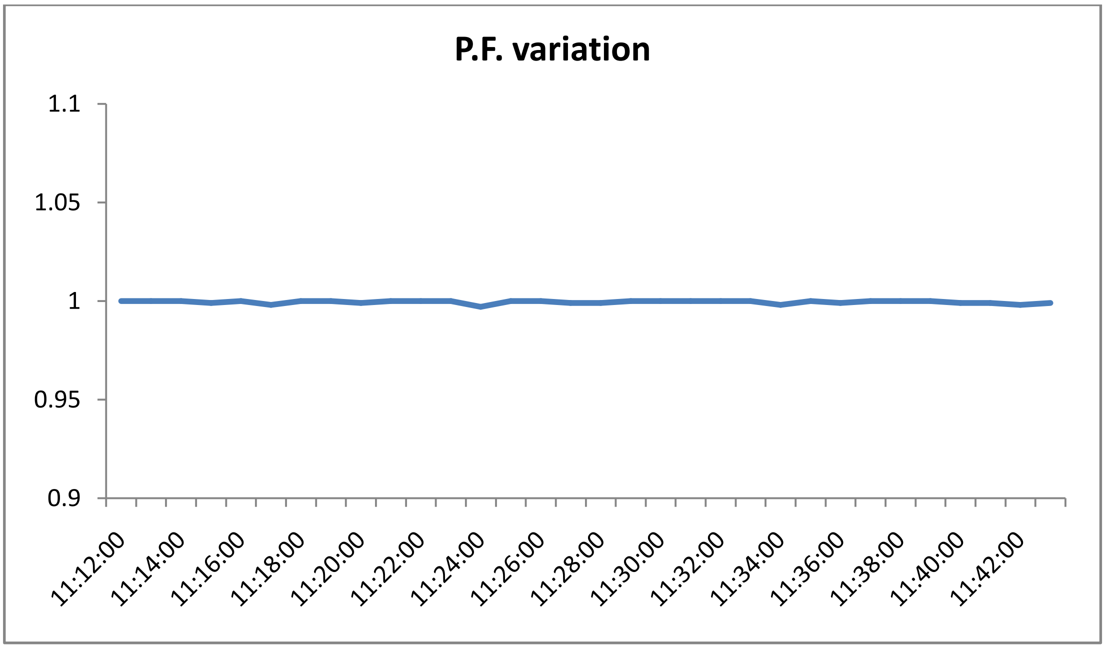

Figure 10 Variation in power factor at main incomer of plant during BEA

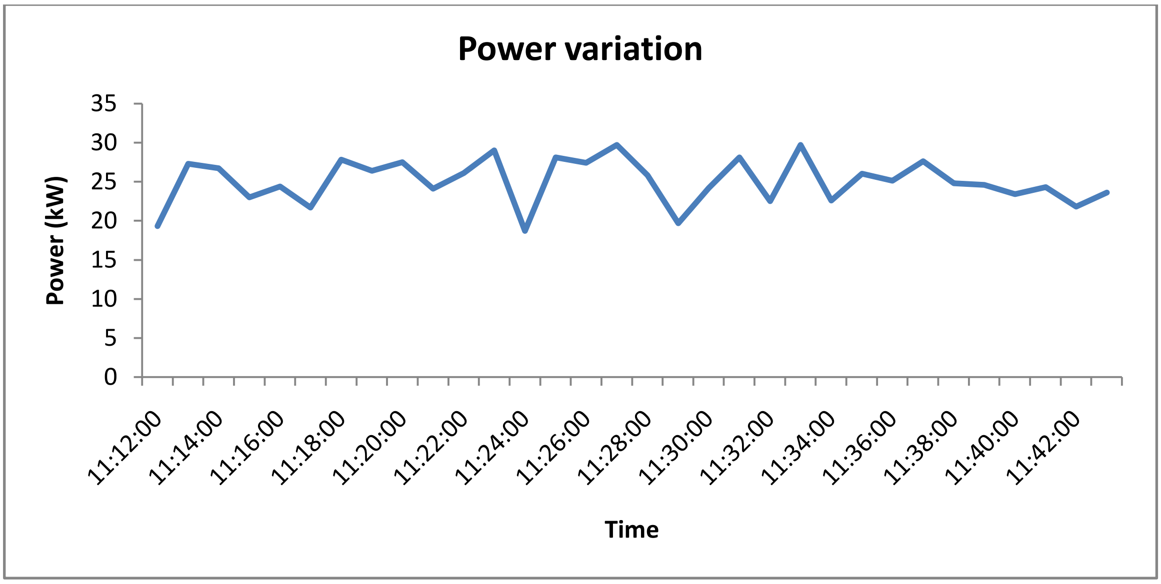

Figure 11: Variation in total load on main incomer of plant

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 sanctioned load of the unit is 60 HP	As per the electricity bill analysis, it was found that the electricity tariff was Rs. 5.74/kWh; Weighted average electricity cost was Rs. 7.94/kWh and the PF according to the electricity bill was about 0.8.	No EPIAs suggested.
Power Factor	Unit has an LT connection (440 V) and billing is in kWh. PF paid by the unit is as per the utility bill.	The average PF found during the measurement was 0.997 and maximum was measured as 1.	No EPIAs suggested.
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 390V	No EPIAs suggested.

3.7.2 Electrical consumption areas

The equipment-wise consumption of electrical energy was measured in consultation with the unit. Following is the list of motors connected in plant.

Electrical Motors

Following types of motors are present in the unit:

1. Motors of fuel handling system - conveyor motor, bucket elevator motor.
2. Motors of Poha machines and flakers.
3. Motors of Roaster section - roaster motor, saw dust feeding motor, paddy feeding motor and blower (FD fan) motor.

Table 12: Installed motors details

Description	Quantity	Power rating
Poha machine	2	29.84
Conveyor	3	2.25
Vibro-cleaner	1	0.75
FD fan	1	1.50
Flacker	1	7.50
Lighting	-	0.60
Roaster motor	1	2.20
Total	**9**	**44.64**

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 5 poha machines. 2 motors rated for 20 HP each run 2 poha machines and 3 poha machines each.</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 (M/C-1,2)
Motor-2 (M/C-3,4, 5)</td><td>7.85
5.35</td><td>0.68
0.60</td></tr>
</table></td><td>Replacement of existing (20 HP X 2) motors of poha machines with smaller sized EE motors (5 numbers of 7.5 HP each) is recommended</td></tr>
<tr><td>Flaker motors</td><td>There is 1 flaker machine. 1 motors of 15 HP operates this machine.</td><td>Study was conducted on flaker 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>Flaker Motor</td><td>8.04</td><td>0.69</td></tr>
</table></td><td>Replacement of existing motor of flaker machine with EE motor of 15 HP is recommended</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. FD fan motor is 1 HP</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>1.2</td><td>0.74</td></tr>
</table></td><td>It is suggested to replace existing fan motor with EE motor of same capacity</td></tr>
<tr><td>Other plant motors – roaster motor (3 HP), paddy cleaner blower motor (10 HP), Paddy cleaner motor (2 HP), two numbers of Poha cleaner motors (1 HP each)</td><td>All the motors mentioned are over 6 years old and several times re-wounded which has de-rated their operating efficiencies.</td><td>
<table>
<tr><th>Machine</th><th>Avg. kW</th><th>Avg PF</th></tr>
<tr><td>Paddy cleaner blower motor</td><td>6.2</td><td>0.74</td></tr>
<tr><td>Paddy cleaner motor</td><td>1.2</td><td>0.81</td></tr>
<tr><td>Poha cleaner motor</td><td>0.52</td><td>0.72</td></tr>
<tr><td>Roaster motor</td><td>2.20</td><td>0.79</td></tr>
</table></td><td>It is recommended to replace these motors with EE motors of same capacity.</td></tr>
</table>

Motors of material handling section (Conveyors, elevators)	There are 2 conveyers of 1 HP each and 5 elevators of 1 HP each. All these motors are over 6 years old and several times re-wounded which has de-rated their operating efficiencies.	The study was conducted on 1 conveyor and 1 elevator. The results of the study are as below: **Machine** / **Avg. kW** / **Avg. PF** Conveyor 1 HP / 0.74 / 0.86 Elevator, 1 HP / 0.68 / 0.75	Replacement of 2 conveyor motors of 1 HP each and 5 elevator motors of 1 HP each with EE motor with gearbox is suggested

3.7.3 Thermal consumption areas

As discussed in the earlier sections, about 69% of total energy cost of the plant and 94% 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 roasters was about 13.70%. 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 53 to 167°C. This resulted in high heat loss from surface of the roaster. There were two ash removal windows of dimension of 45x65 cm^2. It was observed that the windows 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. It was also mentioned by the plant management that the moisture contents in saw dust received (mainly during rainy seasons) were very high. The plants had no equipment to measure the moisture content of saw dust and paddy.	Excess air control with oxygen sensor and temperature meter & moisture meter in panel is proposed. Rebuilding the roaster furnaces with proper insulation on walls is proposed It is suggested to close the ash removal windows for some periods of time using doors, when ash is not being removed. To improve the combustion efficiency shifting to gas based fuel is proposed. It is recommended to provide hand held moisture meter and IR temperature meter to the unit to measure the moisture levels in saw dust and paddy and temperatures of roaster-furnace walls. It is also recommended to install thermocouple on the roaster and control the saw dust feed by installing saw dust feed roll and controller, vibro motor with VFD and temperature sensor for saw dust.

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 the earlier section of this report.

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

4.1 Replacement of poha machine motors with smaller sized (7.5 HP *5 number) EE motors with gear box

Technology description

Replacement of 2 press (poha) machine motors of 20 HP rated capacities with 5 energy efficient motors of 7.5 HP each of IE 3 class. One smaller sized new EE motor of 7.5 HP will be installed for each of the 5 poha machines.

Study and investigation

The unit has two motors for 5 poha machines which are run by using common shaft (motor 1 of 20 HP driving m/c 1 and 2, motor 2 of 20 HP driving m/c 3, 4 and 5 (machine 5 was not working during the time of audit). It was observed that the loading of all the machines were not same – some were loaded at over 80% while some were loaded at less than 50%. This depends on the production of dried poha from the roaster and also on the worker operating the poha machine – how fast or slow he operates during the entire shift. Some operators are faster than others and their machines are loaded for longer durations. A time-motion study was also conducted to note the loading on the eight poha machines. It was found that a fast worker manually transfers 5-6 baskets of roasted paddy from the roaster to the poha machine, while a slow worker transfers 4-5 baskets in 5 minutes. Based on the input to the poha machines, the production output also varies similarly (5-6 baskets of flakes output for the faster worker in a duration of 5 minutes). Each basket contains approximately 4.5 kg of roasted paddy by weight.

Recommended action

It is recommended to replace the present common motors (2 numbers of 20 HP each) of poha machines with new energy efficient motors (5 numbers of 7.5 HP each) for each of the 5 poha machines.

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

Table 13: Cost benefit analysis (EPIA 1)

Parameters	Unit	As is	To be
Motor-1 Rating	40 rpm	20 HP (common motor for 2 poha machines)	
Motor-2 Rating	40 rpm	20 HP (common motor for 3 poha machines; 1 machine not running)	
Total power rating of existing motors	HP	40	
Total power rating of proposed motors	40 rpm		7.5 HP X 5 numbers geared motors
Rated power of poha machine motors	kW	29	27
Average power consumption of Motors-1&2	kW	12	
Estimated power consumption by new motors (5 numbers of 7.5 HP each)	kW		10
No of operating hrs per day	h / day	8	8
Operating Days per Year	days / y	300	300
Average electricity consumption per year by poha machine motors	kWh / y	30,646	26,049
Annual electricity saving per year	kWh / y	4,597	
W. Average Electricity Tariff	Rs. / kWh	7.94	
Annual monetary savings	Rs. Lakh/y	0.37	
Estimate of Investment	Rs. Lakh	1.50	
Simple Payback	y	4.11	

4.2 Replacement of Flaker machine motor with EE motor

Technology description

Replacement of flaker machine motor of 15 HP rated capacity with new EE motor of same capacity.

Study and investigation

The unit has a flaker machine which is driven by a 15 HP motor. The present motor is very old and several times re-wounded due to which its efficiency has de-rated. The raw poha from the poha machines are conveyed to the flaker where the raw poha is smoothened and final poha is produced.

Recommended action

It is recommended to replace the present motor of flaker machine rated for 15 HP with a new EE motor of same capacity. The cost benefit analysis for this energy conservation measure is given below:

Table 14: Cost benefit analysis (EPIA 2)

Parameters	Unit	As is	To be
Flaker machine motor rating	HP	15	15
Total power rating of existing motors	kW	11.19	11.19
Average power consumption of flaker motor	kW	8.04	7.24
No of operating hrs per day	h / day	8	8
Operating days per Year	day / y	300	300

Average electricity consumption per year	kWh / y	19,301.14	17,371.03
Annual electricity savings per year	kWh / y	1,930	
W. average electricity tariff	Rs. / kWh	7.94	
Annual monetary savings	Rs. Lakh / y	0.15	
Estimate of investment	Rs. Lakh	0.3	
Simple payback period	Y	1.96	

4.3 Replacement of conveyor (1HP*2) and elevator (1HP*5) motors with EE motors with gear box

Technology description

Replacement of existing inefficient conveyor and elevator motors with energy efficient motor.

Study and investigation

During BEA, it was found that the motor operating the conveyors and elevators was not replaced since the time of establishment of unit. Further, the motor has been re-wounded several times. Due to inbuilt low design and high wear & tear the power consumption of existing motor was found to be high.

Recommended action

It is recommended that the existing motor be replaced with IE 3 class energy efficient motor of same capacity. The cost benefit analysis of energy conservation measure is given below:

Table 15: Cost benefit analysis (EPIA 3)

Parameters	Unit	As is	To be
Number of conveyor motor & power rating	HP	2 X 1 HP	2 X 1 HP
Number of elevator Motor & power rating	HP	5 X 1 HP	5 X 1 HP
Installed capacity of motors (total)	kW	5.25	5.25
Average running power consumption	kW	4.99	4.49
Power saving using geared motors	kW		0.50
Energy savings per year	kWh / y		1,188
Cost savings per year	Rs. Lakh / y		0.09
Estimated investment on new motor coupled with gear box	Rs. Lakh		0.41
Simple payback period	y		4.35

4.4 Replacement of existing roaster motor with EE motor

Technology description

Replacement of existing inefficient roaster motor with energy efficient motor.

Study and investigation

During BEA, it was found that the motor operating with the roaster was not replaced since the time of establishment of the unit. Further, the motor has been re-wounded several times. Due to inbuilt low design and high wear tear the power consumption of existing motor was found to be high.

Recommended action

It is recommended that the existing motor be replaced with IE 3 class energy efficient motor of same capacity. The cost benefit analysis of energy conservation measure is given below:

Table 16 Cost benefit analysis (EPIA 4)

Description	Unit	Value
Existing motor power rating	kW	2.24
Existing running power	kW	2.2
Power saving through EE motor	%	4
Annual power savings	kWh / y	317
Cost saving	Rs. Lakh / y	0.03
Investment	Rs. Lakh	0.10
Payback	y	3.98

4.5 Replacement of other existing plant process motors with EE motors

Technology description

Replacement of existing inefficient plant motor with energy efficient motors.

Study and investigation

During BEA, it was found that the plant was operating many machines which were over 6 years old, several times re-wounded and in-efficient motors. The rated design efficiencies of these motors were about 88% and due to excessive use over the years and effects of several re-windings, their operating efficiencies had further reduced. Due to this, these motors were drawing more power when compared to energy efficient motors. The motors are

Blower for paddy cleaner motor (1 number) : 10 HP rated

Paddy cleaner motor (1 number) : 2 HP rated

Poha cleaner motor (2 numbers) : 1 HP rated

FD fan (of roaster) motor (1 number) : 1 HP rated

Recommended action

It is recommended that the above motors be replaced with new energy efficient motors of IE-3 class of same capacities. The cost benefit analysis of energy conservation measure is given below:

Table 17: Cost benefit analysis (EPIA 5)

Parameters	Unit	As is	To be
Rating of paddy cleaner blower motor (1 number)	HP	10.00	10.00
Rating of paddy cleaner motor (1 number)	HP	2.00	2.00
Rating of poha cleaner motor – 1	HP	1.00	1.00
Rating of poha cleaner motor - 2	HP	1.00	1.00
Rating of FD fan (of roaster) motor	HP	1.00	1.00
Total power rating of existing motors	kW	11.19	11.19
Average actual power consumption of motors - present	kW	8.44	
Average actual power consumption of motors - proposed	kW	7.76	
No of operating hours per day	h / day	8	8
Operating days per year	day / y	300	300
Average electricity consumption per year	kWh / y	20,256	18,636
Annual electricity savings per year	kWh / y	1,620	
W. average electricity tariff	Rs. / kWh	7.94	
Annual monetary savings	Rs. Lakh / y	0.13	
Estimate of investment	Rs. Lakh	0.49	
Simple payback	y	3.81	

4.6 Reducing heat loss by covering the roaster inspection door with insulated MS plate

Technology description

There is one ash removal opening in the roaster which also doubles up as inspection hole. Plant operator uses this door to manually remove the bottom ash formed as a product of combustion. The operator also inspects the color of the firing chamber during combustion to judge the temperature level of the roaster combustion zone.

The ash removal door is kept always open and results 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 it is not in use, thereby preventing heat loss.

Figure 12: Ash removal opening in roaster

Study and investigation

At the time of BEA, it was found that area of ash chamber opening was 0.52 m^2. The average temperature inside the roaster-furnace was approximately 450˚C approximately. Heat loss due to radiation from the ash removal openings was estimated to be 10,004,392 kCal/h. A portion of this heat loss can be prevented by installing a well-insulated metallic door on the opening and covering it while ash is not removed or when operators are not inspecting the roaster's internal temperature.

Recommended action

It is recommended to install an insulated metallic plate door on the opening and keeping it closed while ash is not being removed or when the operators are not checking the roaster's 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 18: Cost benefit analysis (EPIA 6)

Particulars	Unit	As is	To be
Area of (ash removal) chamber opening	m^2	0.52	0.52
Average temperature	^oC	450	60
Ambient temperature	^oC	37	37
Velocity of air	m / sec	1	1
Heat loss from the ash chamber opening	Watts / m^2	9,516	194
	kCal / m^2	8,183	167
	kCal / h	4,255	87
Savings in thermal energy	kCal/h	4,168	
GCV of fuel	kCal / kg	3,390	3,390
Saving in fuel	kg / h	1.23	
Operating hours / day	h / day	8	8
Running days per year	days / y	300	300
Cost of saw dust	Rs. / kg	6	6
Annual savings	kCal / y	10,004,392	
Annual savings in fuel	kg/y	2,951	
Annual monetary savings	Rs. Lakh / y	0.18	
Investment	Rs. Lakh	0.10	
Payback years	Y	0.56	

4.7 Reduction in radiation and convection loss from roaster by refurbishing refractory and insulation of surface

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. Fire bricks have low thermal conductivity than conventional furnace bricks, hence they provide better thermal insulation.

Study and investigation

The unit has a roaster for heating the moist paddy grains. The skin temperature of the roaster varies from 54 to 167°C at various locations.

Recommended action

It is recommended to rebuild roster furnace with fire bricks and 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.

Table 19: Cost benefit analysis (EPIA 7)

Parameters	Units	Value	TO BE
Length of roaster	m	3.01	3.01
Width of roaster	m	1.75	1.75
Height of roaster	m	2.14	2.14
Average temp of front surface(material outlet)	^0C	102.00	47.00
Average temp of side surface(press-side)	^0C	53.50	47.00
Average temp of side surface(Ash removal side)	^0C	66.33	47.00
Average temp of back surface(fuel feeding side)	^0C	167.33	47.00
Ambient temperature	^0C	37.00	37.00
Velocity of air	m / sec	1.00	1.00
Heat loss due to R&C - Front side	Watt / m^2	715	69
Heat loss due to R&C - Press machine side	Watt / m^2	128	69
Heat loss due to R&C - Ash removal side	Watt / m^2	263	69
Heat loss due to R&C - Back side	Watt / m^2	1,738	69
Heat loss due to R&C - Front side	kCal / m^2	615	59
Heat loss due to R&C - Press machine side	kCal / m^2	110	59
Heat loss due to R&C - Ash removal side	kCal / m^2	227	59
Heat loss due to R&C - Back side	kCal / m^2	1,494	59
Total area - Front side	m^2	3.75	3.75
Total area - Back side	m^2	3.75	3.75
Total area - Press machine side	m^2	6.44	6.44
Total area - Ash removal side	m^2	6.44	6.44
Heat loss due to R&C - Front side	kCal / h	2,304	221
Heat loss due to R&C - Press machine side	kCal / h	710	380
Heat loss due to R&C - Ash removal side	kCal / h	1,459	380
Heat loss due to R&C - Back side	kCal / h	5,596	221
Total heat loss due to R&C from furnace surface	kCal / r	10,069	1,201
Efficiency of roaster-furnace	%	52.00	52.00
Calorific value of fuel - saw dust	kCal / kg	3,380	3,380
Total energy savings by insulating the roaster-furnace	kCal / h		8,869
Total fuel savings per hour	kg / h		2.62
Operating hours / day	hrs / day	8	8
Running days per year	days / y	300	300
Cost of saw dust	Rs. / kg	6	6
Total fuel savings per year	kg / y		6,298
Monitory savings per year	Rs. Lakh / y		0.38
Estimated investment	Rs. Lakh		1.00
Simple payback period	Y		2.65

4.8 Waste heat recovery (WHR) from flue gases of rotating tunnel roaster

Technology description

Flue gases coming out from roaster are at very high. Presently, the flue gases are being released to atmosphere. The high temperature of the flue gases can be used to recover some of the heat for pre-heating the combustion air being supplied to the roaster. This will help in energy conservation and fuel (saw dust) savings.

Study and investigation

At the time of BEA, it was found that the temperature of flue gases coming out from the roaster was approximately 246^{o}C, which indicates that the heat content in the flue gas is very high and it can be used to raise the temperature of combustion air supplied to the roaster.

Recommended action

It is recommended to install an air pre-heater to pre-heat the combustion air with hot exhaust flue gases coming out from the chimney. The cost benefit analysis of energy conservation measure is given below:

Table 20: Cost benefit analysis (EPIA 8)

Parameters	Unit	Value
Temp of flue gas	^{0}C	246.90
Ambient temperature	^{0}C	37.00
Mass of flue gas	kg/h	1,463.64
Specific heat of flue gas	Kcal/(kg-^{0}C)	0.26
Mass of air supplied	kg/h	365.18
Specific heat of air	Kcal/(kg-^{0}C)	1.00
Efficiency of APH	%	50.00
Temp of flue gas After APH	^{0}C	180.00
Calculations		
Temp of air after APH	^{0}C	69.21
Energy savings	Kcal/h	12,729.27
Annual energy savings	Kcal	42,006,604.50
Annual fuel savings	Kg/y	12,428
Annual monetary savings	Lakh Rs./y	0.75
Investment estimated	Lakh Rs.	5.09
Payback	y	6.83

4.9 Controlling excess air and feed being supplied for fuel combustion in rotating tunnel roaster to desirable limits

Technology description

It is necessary to maintain optimum excess air levels in combustion air supplied for complete combustion of the fuel. 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 known 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.

During the BEA study of the roaster, it was observed that fuel was fired with too much of excess air. This resulted in formation of excess flue gases, taking away the heat produced from the combustion and increasing fuel consumption. This also resulted in formation of excess GHG emissions.

Further, management of the unit had mentioned that the saw dust being procured by the unit for combustion in roaster-furnace contains high amount of moisture (especially during rainy season). This creates problems during combustion. The unit does not have any meter to measure the moisture content in fuel and paddy being heated.

It is suggested to control the excess air levels by installation of on-line oxygen sensor in flue gas duct and then adjusting the air blower (FD fan) damper to control excess air being supplied for combustion. VFD on fuel feeder is also suggested to control the excess air to achieve energy savings through intermittent motor use.

Study and investigation

At the time of BEA, it was found that there was no proper automation and control system installed to maintain the optimum excess air levels. Fuel was fired from the existing system and no 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 at the exit of the roaster was 13.7 % which indicates very high excess air levels resulting in high heat loss due to dry flue gas from the roaster.

Recommended action

It is recommended to control the excess air levels being supplied with combustion air by measuring the oxygen content in flue gases by an online oxygen analyzer and limiting the oxygen levels to approximately 5% by manually adjusting the blower air (FD fan) damper.

As a thumb rule, reduction in every 10% of excess air will save 1% in specific fuel consumption. The cost benefit analysis of energy conservation measure is given below:

Table 21: Cost benefit analysis (EPIA 9)

Parameters	UOM	Present	Proposed
Oxygen level in flue gas	%	13.70	5.00
Excess air level	%	187.67	31.25
Flue gas temperature	^{0}C	246.90	246.90
Saving in fuel	With every 10% reduction in excess air leads to savings in fuel consumption by 1%		
Fuel consumption	kg / y	204,000	172,090
Saving in fuel consumption	kg / y		31,910
Cost of fuel	Rs. / kg	6	6
Savings in fuel cost	Rs Lakh / y		1.91
Running load of blower	kW	1.50	1.35
Operating hours	h / y	2,400	2,400
Electrical energy consumed	kWh / y	3,600	3,240
Savings in electrical energy	kWh / y		360
Savings in terms of cost of electrical energy	Rs. Lakh / y		0.03
Total savings	Rs. Lakh / y		1.94
Estimated investment	Rs. Lakh		2.55
Simple payback	y		1.31

4.10 Replacing present roaster fuel system to Gas based system

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 requirement of a lot of storage space 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 Abhishek Industries is interested to change the unit's 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 the 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 got lesser time for proper combustion. This resulted in formation of un-burnts at the bottom and fly ash. The color 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 1,600 ppm during the 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 operate the roaster-furnace with LPG by installation of duel fuel burners. The cost benefit analysis of energy conservation measure is given below:

Table 22: Cost benefit analysis (EPIA 10)

Particulars	Units	Value
Roaster efficiency by using saw dust	#	38%
GCV of saw dust	kCal/kg	3,390
Present saw dust consumption	kg/y	204,000
Annual heat requirement	kCal/y	265,883,385
Annual heat supply cost (Saw Dust)	Rs. Lakh / y	12.24
Calculations		
Roaster efficiency by using gas based fuel	#	75%
GCV of LPG	kCal/kg	12,500
Mass of LPG required	kg/y	28,361
Annual cost of LPG	Rs. Lakh / y	18.43
Present energy consumption	MTOE	69.16
Post energy consumption	MTOE	35.45
Energy savings	MTOE	33.70
Production Enhancement	%	2.00
Present Production	kg/h	572.83
Production Enhancement	kg/h	11.46
Average selling price	Rs./kg	35.00
Cost benefit through production	Rs. Lakh / y	9.62
Total cost savings	Rs. Lakh / y	3.43
Estimated investment	Rs. Lakh	7.00
Simple payback period	Y	2.04

Note: Following data is taken on assumption basis for calculating above EPIA

Cost of saw dust	Rs/kg	6
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	0.0017699
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	***3390***	kcal/kg
Flue Gas Details		
Flue gas temp	**246.9**	*˚C*
O2 in flue gas	**13.7**	*%*
CO2 in flue gas	**2.3**	*%*
CO in flue gas	**5205.0**	*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.	**37**	*˚C*
Relative Humidity	**48**	*%*
Humidity in ambient air	**0.0120**	*kg/kgdry air*
Mass flow rate of fuel	85	*kg/h*
Production of Roasted Paddy	573	*kg/h*

Efficiency calculations

Calculations	**Values**	**Unit**
Theoretical air required	**5.82**	*kg/kg of fuel*
Excess air supplied	**187.67**	*%*
Actual mass of supplied air	**16.76**	*kg/kg of fuel*

Mass of dry flue gas	**17.22**	*kg/kg of fuel*
Amount of water vapour in flue gas	**-**	*Kg of H2O/kg of fuel*
Specific fuel consumption	**0.15**	*kg of fuel/kg of Paddy*
Heat loss in dry flue gas	79,876.67	*kCal/h*
Heat loss due to formation of water from H2 in fuel	25,379.98	*kCal /h*
Heat loss due to moisture in fuel	3,690.80	*kCal /h*
Heat loss due to moisture in air	1,614.37	*kCal /h*
Heat loss due to partial conversion of C to CO	43,594.39	*kCal /h*
Heat loss due to radiation and Convection losses	18,580.79	*kCal /h*
Heat loss from Unburnt in fly ash	841.50	*kCal /h*
Heat loss from bottom ash	3,786.75	*kCal /h*
Roaster Efficiency by indirect Method	38%	

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 23 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