BASELINE ENERGY AUDIT REPORT

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

Patel Industries

75 / 17-B, Industrial area, Maxi Road
Ujjain
Madhya Pradesh

April 2016

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

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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 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. Ishwar Patel, owner, for showing keen interest in the energy audit and also thankful to the management of Patel Industries for their wholehearted support and cooperation for the preparation of this baseline energy audit report, without which the study would not have steered to its successful completion. Special thanks to other members of the unit for their diligent involvement and cooperation.

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

Last but not the least, the interaction and deliberation with Mr. 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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Team leader and co-coordinator	Mr. Suparno R Majumdar Consultant
Team Members	Mr. Mithlesh Priya Analyst
	Mr. Chintan Shah Asst. Analyst
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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
UNIDO	United Nations Industrial Development Organization
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.

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

Brief Introduction of the Unit

Table 1: Details of the unit

Name of the unit	Patel Industries
Constitution	Private Limited
MSME Classification	Small
No. of years in operation	10
Address: Registered Office	75 / 17-B, Industrial area, Maxi Road, Ujjain, MP
Administrative Office	75 / 17-B, Industrial area, Maxi Road, Ujjain, MP
Factory	75 / 17-B, Industrial area, Maxi Road, Ujjain, MP

Industry-sector	Food
Products Manufactured	Poha (Rice flakes)
Name(s) of the Promoters / Directors	Mr. Ishwar Patel

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

Production process of the unit

The production process description is as follows:

Paddy is used as raw material for production of poha, which is purchased from nearby food grains markets. The purchased paddy is cleaned in mega and vibro cleaners to remove large-sized and small-sized sand particles which come along with the paddy. The cleaned paddy is then soaked in water for one 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 at 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 96% of the total energy use and 83% 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 Table – 2.

Table 2: Summary of EPIA

Sl. No.	Energy Performance Improvement Action (EPIA)	Annual electricity savings (kWh/y)	Annual fuel savings (kg/y)	Investment cost (Rs. Lakh)	Monetary energy cost savings (Rs. Lakh /y)	Payback period (y)	MTOE savings
1	Replacing poha machine motors with smaller sized (7.5 HP X 8 numbers) EE motors with VFD	8,677.83		1.20	0.67	1.78	0.7
2	Replacing flaker machine motors (20 HP) with EE motors with VFD	3,580.80		0.80	0.28	2.87	0.3
3	Replacing conveyor (1 HP X 6 numbers) and elevator (2 HP X 2 number + 1 HP X 1 number) motors with EE motors with gear box	1,723.26		0.48	0.13	3.58	0.1
4	Replacing roaster (5 HP) motor with EE motor and VFD	895.20		0.27	0.07	3.88	0.1
5	Replacing other plant process motors with EE motors (blower, 7.5 HP; saw dust cleaner, 2 HP; Paddy cleaner blower motor, 10 HP; FD fan of roaster, 1 HP; Paddy cleaner chalna motor, 1.5 HP; 2880 rpm motor, 5.5 HP)	4,923.60		0.79	0.38	2.06	0.4
6	Reducing heat loss by covering the roaster inspection door with insulated MS plates		3,707.11	0.30	0.22	1.35	1.3
7	Reduction in radiation and convection loss from roaster by refurbishing refractory and insulation of surface		11,322.45	1.00	0.68	1.47	3.8
8	Fuel savings by waste heat recovery from flue gases from roaster-furnace		43,179.60	5.09	2.59	1.97	14.6
9	Fuel savings by controlling excess air supplied for combustion in roaster and controlling fuel feed	450.00	60,497.18	2.55	3.66	0.70	20.5
10	Energy cost savings by switching from saw dust to gas based fuel for roaster			7.00	1.03	6.77	0.0
	Total	**20,250.69**	**118,706.34**	**12.48**	**8.70**	**1.44**	**41.86**

- With the implementation of these EPIAs, overall cost saving Rs. 8.7 lakh can be achieved.
- Sl. No. 10 has not been considered in total costing.

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 Madhya Pradesh.

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 MSME 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 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 units to establish 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 baseline energy audits is as follows:

- Data Collection
    - Current energy usage (month wise) for all forms of energy from Jan-2015 to Nov-2015 (quantity and cost)
    - Data on production for corresponding period (quantity)
    - Mapping of process
    - List of major equipment and specifications
    - Baseline energy measurements for the process / 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 in the project:

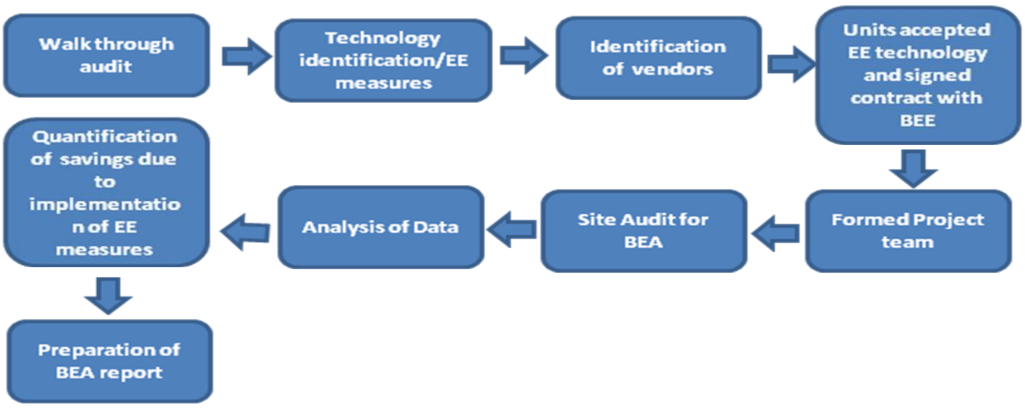

Figure 1 General Methodology

The study was conducted in fallowing stages:

Stage 1: Identification of units and conducting walk through energy audits in 5 units to understand the process and its energy intensiveness, identification of energy saving technologies, assessment of the measurement system, proposing energy efficient technologies to BEE and units for acceptance.

Stage 2: Identification of vendors for implementation of energy efficient technologies and facilitating BEE to sign tripartite MOUs with the units that are willing to implement the EE technology and their cluster association.

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

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

1.3.3 Baseline energy audit – field assessment

A walk around 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 units' financial performance
- Assess the energy conservation potential for the identified EE measures
- Check for accessibility of measurement points for measurement of energy parameters

The equipment and technologies identified for study are as 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 equipment
- Field testing and measurement
- Data analysis for preliminary estimation of savings potential at site
- Discussion with the unit on the summary of findings and energy efficiency measures identified

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

The various instruments used for energy audit are as shown in the table below:

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	Enercon and Circutor	AR-5	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 1 sec

	PT			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	Patel 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. Ishwar Patel +91 – 9425091595 NA
5	Address of the unit	75 / 17-B, Industrial area, Maxi 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	300

3 DETAILED TECHNICAL FEASIBILITY ASSESSMENT OF THE UNIT

3.1 Description of manufacturing process

3.1.1 Process & energy flow diagram

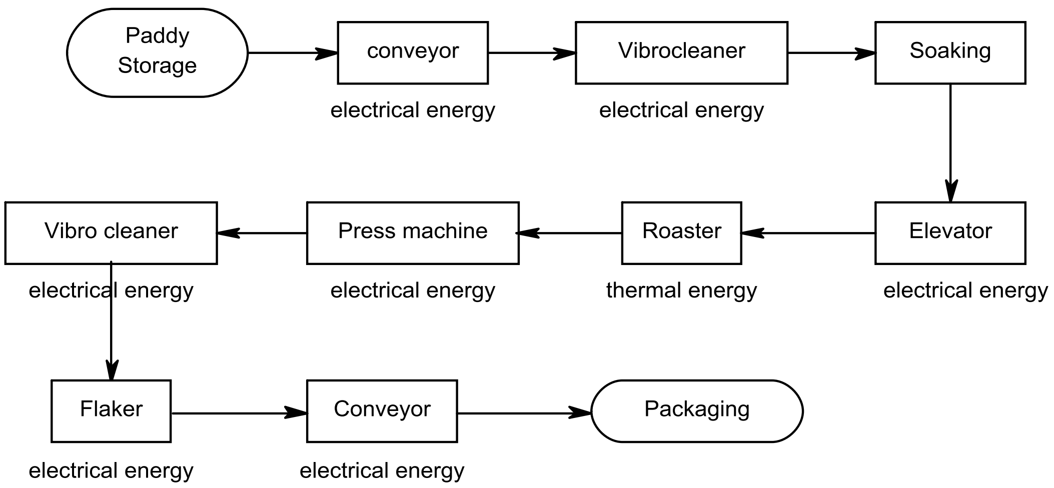

Figure 2: Production flow diagram

3.1.2 Process description

Patel Industries, Ujjain is a rice flake (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 sand particles which come along with the paddy from fields. After removal of large-sized sand particles in the mega cleaner, the smaller sand particles are removed from the paddy in a vibro cleaner. Post cleaning, the paddy is soaked in water for about 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 removal of husk, the rice is processed into flakers that produce rice flakes. The material is then cleaned in 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 husk from the paddy.

- **Flaker:** Processes the pressed rice into flakes.
- **Conveyor:** This belt type conveyor is 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 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 Mar-15 to Feb-16, from different sources is as follows:

Table 5: Energy cost distribution

Particulars	Energy cost distribution		Energy use distribution	
	Rs. Lakh	% of Total	MTOE	% of Total
Grid –electricity	9.5	17	11	4
Thermal – Saw dust	46.1	83	260	96
Total	**55.6**	**100**	**271**	**100**

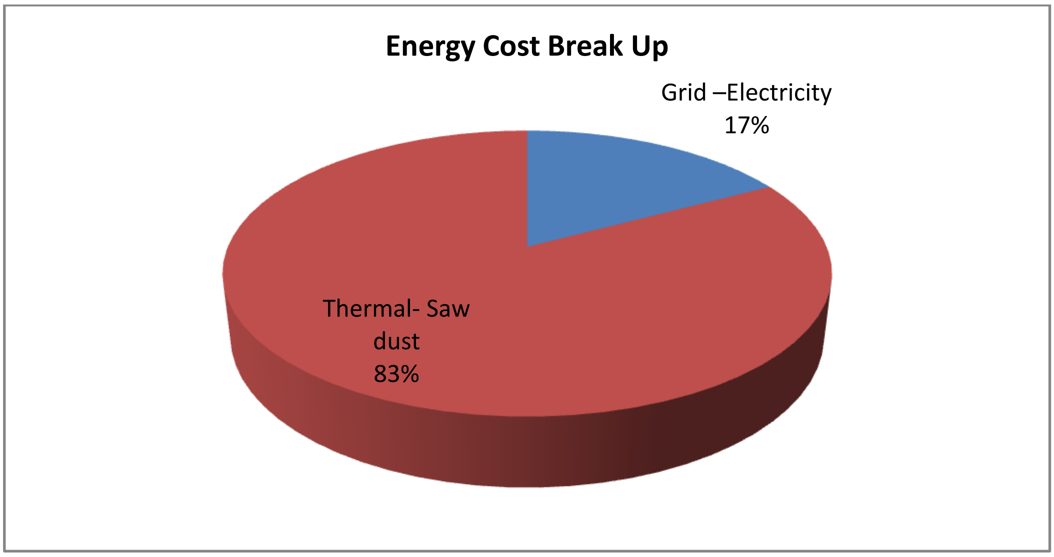

Figure 3: Energy cost share

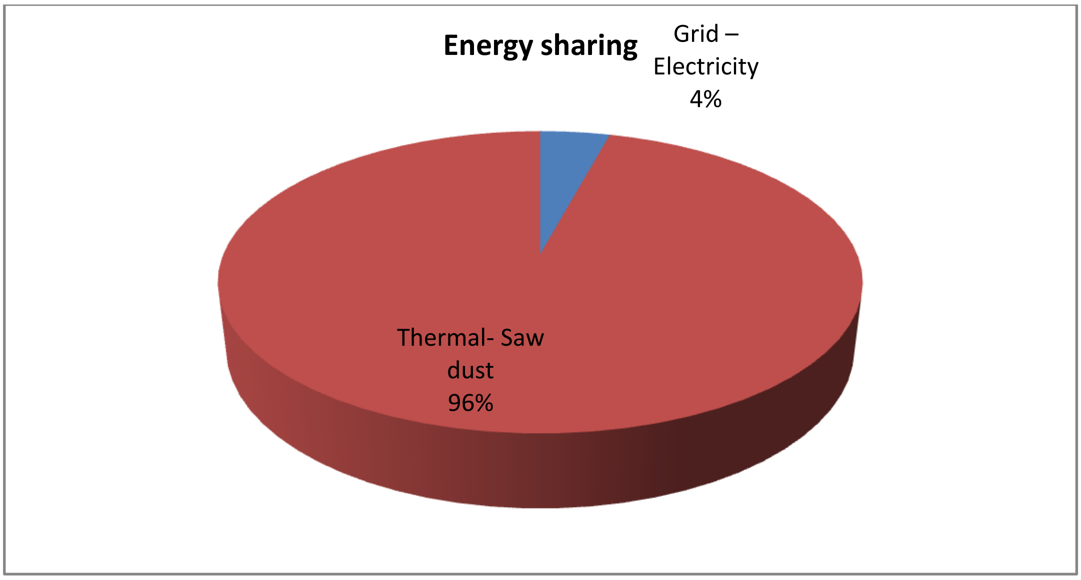

Figure 4: Energy use share

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 72% of the total energy cost and 93% of overall energy consumption.
- Electricity used in the process accounts for 28% of the energy cost and 7% 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 installed capacity of electric load in the plant is 64.7 kW

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

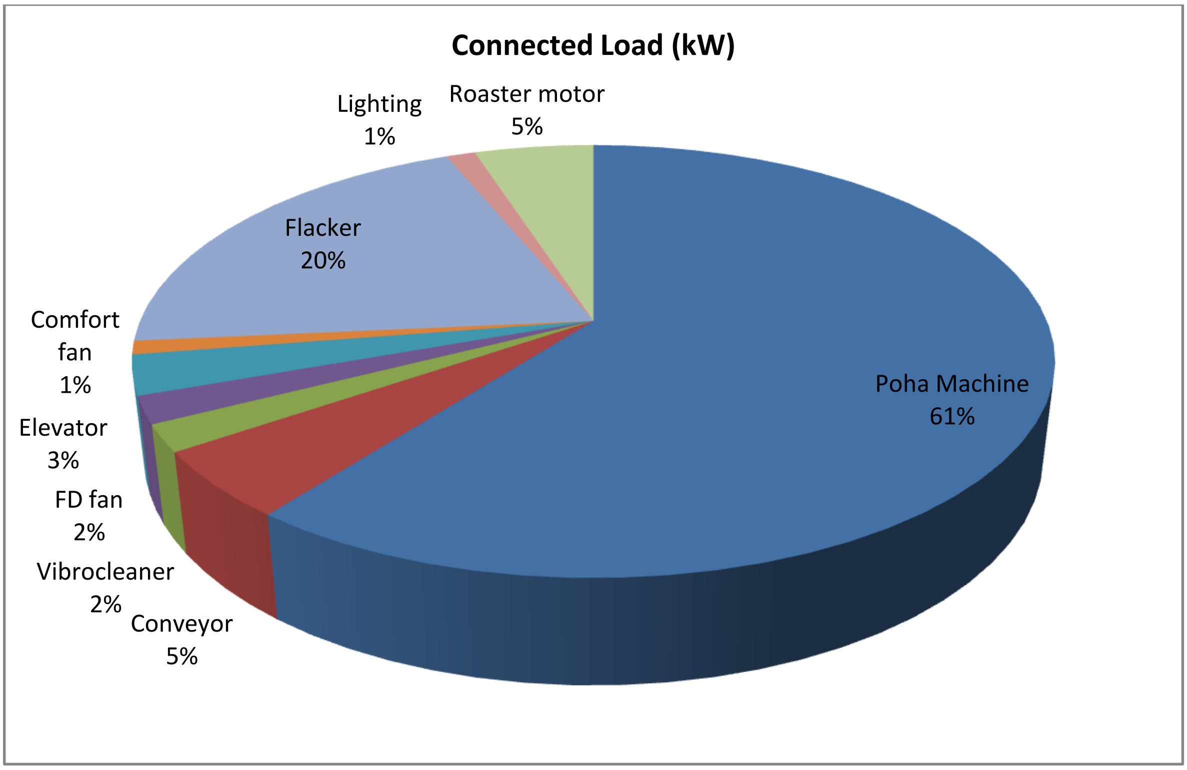

Figure 5: Details of connected load

As shown in the pie chart, the connected load is divided between poha machine – 61%, flaker- 20%, conveyor- 5%, roaster motor– 5%, FD fan blower– 2%, vibrocleaner- 2%, while the lighting contributes around 1% to 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 abelow:

Table 6: Area wise electricity consumption (estimated)

Machine	Connected load (kW)	kWh/y
Poha Machine	44.76	107,424
Conveyor	3.70	8,880
Vibrocleaner	1.50	3,600
FD fan	1.50	4,050
Elevator	2.20	4,620
Comfort fan	0.75	2,025
Flaker	15.00	36,000
Lighting	0.90	2,700
Roaster motor	3.70	8,880
Total	**74.01**	**178,179**

This is represented graphically in the figure below:

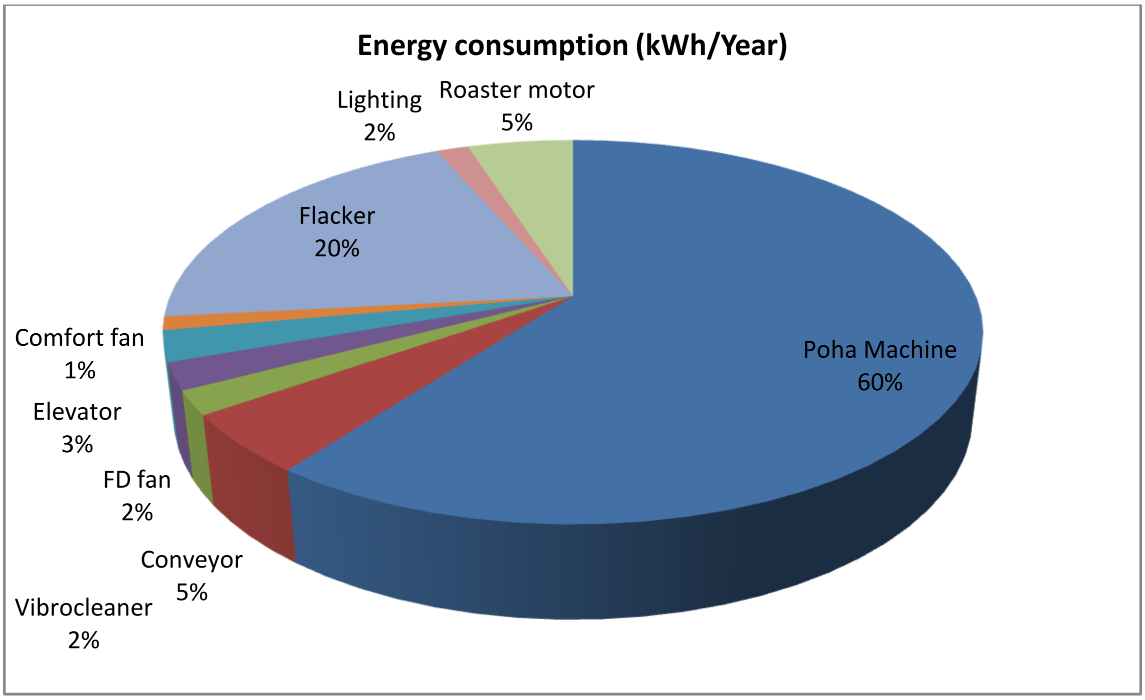

Figure 6: Area wise electricity consumption

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 set in the unit

As there is no DG in the unit, the share of grid is 100% in electricity cost. It is about Rs. 5.5 lakh for 12 months.

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	:	99 HP
c)	Nature of Industry	:	LT – G

The tariff structure is as follows:

Table 7: Tariff structure

Particulars	Tariff Structure	
Present energy charge	5.74	Rs./kWh
Electricity duty	0.51	Rs./kWh
TOD rebate	0.0	Rs./kWh
TOD surcharge	0.0	Rs./kWh
FCA Charge	1.59	Rs./kWh
Weighted Average	7.77	Rs./kWh

(As per Dec-2015 bill)

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

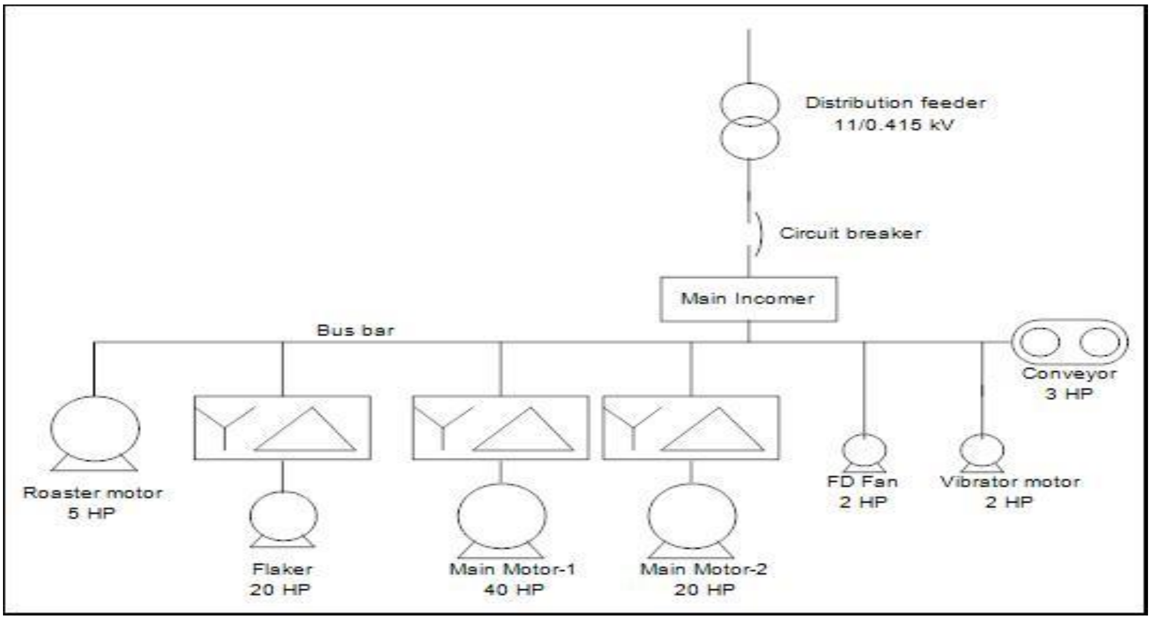

Figure 7: SLD of electrical load

Power factor

The power factor of the unit varied from 0.80 to 0.93 according to electricity bill. However, during the energy audit study, measurement of the power factor was done by logging into the main incomer. The average power factor measured was found to be 0.91 with the maximum being 0.92.

3.3.4 Electricity consumption and production

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

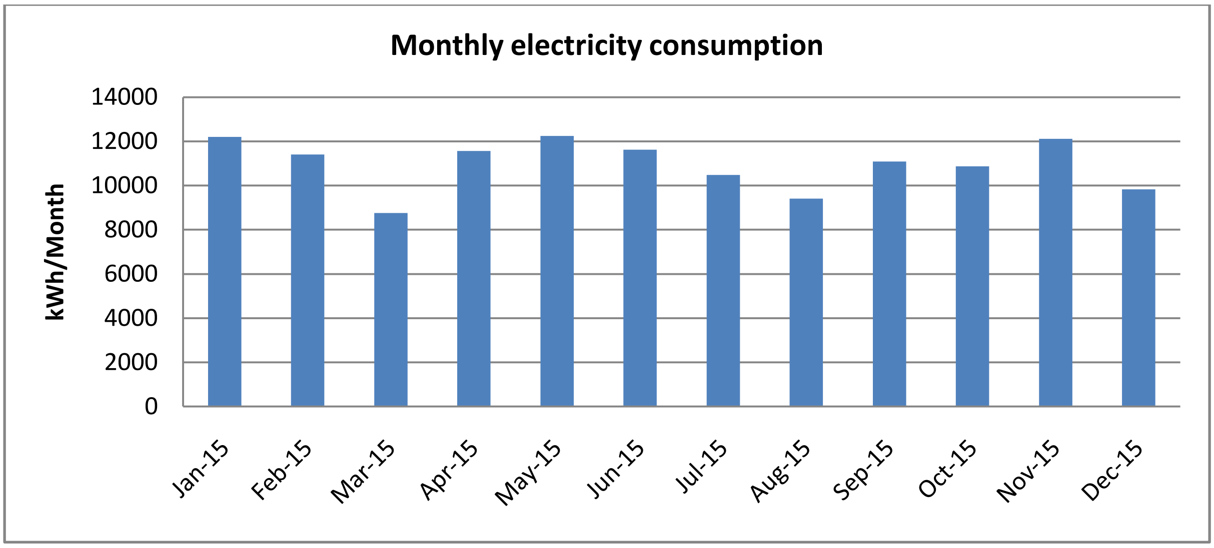

Figure 8: Month wise variation in electricity consumption from different sources

As shown in the figure above, the consumption of electrical energy was on the higher side during the month of May- 2015. The corresponding month wise variation in electricity cost is shown graphically in the figure below:

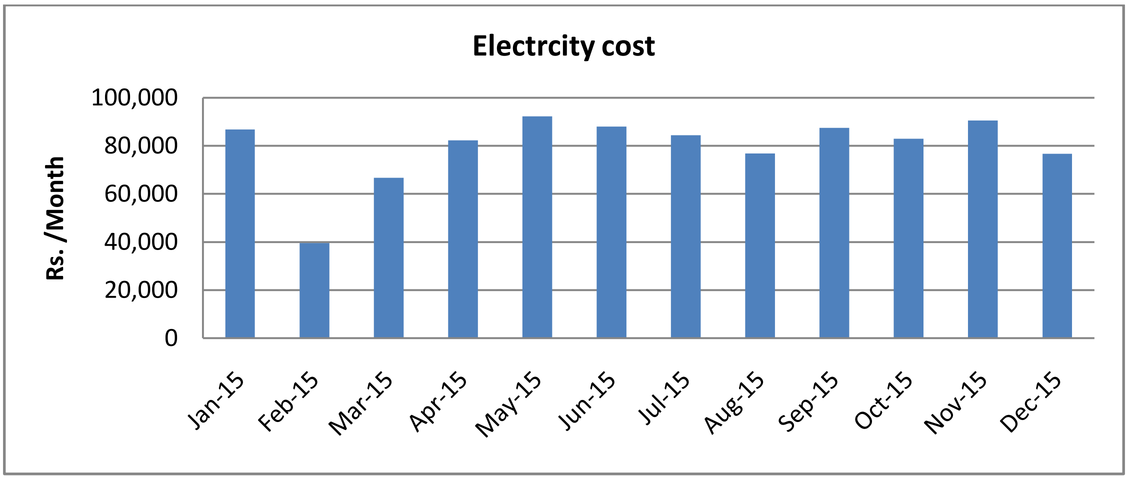

Figure 9 Month wise variation in electricity cost from different sources

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

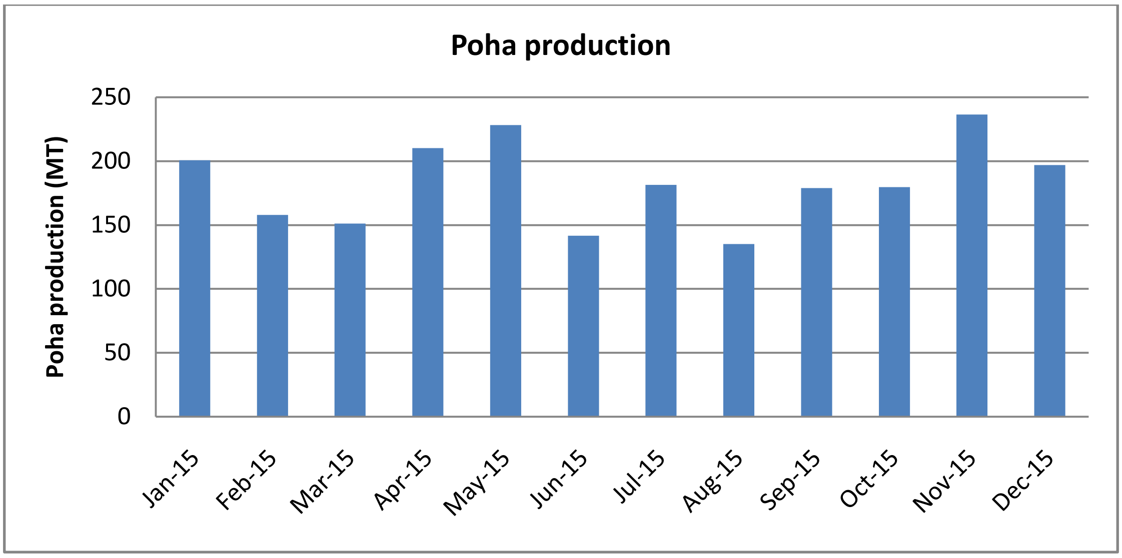

Figure 10 : Month wise poha production for 2015

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. Annual saw dust consumption is 262 MT, costing Rs. 1,441,200.

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 saw dust consumption value was provided, the monthly data for the same was not provided by the unit.***

Table 8: Overall specific energy consumption

Parameters	Unit	Value
Annual grid electricity consumption	kWh	131,604
Annual DG generation unit	kWh	0
Annual total electricity consumption	kWh	131,604
Annual thermal energy (saw dust) consumption	MT	768
Annual energy consumption; MTOE	MTOE	271
Annual energy cost	Lakh Rs.	55.6
Annual production	MT	2,198
SEC; Electrical	kWh/MT	59.9
SEC; Thermal	MT/MT	0.35
SEC; Overall	MTOE/MT	0.12
SEC; Cost based	Rs./MT	2,531

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
- 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 9: Baseline parameters

Particulars	Values	
Electricity rate	5.67	Rs. / kWh inclusive of taxes
Weighted average electricity cost	7.77	Rs. / kWh as per Dec-15 bill
Average cost of saw dust	6	Rs. / kg as per April 2015
Annual operating days per year	300	days/y
Annual operating hours per day	10	h/day

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 were substantiated with measured data. Summary of key observations are 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 was recorded by using the portable power analyzer instrument. The recorded parameters like voltage, current, power and power factor are shown in the figures below.

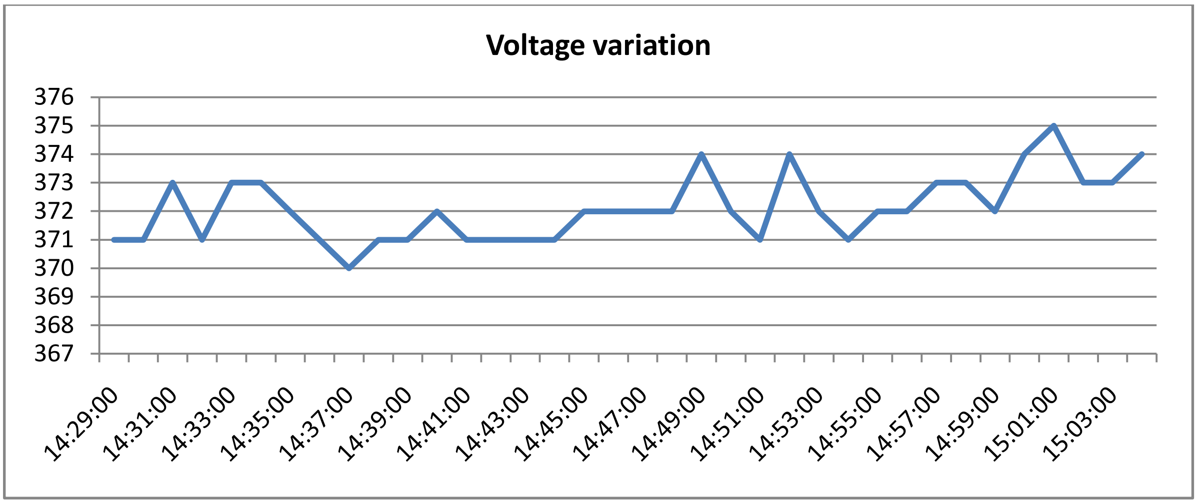

Figure 11: Graph of voltage variation in main incomer

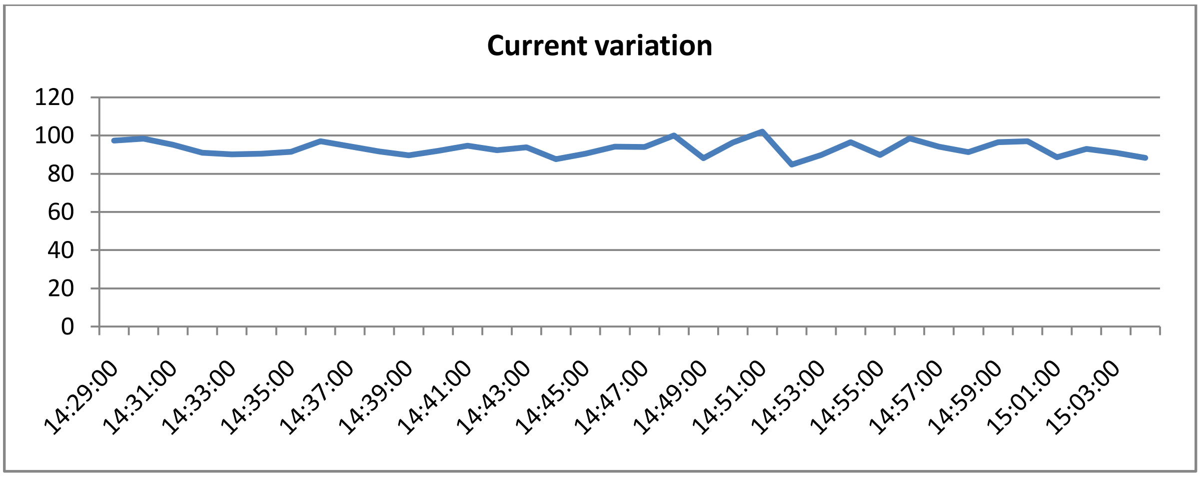

Figure 12: Graph of current variation in main incomer

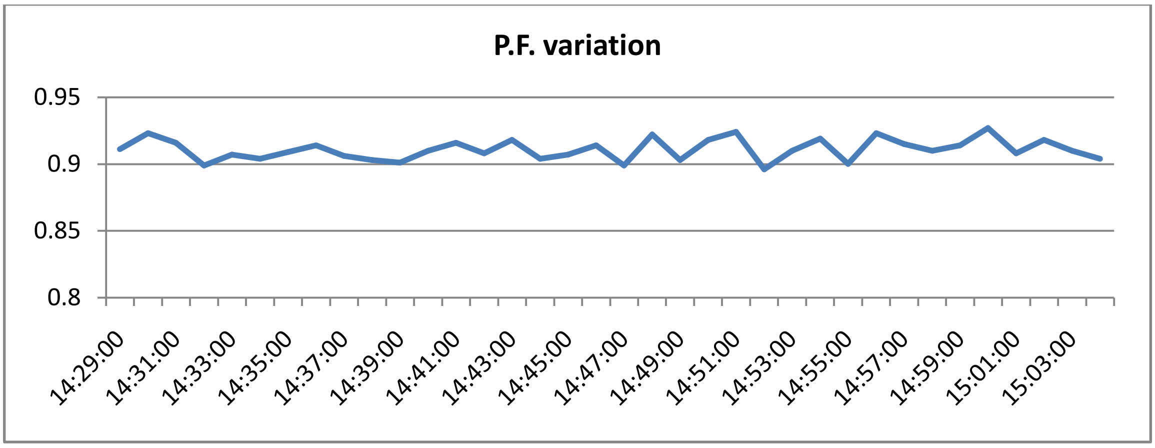

Figure 13: Graph of PF variation in main incomer

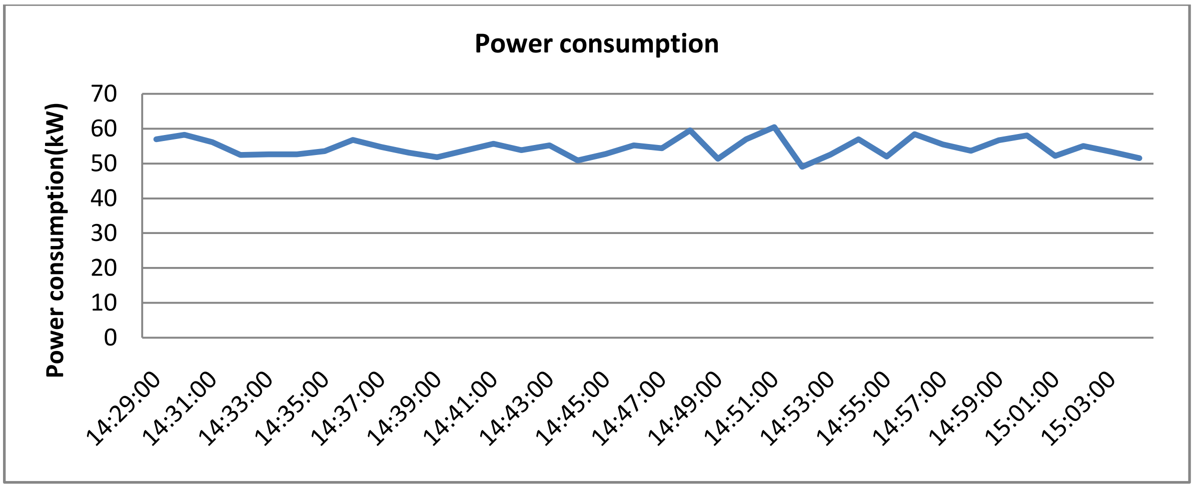

Figure 14: Graph of power consumption variation in main incomer

Following observations have been made:

Table 10: 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. Total sanctioned load is 99 HP.	As per the electricity bill analysis, it was found that the electricity tariff was Rs. 5.67/kWh, Weighted average electricity cost was Rs. 7.77/kWh and the PF according to the electricity bill was about 0.92.	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 0.92 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 was about 372V	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
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 11 Installed motor details

Machine	Rating (kW)
Poha Machine	44.76
Conveyor	3.70
Vibro cleaner	1.50
FD fan	1.50
Elevator	2.20
Comfort fan	0.75
Flaker	15.00
Lighting	0.90
Roaster motor	3.70
Total	**74.01**

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. 1 motor of 30 HP operates 4 poha machines with counter shaft. 1 motor of 20 HP operates the other 4 poha machines by a counter shaft. During audit, 7 poha machines were in operation and 1 machine operated by the 20 HP motor was not in operation.</td><td>Study was conducted on all the poha machines and motors. The results of the study are as below:
<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Average loading of the poha motor of rating 30 HP</td><td>14.35</td><td>0.80</td></tr><tr><td>Average loading of the poha motor of rating 20 HP</td><td>4.92</td><td>0.55</td></tr></table></td><td>Replacement of existing motors of poha machines with smaller sized (8 numbers X 7.5 HP each) EE motors with VFD is recommended</td></tr>
<tr><td>Flaker motors</td><td>The unit has 1 flaker which is operated by a 20 HP motor.</td><td>Study was conducted on flaker machine. 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>14.17</td><td>0.92</td></tr></table></td><td>Replacement of existing of flaker machine motor with EE motor and VFD is recommended</td></tr>
<tr><td>Motor of roaster</td><td>There is 1 roaster motor of 5 HP.</td><td><table><tr><th>Machine</th><th>Avg. kW</th><th>Avg PF</th></tr><tr><td>Roaster motor</td><td>3.54</td><td>0.91</td></tr></table></td><td>EPIA is suggested to replace present roaster motor with EE motor and gearbox controlled</td></tr>
</table>

<table>
<tr>
<td>FD fan for roaster</td>
<td>FD fan (blower) is used to supply combustion air and also for conveying saw dust in roaster. FD fan motor was 1 HP</td>
<td>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>0.71</td><td>0.87</td></tr></table></td>
<td>EPIA suggested to replace existing fan motor with EE motor with VFD. Installation of feed controller for this motor and thermocouple on roaster. Based on roaster temperature, measured by the thermocouple, the feed controller will control the feeding of saw dust (fuel) to the furnace</td>
</tr>
<tr>
<td>Conveyors and elevators</td>
<td>The unit has 6 conveyors, each rated for 1 HP. The plant also has 3 bucket elevators, out of which 2 elevators are rated for 2 HP each and 1 elevator rated for 1 HP.</td>
<td>Study was conducted on conveyor and elevator on sample basis. 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, 1 HP</td><td>0.70</td><td>0.87</td></tr><tr><td>Elevator, 2 HP</td><td>1.40</td><td>0.91</td></tr></table></td>
<td>It is recommended to replace the present conveyor and elevator motors with energy efficient motors and geared drives.</td>
</tr>
<tr>
<td>Other plant process motors – blower motor – 7.5 HP X 1 number; saw dust cleaner motor – 2 HP X 1 number; paddy cleaning blower motor – 10 HP X 1 number; paddy cleaner motor – 1.5 HP X 1 number</td>
<td>There are in total 5 motors of process machineries – blower motor (7.5 HP X 1 number); saw dust cleaner motor (2 HP X 1 number); paddy cleaning blower motor (10 HP X 1 number); paddy cleaner motor (1.5 HP X 1 number) and high speed motor, 2880 rpm (5.5 HP X 1 number)</td>
<td>The study was conducted on all motors that were running during audit. The results of the study are as below:
<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Blower, 7.5 HP X 1</td><td>5.32</td><td>0.91</td></tr><tr><td>Saw dust cleaner, 2 HP X 1</td><td>1.42</td><td>0.94</td></tr><tr><td>Paddy cleaning blower, 10 HP X 1</td><td>7.09</td><td>0.89</td></tr><tr><td>Paddy cleaner, 1.5 HP X 1</td><td>1.06</td><td>0.93</td></tr><tr><td>High speed motor, 2880 rpm, 5.5 HP X 1</td><td>3.90</td><td>0.94</td></tr></table></td>
<td>Replacement of all the process motors with EE motors with gearbox controlled is suggested</td>
</tr>
</table>

3.7.3 Thermal consumption areas

As discussed in earlier sections, about 64% of total energy cost of the plant and 91% of the total energy usage was 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 11.4% at a temperature of 398°C. This reflects high amount of excess air (about 118%) supplied than required for efficient combustion. This also results in high heat loss due to dry flue gases. The flue gas temperature was 398 °C The surface temperature of the roaster is very high varying from 64 to 101°C at various locations. This results in high heat loss from surface of the roaster. There were two ash removal windows of dimension 2.25 X 2.5 ft^2. It was observed that the window was 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 content in saw dust received (mainly during rainy seasons) was very high. The plant 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. It is proposed to install waste heat recovery system to pre-heat combustion air from the high heat available in the flue gases. Rebuilding the roaster furnaces with proper refractory bricks and insulation on walls. It is suggested to close the ash removal windows for some period of time using doors, when ash is not being removed. To improve 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 FEASIBILTY

During BEA of the plant, all energy consuming equipment and processes were studied. The analysis of all major energy consuming equipment and appliances were carried out, which have been already discussed in earlier sections of this report.

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

4.1 EPIA 1: Replacement of poha machine motor with smaller sized EE motors with VFD

Technology description

The plant has 8 poha machines which are operated by 2 motors of 30 HP and 20 HP rated capacities each. Both these motors are old, several times re-wounded and of lower design efficiency. Replacing these old motors with new energy efficient smaller sized motors coupled with VFD will help in reduction in electricity consumption by these motors.

Study and investigation

The unit has 8 poha machines which are operated by 2 motors of 30 HP and 20 HP respectively using counter shaft and belt drives. 4 machines run on the 30 HP motor and the other 4 are operated by the 20 HP motor. During audit, 7 poha machines were in operation. The 20 HP motor was operating only 3 poha machines. Measurements were conducted on the poha machine motors and it was found that they were consuming higher power for production at that time. It was found that energy efficiency ratings of both the poha machine motors were very low and they were re-wounded several times by un-skilled technicians. This was the reason for their poor performance.

Recommended action

It is recommended to replace the 2 existing motors with 8 smaller sized (7.5 HP each) energy efficient motors and VFD controlled. The cost benefit analysis for this energy conservation measure is given below:

Table 12: Cost benefit analysis (EPIA 1)

Description	Unit	As is	To be
No. of poha machines running	#	8	8
No. of motors	#	2	8
Present motors installed in poha machines	720 rpm	30 HP (common for 4 machines); 20 HP (common for 4 machines)	
Proposed motors for Poha machines (with VFD)	720 rpm		8 X 7.5 HP
Present rated power of motors	kW	37.3	

Proposed rated power of motors	kW		44.76
Power consumption by poha machine motors	kW	19.28	16.39
Power savings by replacing existing motors with EE motors	kW		2.89
Running hours / day	h / day	10	10
Operating days / year	days / y	300	300
Weighted avg. cost of electricity	Rs. / kWh	7.77	7.77
Annual energy savings	kWh / y		8,678
Annual cost savings	Rs. Lakh / y		0.67
Estimated Investment	Rs. Lakh		1.20
Simple payback period	y		1.78

4.2 EPIA 2: Replacement of flaker motor with EE motors with VFD

Technology description

The plant has 1 flaker machine which is operated by a motor of 20 HP rated capacity. This motor is very old and several times re-wounded and of lower design efficiency. Replacing this old motor with new energy efficient motor coupled with VFD will help in reducing electricity consumption.

Study and investigation

The unit operates a flaker which is run by a 20 HP motor. During audit, it was observed that the power consumption by this old flaker motor was high due to effects of several times re-winding.

Recommended action

It is recommended to replace the flaker motor with a new energy efficient motor of same capacity with VFD controls. The cost benefit analysis for this energy conservation measure is given below:

Table 13: Cost benefit analysis (EPIA 2)

Description	Unit	As is	To be
No. of flaker machines running	#	1	1
No. of motors	#	1	1
Present motors installed in flaker machines	960 rpm	20 HP	
Proposed motors for flaker machines (with VFD)	960 rpm		20 HP
Present rated power of motors	kW	14.92	
Proposed rated power of motors	kW		14.92
Power consumption by flaker machine motors	kW	14.17	12.98
Power savings by replacing existing motors with EE motors	kW		1.19
Running hours / day	h / day	10	10
Operating days / year	days / y	300	300
Weighted avg. cost of electricity	Rs. / kWh	7.77	7.77

Annual energy savings	kWh / y	3,581
Annual cost savings	Rs. Lakh / y	0.28
Estimated Investment - new EE motor and VFD	Rs. Lakh	0.80
Simple Payback period	y	2.87

4.3 EPIA 3: Replacement of conveyor and elevator motors with EE motors with geared controls

Technology description

Replacement of old and inefficient motors with energy efficient motors with geared controls will help in reducing electrical energy consumption by those motors by approximately 10%.

Study and investigation

The unit has 6 conveyors of 1 HP rated capacities. The unit also has 3 elevators out of which 2 are rated for 2 HP each and 1 elevator is rated for 1 HP. All these motors are old and several times re-wounded and have been in operation since inception of the plant. Due to wear and tear and effects of several re-windings, the operating efficiencies of these motors have decreased and they consume more power.

Recommended action

It is recommended to replace the motors of the conveyors and elevators with energy efficient motors of same capacities coupled with gear box drives. This will help in reducing power consumption by these motors. The cost benefit analysis for this energy conservation measure is given below:

Table 14: Cost benefit analysis (EPIA 3)

Parameters	Unit	As Is	To Be
Total number of conveyor motors and their ratings (6 numbers, 100 rpm)	HP	6 X 1 HP each	6 X 1 HP each
Total number of elevator motors and their ratings (2 numbers, 960 rpm, 2 HP each + 1 number, 960 rpm, 1 HP)	HP	2 X 2 HP each + 1 X 1 HP	2 X 2 HP each + 1 X 1 HP
Total number of motors for conveyors and elevators	#	9.00	9.00
Total rated power of conveyor and elevator motors	HP	11.00	11.00
	kW	8.21	8.21
Average actual power consumption of motors - present	kW	7.80	
Average actual power consumption of motors - proposed	kW		7.22
Power savings by replacing existing plant motors with EE motors and accessories (gear box)	kW		0.57

No of operating hours per day	h / day	10	10
Operating days per year	days / y	300	300
Annual electricity savings per year	kWh / y	1,723	
W. Average electricity tariff	Rs / kWh	7.77	
Annual monetary savings	Rs. Lakh / y	0.13	
Estimated investment	Rs. Lakh	0.48	
Simple payback period	y	3.58	

4.4 EPIA 4: Replacement of roaster motor with EE motor

Technology description

The plant has an old and several times re-wounded motor for rotating the roaster. The present roaster motor consumes high power due to its reduced efficiency levels.

Study and investigation

The unit has one roaster motor for rotating the roaster. The rated capacity of the roaster motor is 5 HP. The motor is old, several times re-wounded and inefficient which resulted in it consuming higher power than required.

Recommended action

It is recommended to replace the existing inefficient roaster motor with a new energy efficient motor of same capacity (5 HP). The cost benefit analysis for this energy conservation measure is given below:

Table 15: Cost benefit analysis (EPIA 4)

Description	Unit	As Is	To be
Rating of roaster motor	HP	5.00	5.00
Present Power consumption by roaster motor	kW	3.54	3.25
Power saving by replacing existing motor with EE motor	kW		0.30
Running hours / day	h / day	10	10
Operating days / year	days / y	300	300
Weighted avg. cost of electricity	Rs. / kWh	7.77	7.77
Annual energy savings	kWh / y		895
Annual monetary savings	Rs. Lakh / y		0.07
Estimated Investment - EE motor and VFD	Rs. Lakh		0.27
Simple payback period	y		3.88

4.5 EPIA 5: Replacement of other plant process motor with EE motors (FD fan motor, saw dust cleaner and blower motors, paddy cleaner and blower motor, high speed motor)

Technology description

The plant has one blower motor of 7.5 HP rated capacity, one saw dust cleaner of 1 HP rated capacity, one paddy cleaning blower of 10 HP rated capacity, one paddy cleaner of 1.5 HP rated capacity, FD fan of roaster of 1 HP and a high speed motor of 5.5 HP rated capacities. These motors are old and several times re-wounded by un-skilled technicians. Replacing these motors with energy efficient motors of similar capacity will help in reduction of power consumption by those motors.

Study and investigation

There are total of 6 plant process motors of various rated capacities as mentioned above which are old and operating since inception of the plant. These motors have also been several times re-wounded due to which their operating efficiencies have degraded over the period of time. The energy consumption by these motors is very high and utilization of input electrical energy is very low because of low efficiency ratings.

Recommended action

It is recommended to replace the existing motors with energy efficient motors of similar capacities. The cost benefit analysis for this energy conservation measure is given below:

Table 16 Cost benefit analysis (EPIA 5)

Parameters	Unit	As Is	To Be
Rating of blower motor	HP	7.5 HP X 1	7.5 HP X 1
Rating of saw dust cleaner motor, 1,440 rpm	HP	2 HP X 1	2 HP X 1
Rating of paddy cleaner (blower) motor, 1,455 rpm	HP	10 HP X 1	10 HP X 1
Rating of FD fan motor, 1,440 rpm	HP	1 HP X 1	1 HP X 1
Rating of Paddy cleaner (chalna) motor, 1415 rpm	HP	1.5 HP X 1	1.5 HP X 1
Rating of 2880 rpm motor	HP	5.5 HP X 1	5.5 HP X 1
Total number of plant process motors to be replaced with EE motors	#	6.00	6.00
Total rated power of other plant process motors	HP	27.50	27.50
	kW	20.52	20.52
Average actual power consumption of motors - present	kW	19.49	
Average actual power consumption of motors - proposed	kW		17.85
Power savings by replacing existing plant motors with EE motors and accessories (gear box)	kW		1.64
No of operating hours per day	h / day	10	10
Operating days per year	days / y	300	300
Annual electricity saving per year	kWh / y	4,924	
W. Average Electricity Tariff	Rs. / kWh	7.77	
Annual monetary savings	Rs. Lakh / y	0.38	
Estimated Investment	Rs. Lakh	0.79	
Simple payback period	y	2.06	

4.6 EPIA 6: Reducing heat loss by covering the roaster inspection door with insulated MS

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 color of the firing chamber during combustion to judge the temperature level of the roaster combustion zone.

These ash removal holes are kept always open, which 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 they are not in use, thereby preventing heat loss.

Figure 15: Ash removal opening in roaster

Study and investigation

At the time of BEA, it was found that the combined total area of the ash chamber opening was 0.52 m^2. The average temperature inside the roaster was approximately 450^0C. Heat loss due to radiation from the ash removal openings was estimated to be 4,276 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's internal temperature.

Recommended action

It is recommended to install an insulated metallic plate door on the openings and keeping them 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 17: 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	450.00	60.00
Ambient temperature	^oC	37.00	37.00
Velocity of air	m / sec	1.00	1.00
Heat loss from the ssh chamber opening	Watts / m2	9,516	194
	kCal / m2	8,183	167
	kCal / h	4,276	87
Savings in thermal energy	kCal/h	4,189	
GCV of fuel	kCal / kg	3,390	3,390
Saving in fuel	kg / h		1.24
Operating hours / day	h / day	10	10
Running days per year	days / y	300	300
Cost of saw dust	Rs. / kg	6.00	6.00
Annual savings	kCal/year	12,567,115	
Annual savings in fuel	kg/year	3,707	
Annual monetary savings	Rs. Lakh / y	0.22	
Investment	Rs. Lakh	0.30	
Payback years	y	1.35	

4.7 EPIA 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.

Study and investigation

The unit has a roaster for heating the moist paddy grains. The skin temperature of the roaster varies from 64 to 101^{o}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 18: Cost benefit analysis (EPIA 7)

Parameters	Units	Value	To Be
Length of roaster	m	4.15	4.15
Width of roaster	m	2.30	2.30
Height of roaster	m	2.90	2.90
Average Temp of front surface (material outlet)	^0C	64.00	47.00

Average Temp of side surface (press-side)	^0C	64.83	47.00
Average Temp of side surface (Ash removal side)	^0C	101.25	47.00
Average Temp of Back Surface (fuel feeding side)	^0C	97.50	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	237	69
Heat loss due to R&C - Press machine side	Watt / m^2	247	69
Heat loss due to R&C - Ash removal side	Watt / m^2	705	69
Heat loss due to R&C - Back side	Watt / m^2	654	69
Heat loss due to R&C - Front side	kCal / m^2	204	59
Heat loss due to R&C - Press machine side	kCal / m2	212	59
Heat loss due to R&C - Ash removal side	kCal / m^2	606	59
Heat loss due to R&C - Back side	kCal / m^2	562	59
Total area - Front side	m^2	6.67	6.67
Total area - Back side	m^2	6.67	6.67
Total area - Press machine side	m^2	12.04	12.04
Total area - Ash removal side	m^2	12.04	12.04
Heat loss due to R&C - Front side	kCal / h	1,362	393
Heat loss due to R&C - Press machine side	kCal / h	2,553	709
Heat loss due to R&C - Ash removal side	kCal / h	7,298	709
Heat loss due to R&C - Back side	kCal / h	3,749	393
Total heat loss due to R&C from furnace surface	kCal / h	14,961	2,204
Calorific value of fuel - saw dust	kCal / kg	3,380	3,380
Total energy savings by insulating the roaster-furnace	kCal / h		12,757
Total fuel savings per hour	kg / h		3.77
Operating hours / day	h / day	10	10
Running days per year	days / y	300	300
Cost of saw dust	Rs. / kg	6	6
Total fuel savings per year	kg / y		11,322
Monitory savings per year	Rs. Lakh / y		0.68
Estimated investment	Rs. Lakh		1.00
Simple Payback period	y		1.47

4.8 EPIA 8: Fuel savings by waste heat recovery from flue gases from roaster-furnace

Technology description

Flue gases coming out from roaster are at very high temperature of 398^{0}C. Presently, the flue gases are released to atmosphere without recovering any heat from them. 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 DEA, it was found that the temperature of flue gases coming out from the roaster was approximately 398°C, which indicates that the heat content in the flue gas was very high, which could 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 19: Cost benefit analysis (EPIA 8)

Parameters	Unit	Value
Temp of flue gas	°C	398.00
Ambient Temperature	°C	40.00
Mass of flue gas generated	kg / h	1,716.62
Specific heat of flue gas	kCal / (kg-°C)	0.26
Mass of Air supplied	kg / hr	377.51
Specific heat of air	kCal / (kg-°C)	1.00
Efficiency of APH	%	50.00
Temp of flue gas After APH	°C	180.00
Calculations		
Temp of Air After APH	°C	168.87
Energy savings	kCal / h	48,649
Annual Energy savings	kCal / y	145,947,036
Annual Fuel savings	kg / y	43,180
Annual Monetary Saving	Rs. Lakhs / y	2.59
Investiment Estimated	Rs. Lakhs	5.09
Payback	y	1.97

4.6 EPIA 9: Controlling excess air and fuel being supplied for 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 and 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 11.4% 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 20: Cost benefit analysis (EPIA 9)

Excess air control using temperature and moisture sensors and VFD control of fuel feed			
Parameters	**UOM**	**Present**	**Proposed**
Oxygen level in flue gas	%	11.40	6.00
Excess air levels	%	118.75	40.00
Flue Gas temperature	^{0}C	398.00	398.00
Savings in fuel	With every 10% reduction in excess air leads to savings in fuel consumption by 1%		
Annual fuel consumption	kg / y	768,218	707,721
Saving in fuel consumption annually	kg / y		60,497
Cost of fuel	Rs. / kg	6.00	6.00
Annual savings in fuel cost	Rs. Lakh / y		3.63
Running load of blower	kW	1.50	1.35
Annual operating hours	h / y	3,000.00	3,000.00
Electrical energy consumed	kWh / y	4,500.00	4,050.00
Savings in electrical energy per year	kWh / y		450.00

Savings in terms of cost of electrical energy	Rs. Lakh / y	0.03
Total monetary cost savings per year	Rs. Lakh / y	3.66
Estimated investment	Rs. Lakh	2.55
Simple payback	y	0.70

4.9 EPIA 10: Energy cost savings by switching from saw dust to gas based fuel for roaster

Technology description

Fuel switching in roaster from present saw dust based to PNG / LPG based will help in improved productivity, better control over poha quality in the roaster, reduced environmental hazards and better working atmosphere within the plant.

Study and investigation

The unit is using saw dust as a fuel in its roaster. In the present saw dust based fuel firing system, the losses of thermal energy were very high. Moreover, considerable amount of ash was being generated as a by-product of fuel combustion which needed to be disposed. Storage of saw dust (fuel) also required a lot of plant space.

It is recommended to install gas based fuel firing system as PNG pipelines were being laid down in the industrial area of this unit by Avantika Gas Company and the unit hopes to receive gas in a few months' time. The productivity of the unit will increase by using gas based system due to improved quality and productivity and reduced heat losses.

Recommended action

It is recommended to replace the present fuel of the roaster from saw dust to gas which will improve productivity and quality and result in cost savings for the unit. The cost benefit analysis of this measure is given in the table below.

Table 21: Cost benefit analysis (EPIA 10)

Parameters	Units	Value
Roaster efficiency	#	**53%**
GCV of saw dust	kCal/kg	3380
Present saw dust consumption	kg/y	768,218
Annual heat requirement	kCal/y	1,371,139,393
Annual heat requirement cost (Saw Dust)	Lakh	46.09
Calculations		
Roaster efficiency	#	**75%**
GCV of LPG	kCal/kg	12,500
Mass of LPG required	kg/y	146,255

Annual cost of LPG	Lakh	**95.07**
Present Energy Consumption	MTOE	259.66
Post Energy Consumption	MTOE	182.82
Energy Saving	MTOE	76.84
Production Enhancement	%	**6.50**
Present Production	kg/h	732.70
Production Enhancement	kg/h	47.63
Average Selling price	Rs./kg	35.00
Cost benefit through production	Lakh Rs./y	50.01
Total cost savings	Rs. Lakhs / y	1.03
Investment Estimated	Rs. Lakh	7.00
Payback	y	6.77

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	294	*^0C*
O2 in flue gas	10.7	*%*
CO2 in flue gas	5.3	*%*
CO in flue gas	1978.0	*ppm*
Specific heat of flue gas	0.26	*Kcal/kg^0C*
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.	40	*^0C*
Relative Humidity	48	*%*
Humidity in ambient air	0.0120	*kg/kgdry air*
Mass flow rate of fuel	137.43625	*kg/h*
Production of Roasted Paddy	456	*kg/h*

Efficiency calculations

Calculations	Values	Unit
Theoretical air required	5.82	*kg/kg of fuel*
Excess air supplied	103.88	*%*
Actual mass of supplied air	11.88	*kg/kg of fuel*
Mass of dry flue gas	12.34	*kg/kg of fuel*
Amount of water vapour in flue gas	-	*Kg of H2O/kg of fuel*
Specific fuel consumption	0.30	*kg of fuel/kg of Paddy*
Heat loss in dry flue gas	111,990.76	*kCal/h*
Heat loss due to formation of water from H2 in fuel	42,237.16	*kCal /h*

Heat loss due to moisture in fuel	6,142.19	*kCal /h*
Heat loss due to moisture in air	2,238.68	*kCal /h*
Heat loss due to partial conversion of C to CO	13,693.46	*kCal /h*
Heat loss due to radiation and Convection losses	20,251.55	*kCal /h*
Heat loss from Unburnt in fly ash	1,360.62	*kCal /h*
Heat loss from bottom ash	6,122.78	*kCal /h*
Roaster Efficiency by indirect Method	56%	

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 22 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