BASELINE ENERGY AUDIT REPORT

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

Patel Rice Mills

38, B.D. 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

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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. Mohanji Patel, Owner, for showing keen interest in the energy audit and also thankful to the management of Patel Rice Mill 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.

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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
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 Madhya Pradesh.

As part of this project, DESL has been engaged to implement the project in the SME food cluster in 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 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	Patel Rice Mills
Constitution	Partnership
MSME Classification	Small
No. of years in operation	NA
Address: Registered Office	Plot No:38 ,B.D Industrial area Maksi road, Ujjain
Administrative Office	Plot No:38, B.D Industrial area Maksi road, Ujjain
Factory	Plot No: 38,B.D Industrial area Maksi road, Ujjain
Industry-sector	Food
Products Manufactured	Poha (Rice flakes)
Name(s) of the Promoters / Directors	Mr. Mohanji Patel/ Mayank 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

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 66% 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 (10 HP X 2 numbers and 15 HP X 2 numbers) EE motors	15,075		1.75	1.20	1.45
2	Replacing roaster (5 HP) motor with EE motor and VFD	1,044		0.27	0.08	3.24
3	Replacing other plant process motors with EE motors (flaker motor, 15 HP; conveyor motors with gear box, 1.5 HP X 2 numbers; elevator motors with gear box, 2 HP X 2 numbers; FD fan of roaster, 1 HP X 1 number with accessories)	4,804		1.44	0.38	3.75
4	Reducing heat loss by covering the roaster inspection door with insulated MS plates		5,097	0.10	0.26	0.38
5	Reduction in radiation and convection loss from roaster by refurbishing refractory and insulation of surface		20,228	1.00	1.04	0.96
6	Fuel savings by waste heat recovery from flue gases from roaster-furnace		43,101	5.09	2.22	2.29
7	Fuel savings by controlling excess air supplied for combustion in roaster and controlling fuel feed	196	54,173	2.55	2.81	0.91
8	Energy cost savings by switching from saw dust to gas based fuel for roaster[1]			7.00	3.07	2.28
	Total	**21,120**	**122,599**	**12.20**	**8.00**	**1.53**

- With the implementation of these EPIAs, overall cost savings of Rs. 8.00 Lakh can be achieved.
- Total estimated investment of Rs. 12.20 Lakh can be incurred with simple payback in nearly 2 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 micro small and medium enterprises (MSMEs) 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 SME units within the cluster that are willing to implement and demonstrate the above technologies in their units;
- Facilitate Bureau of Energy Efficiency (BEE), New Delhi to sign tri-partite Memorandum of Understanding (MoUs) with the 20 SME units of Indore food cluster (that are willing to implement the energy efficient technologies) and their cluster association;
- Conducting Baseline Energy Audits in 20 SME food units of the Indore food cluster who have signed MoUs with BEE;
- Establishing baseline energy efficiency scenario for the 20 units against which energy savings will be computed post implementation;
- Facilitating the 20 SME units in implementing the proposed energy efficient technologies in their units;
- Conducting post implementation energy audits in the 20 SME units to establish the actual energy savings in those units;
- Development of technology specific case studies (audio-visual and print) for each technology (during pre-implementation, implementation and post implementation stages).

1.2 Scope of work for Baseline Energy Audit (BEA)

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

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

- Quantification of energy cost savings by implementing EE measures / technologies
- 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:

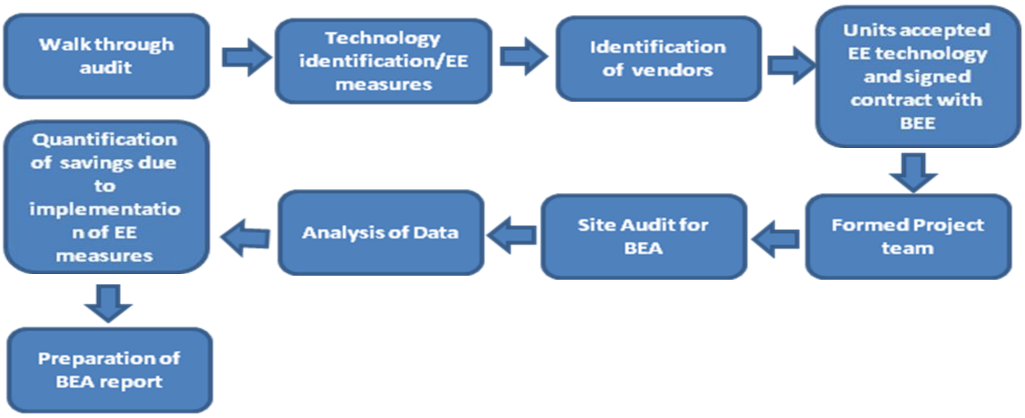

Figure 1: General Methodology

The study was conducted in following stages:

Stage 1: Identification of units and conducting walk through energy audits in 8 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 facilitate 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 Base line energy audit – field assessment

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

- Collect historical energy consumption data
- Obtain cost and other operational data for understanding the impact of energy cost on the 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 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 following:

Table 3: Energy audit instruments

Sl. No.	Instruments	Make	Model	Parameters measured
1	Power Analyzer – 3 Phase (for un balanced Load) with 3 CT and 3 PT	Enercon and Circutor	AR-5	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 1 sec interval
2	Power Analyzer – 3 Phase (for balance load) with 1 CT and 2 PT	Elcontrol Energy	Nanovip plus mem	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 2 sec interval
3	Flue Gas Analyzer	Kane-May	KM-900	O2%, CO2%, CO in ppm and Flue gas

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

1.3.4 Baseline energy audit – desk work

Post audit off-site work carried out included:

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

2 ABOUT THE MSME UNIT

2.1 Particulars of the unit

Table 4: General particulars of the unit

Sl. No	Particulars	Details
1	Name of the unit	Patel Rice Mills
2	Constitution	Partnership
3	Date of incorporation / commencement of business	NA
4	Name of the contact person Mobile/Phone No. E-mail ID	Mr. Mayank Patel / Mr. Mohan ji Patel +91 – 9425332584 mayankpatel.mail@gmail.com
5	Address of the unit	38, B.D 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

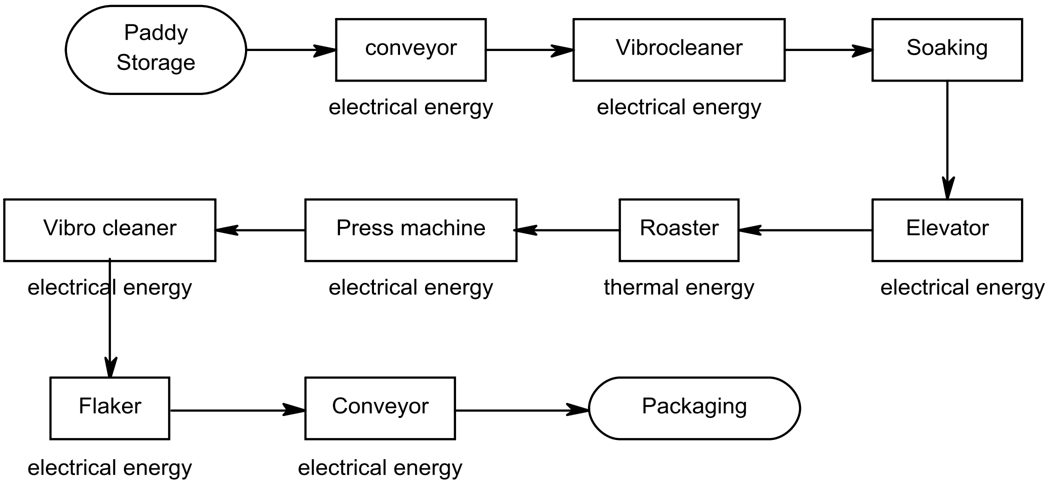

Figure 2: Production flow diagram

3.1.2 Process description

Patel Rice Mills, 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 large sand particles which come along with the paddy from fields. After removal of larger 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 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 into cleaner to produce poha (rice flakes) which is then packed and dispatched.

3.2 Inventory of process machines / equipment and utilities

Major energy consuming equipments in the plant are:

- **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 two different sources:
  - 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 April-15 to March-16, from different sources are as follows:

Table 5: Energy cost distribution

Particular	Rs. (Lakh)	% of Total	MTOE	% of total
Grid –Electricity	10.4	34%	11.77	8%
Thermal- Saw dust	20.2	66%	133.10	92%
Total	**30.6**	**100%**	**144.87**	**100%**

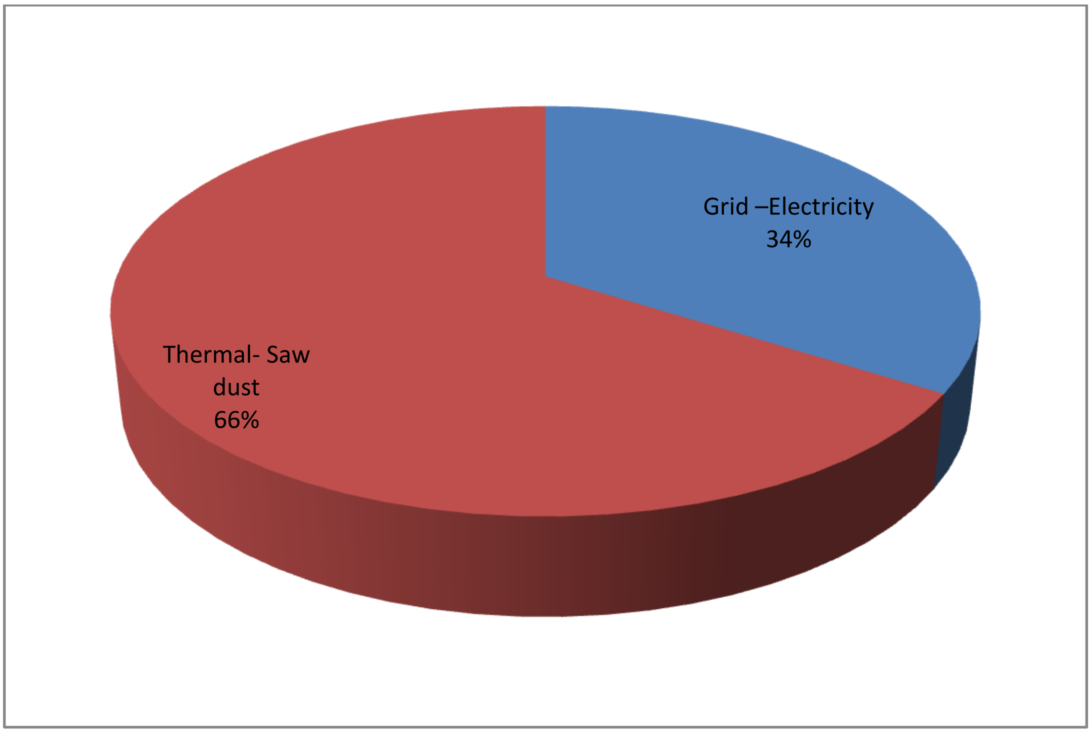

Figure 3: Energy cost share

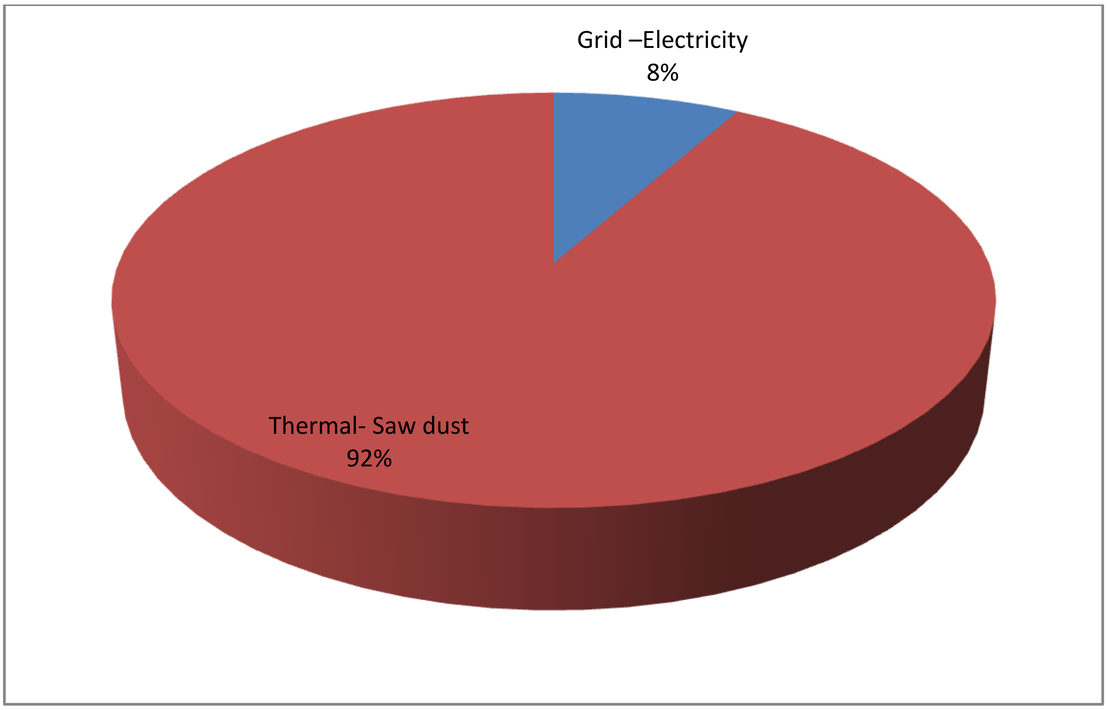

Figure 4: Energy use share

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 66% of the total energy cost and 92% of overall energy consumption.
- Electricity used in the process accounts for 34% 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 installed capacity of electric load in plant is 79 kW

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

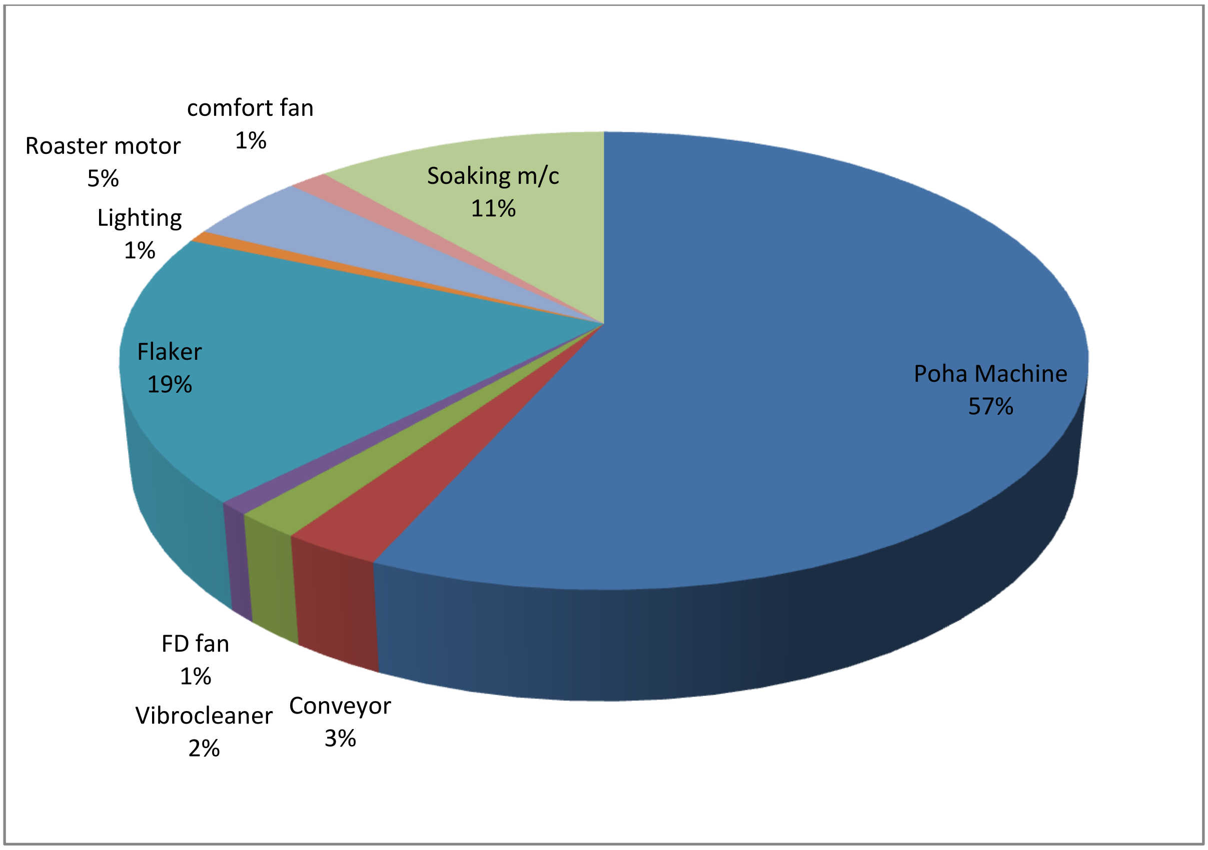

Figure 5: Details of connected load

As shown in the pie chart of connected load, the connected load is divided between poha machine – 57%, flaker- 19 %, conveyor-3%, roaster motor – 5%, FD fan blower – 1%, vibrocleaner-2%, and lighting contribute around 1 % to 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 in the unit

As there is no DG in the unit the share of grid is 100% in electricity cost. It is about Rs. 10.4 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	:	100 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	0.0	Rs./kWh
TOD surcharge	0.0	Rs./kWh
FCA charge	1.73	Rs./kWh
Weighted average	7.98	Rs./kWh

(As per Dec-2015 bill)

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

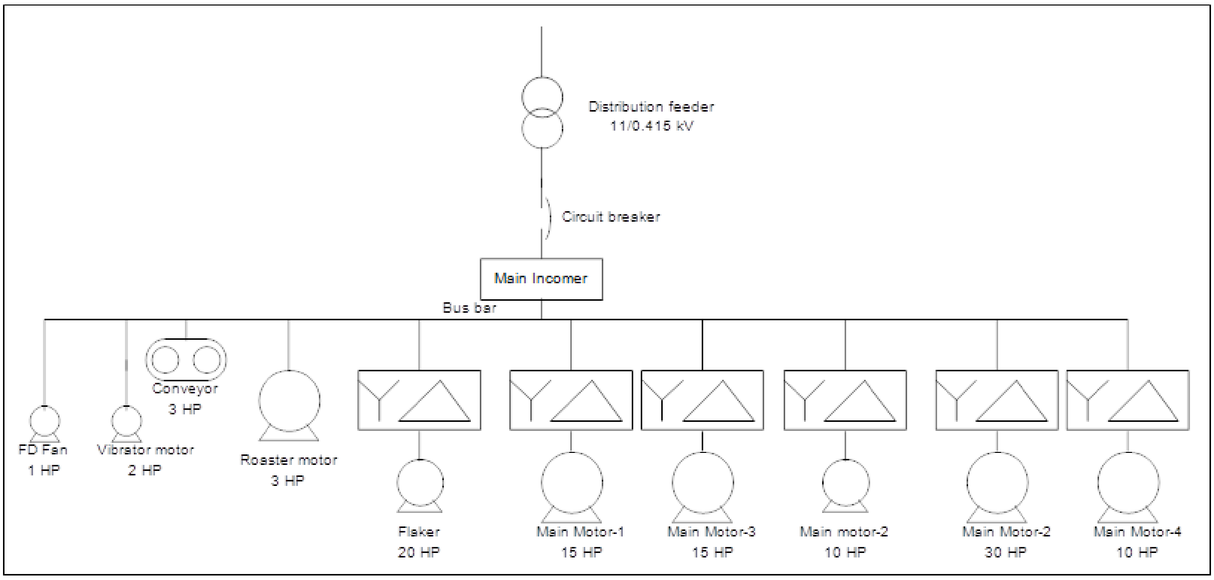

Figure 6: SLD of electrical load

Power factor

The power factor of the unit varies from 0.8 to 0.94 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 0.977.

3.3.4 Electricity consumption

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

Table 7: Electricity consumption & cost

Bill for month	Units (kWh)	Bill amount
Mar-15	9,780	79,217
Apr-15	8,980	72,060
May-15	8,800	71,144
Jun-15	9,540	74,014
Jul-15	11,406	86,853

Aug-15	17,340	128,967
Sep-15	11,620	90,969
Oct-15	10,640	80,810
Nov-15	9,180	72,534
Dec-15	12,840	94,315
Jan-16	11,406	86,853
Feb-16	15,340	104,504

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

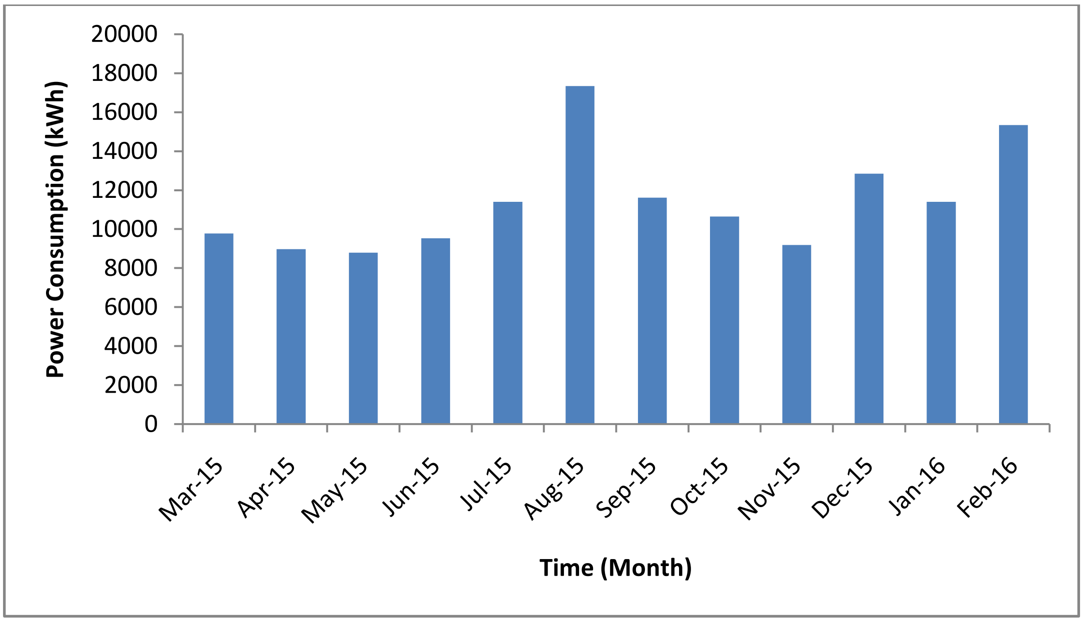

Figure 7: Month wise variation in electricity consumption from different sources

3.4 Analysis of thermal consumption by the unit

Fuel used for roaster is saw dust which is bought at the rate of Rs. 5.15/kg. There is no provision for measurement of saw dust consumption in the roaster. Average annual saw dust consumption is 392.62 MT, costing Rs. 20.22 Lakh.

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:

Table 8: Specific energy consumption

Month	Poha (MT)	Saw dust (MT)	Electricity (kWh)	SPC (kWh/MT)	SFC (MT/MT)
Apr-15	220.8	35	9,780	44	0.158
May-15	252.08	34	8,980	36	0.137
Jun-15	216.87	34	8,800	41	0.159
Jul-15	172.11	34	9,540	55	0.199
Aug-15	219.53	35	11,406	52	0.161
Sep-15	283.40	35	17,340	61	0.124
Oct-15	271.63	36	11,620	43	0.131
Nov-15	271.83	36	10,640	39	0.131

Dec-15	269.65	36	9,180	34	0.132
Jan-16	214.43	26	12,840	60	0.121
Feb-16	213.15	26	11,406	54	0.122
Mar-16	188.38	25	15,340	81	0.134
Total	**2,793.84**	**392.616**	**136,872**	**49**	**0.141**

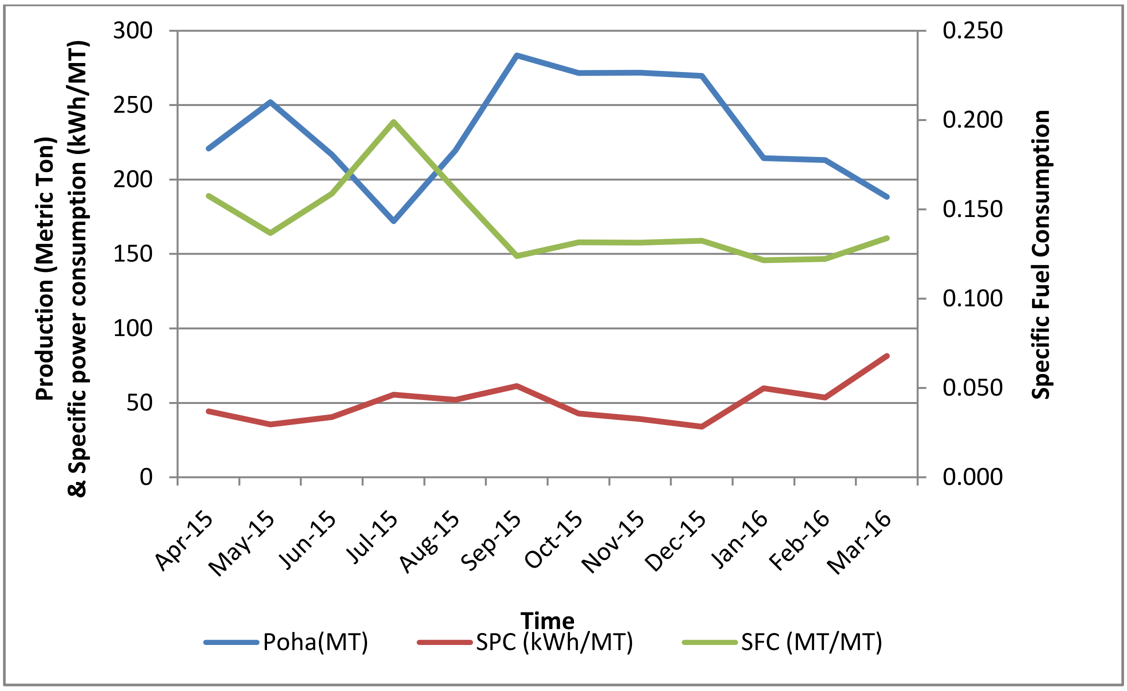

Figure 8: Specific energy consumption for the year 2015

Table 9: Overall specific energy consumption

Parameters	Unit	Value
Annual grid electricity consumption	kWh	136,872
Annual thermal energy(saw dust) consumption	MT	392.62
Annual energy consumption; MTOE	MTOE	144.9
Annual energy cost	Lakh Rs.	30.6
Annual production	MT	2,793.84
SEC; Electrical	kWh/MT	49.0
SEC; Thermal	MT/MT	0.14
SEC; Overall	MTOE/MT	0.05
SEC; Cost Based	Rs./MT	1,097

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

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	5.7
Weighted average electricity cost	Rs./ kWh	7.98
Annual operating days	days	300
Operating hours per day	h	8
Production	MT/y	2,793.84
GCV of grid electricity	kCal/kWh	860
Saw dust cost	Rs. /kg	5.15
GCV of saw dust	kCal/kg	3,390
Cost of LPG	Rs./kg	51
GCV of LPG	kCal/kg	12,500
CO2 emission factor - grid	kg/kWh	0.9
CO2 emission factor - saw dust	tons/ton	1.6

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 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 the portable power analyzer instrument.

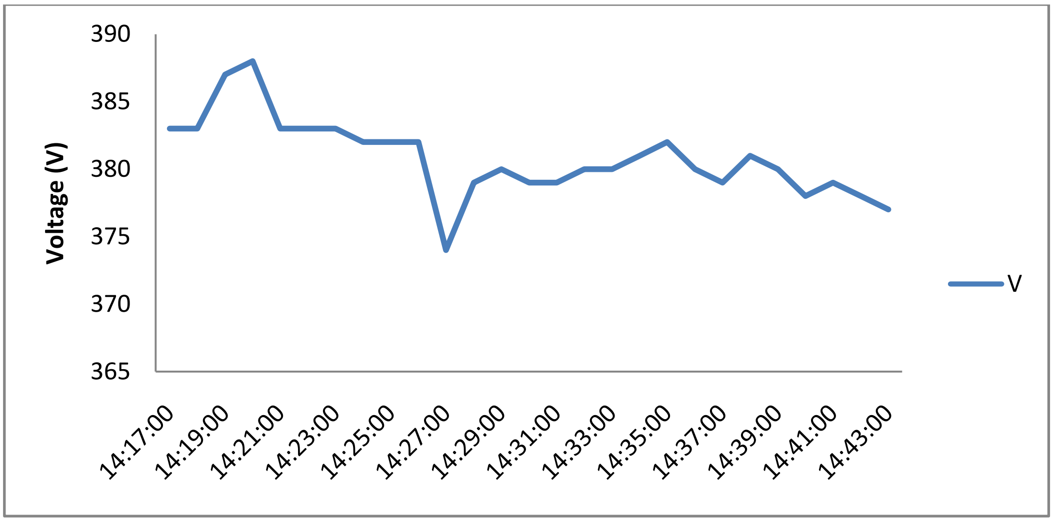

Figure 9: Variation in voltage at main incomer of plant

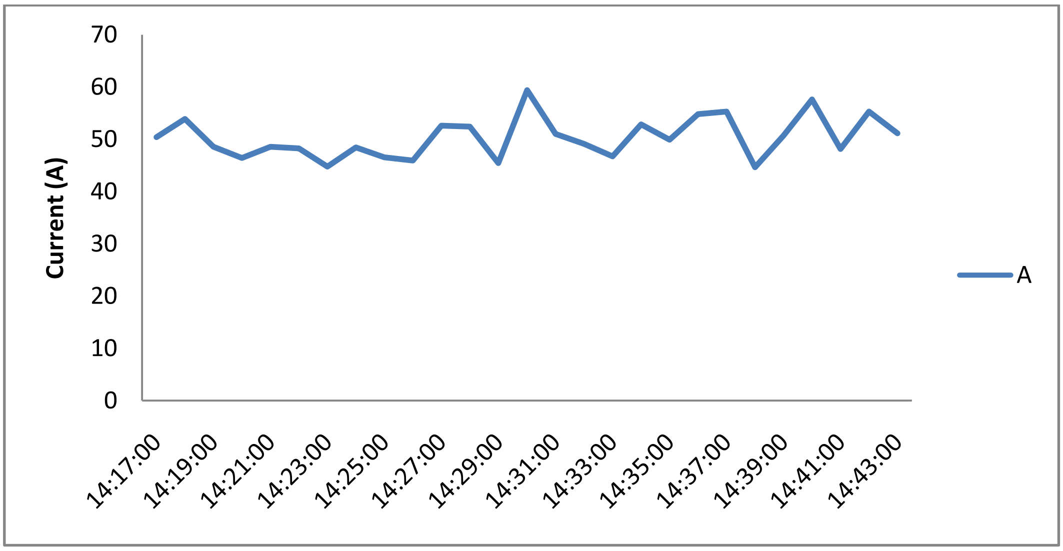

Figure 10: Variation in voltage at main incomer of plant

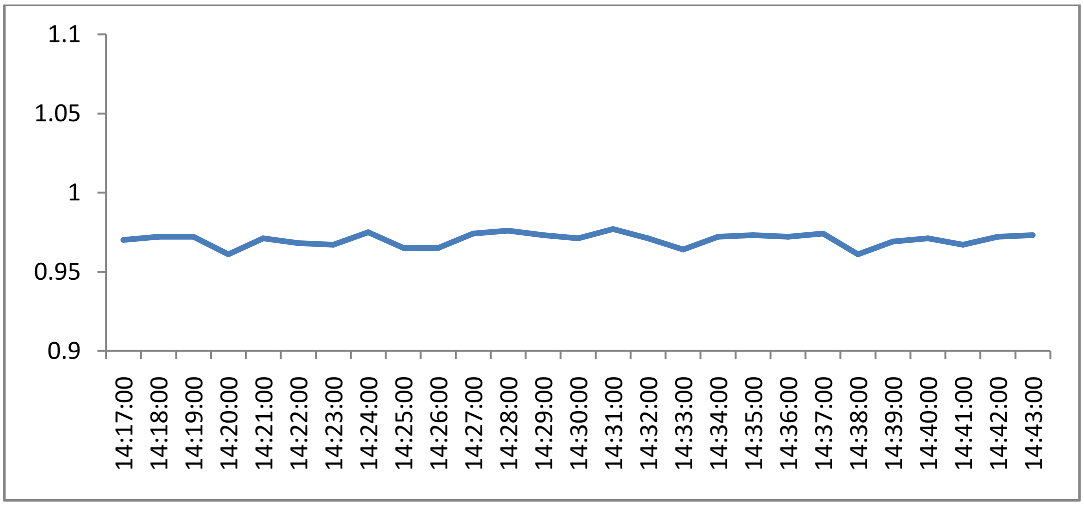

Figure 11: Variation in power factor at main incomer of plant

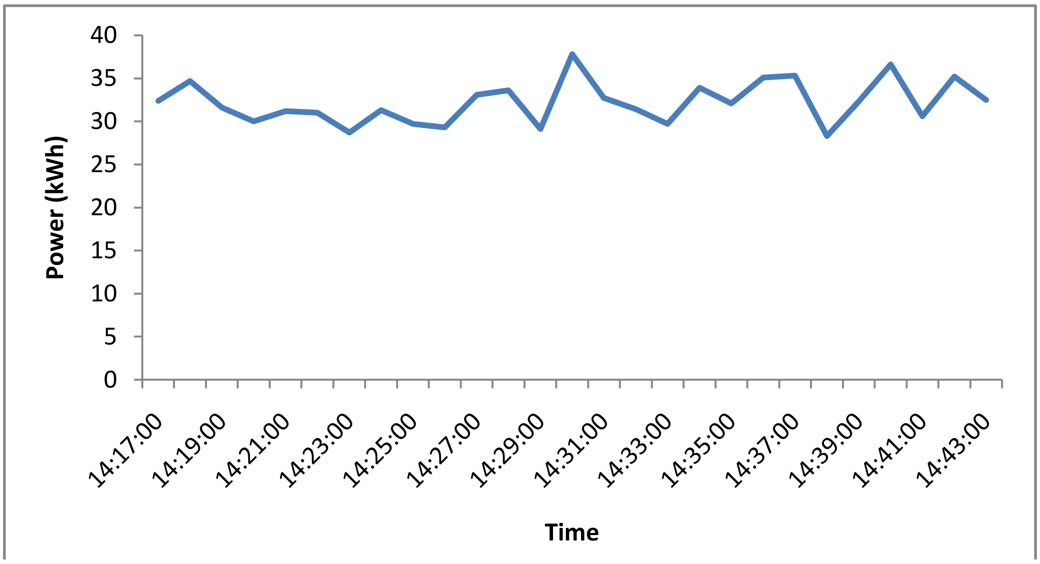

Figure 12: Variation in load at main incomer of plant

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 an LT connection.	As per the electricity bill analysis, the electricity tariff was Rs. 5.74/kWh; Weighted average electricity cost was Rs. 7.98/kWh and the PF according to the electricity bill was about 0.84.	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 0.96 and maximum was measured as 0.977.	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 390 V	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, paddy feeding motor and blower (FD fan) motor.

Table 12: Installed motor details

Description	Quantity	Power rating
Conveyor for paddy	1	0.75 kW
Conveyor for rice flakes	2	0.75 kW
Vibro-cleaner	2	0.75 kW
Roaster motor	1	3.75 kW
Press machine	3 2	7.5 kW 11.25 kW
FD fan with saw dust vibro hopper	1	0.75 kW
Flaker	1	15 kW
Soaking M/c	1	9 kW
Comfort fan	2	0.6kW
Total	**16**	**78.21 kW**

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 and flaker machine</td><td>There are 6 poha machines. Poha machines no. 5 and 6 have separate motors of 10 HP capacities each. Poha machines no. 1 and 2 run on one common motor of 15 HP capacity. Poha machines no. 3 and 4 run on another common motor of 15 HP capacity.
Flaker motor is rated for 20 HP capacity.</td><td>Study was conducted on motors of 2 poha machines. One motor was rated for 10 HP and other for 15 HP. For the remaining 3 motors, access point was not available on the starter. Study was also 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>Motor-1 (10 HP)</td><td>5.9</td><td>0.9</td></tr>
<tr><td>Motor-2 (15 HP)</td><td>12.77</td><td>0.68</td></tr>
<tr><td>Flaker machine motor (20 HP)</td><td>10.84</td><td>0.72</td></tr>
</table></td><td>Replacement of all the 4 existing motors of poha machines of capacities 10 HP, 10 HP, 15 HP and 15 HP with EE motors and soft starters is recommended.
Replacement of existing motor of flaker machine with EE motor is recommended.</td></tr>
<tr><td>FD fan for roaster</td><td>There is an FD fan for supplying air for conveying and for combustion of saw dust in roaster. FD fan motor was 0.75 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>0.75</td><td>0.81</td></tr>
</table></td><td>EPIA is suggested to replace existing fan motor with EE motor</td></tr>
<tr><td>Motors of roaster section –</td><td>The fuel feeder and FD fan (blower) are connected to a single motor with shaft and gear. The feeder vibrates and saw dust is hopped into the blower where motive air carries saw dust inside roaster. Roaster motor is of 5 HP</td><td>Measurements of roaster motor is given below
<table>
<tr><th>Machine</th><th>Avg. kW</th><th>Avg PF</th></tr>
<tr><td>Roaster motor</td><td>3.59</td><td>0.73</td></tr>
</table></td><td>EPIA is suggested to replace roaster motor with EE motors with VFD control.</td></tr>
</table>

<table>
<tr><td></td><td>and it rotates the roaster inside which paddy is heated in a sand bed.</td><td></td><td></td></tr>
<tr><td>Conveyors and elevators</td><td>There are 2 conveyors and 2 elevators. Conveyors are rated for 1.5 HP each and elevators for 2 HP each.</td><td>The study was conducted on one conveyor and one elevator motor. The results of the study are as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Conveyor 1.5 HP</td><td>1.06</td><td>0.86</td></tr><tr><td>Elevator, 2 HP</td><td>1.42</td><td>0.89</td></tr></table></td><td>Replacement of conveyor and elevator motors with EE motors of same ratings with gearbox is suggested</td></tr>
</table>

3.7.3 Thermal consumption areas

As discussed in the earlier sections, about 69% of total energy cost of the plant and 93% of the total energy usage is in the roaster. The details of present set-up, key observations made and potential areas for energy cost reduction have been mentioned in the table below:

Name of Area	Present set-up	Observations during field Study & measurements	Proposed Energy performance improvement actions
Roaster	The fuel used for roasting the paddy in roaster is saw dust. The air supplied for combustion of saw dust in roaster is supplied by electrical driven blower (FD fan).	There was no metering system available for - measuring saw dust consumption, combustion air flow and pressure, flue gas parameters. The O_2 level in flue gases coming out of the roaster was about 13.2%. 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. Flue gas temperature at stack was 330°C. The surface temperature of the roaster is very high varying from 51 to 154°C. This results in high heat loss from surface of the roaster. There is an ash removal window of area of 0.77 m^2. 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 colour 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 plant had no equipment to measure the moisture content of saw dust and paddy.	Excess air control with oxygen sensor in panel is proposed. Rebuilding the roaster furnace with proper insulation on walls is proposed It is suggested to close the ash removal windows for some period of time using doors, when ash is not being removed. It is suggested that waste heat recovery from flue gas be utilized in preheating material. 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 FEASIBILTY

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

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

4.1 EPIA 1: Replacing poha machine motors with (10HP*2, 15 HP*2) EE motors

Technology description

Replacement of 4 press (poha) machine motors with 4 energy efficient motors of IE 3 class. The ratings of EE motors are 10 HP, 10 HP, 15 HP and 15 HP. Replacement of flaker machine motor with EE motor of same capacity of 20 HP.

Study and investigation

The unit has four motors for six poha machines which are run by 4 motors. Two motors are rated for 10 HP each and operate one machine each. Two other motors are rated for 15 HP each and both these motors run two poha machines each. The unit also has one flaker machine which is operated by a motor of 20 HP capacity.

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 five 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 motors of poha machines with energy efficient motors (4 numbers – 10 HP, 10 HP, 15 HP and 15 HP). It is also recommended to replace the flaker machine motor of 20 HP to be replaced with an energy efficient motor of similar capacity.

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

Table 13: Cost benefit analysis (EPIA 1)

Description	Unit	As is	To be
No. of poha machines running	#	6	6
No. of motors	#	4	4
Present motors installed in poha machines	960 rpm	10 HP (for 1 poha machine); 10 HP (for 1 poha machine); 15 HP (common for 2 machines); 15 HP (common for 2 machines)	
Proposed motors for poha machines	960 rpm		2 X 10 HP + 2 X 15 HP
Present rated power of motors	kW	37.3	
Proposed rated power of motors	kW		37.3
Power consumption by poha machine motors	kW	26.92	21.54
Power savings by replacing existing motors with EE motors	kW		5.38
Running hours / day	h / day	10	10
Operating days / year	days / y	280	280
Weighted avg. cost of electricity	Rs. / kWh	7.98	7.98
Annual energy savings	kWh / y		15,075
Annual cost savings	Rs. Lakh / y		1.20
Estimated investment	Rs. Lakh		1.75
Simple payback period	y		1.45

4.2 EPIA 2: Replacing roaster motor with EE motor and VFD

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 results 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) and VFD or geared control system. The cost benefit analysis for this energy conservation measure is given below:

Table 14: Cost benefit analysis (EPIA 2)

Description	Unit	As Is	To be
Rating of roaster motor	HP	5.00	5.00
Present Power consumption by roaster motor	kW	3.54	3.17
Power saving by replacing existing motor with EE	kW		0.37

motor and VFD			
Running hours / day	h / day	10	10
Operating days / year	days / y	280	280
Weighted avg. cost of electricity	Rs / kWh	7.98	7.98
Annual energy savings	kWh / y		1,044
Annual monetary savings	Rs. Lakh / y		0.08
Estimated Investment	Rs. Lakh		0.27
Simple payback period	y		3.24

4.3 EPIA 3: Replacing other plant process motors with EE motors

Technology description

The plant has one flaker motor of 15 HP rated capacity, two conveyor motors of 1.5 HP rated capacity, 2 elevators of 2 HP rated capacity and FD fan of roaster of 1 HP rated capacity. These motors are old and several times re-wounded by un-skilled technicians. Replacing these motors with energy efficient motors of similar capacities will help in reduction of power consumption.

Study and investigation

There are 6 plant process motors of various rated capacities as mentioned above which are old and are in operation 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 15: Cost benefit analysis (EPIA 3)

Parameters	Unit	As is	To be
Rated power of flaker motor	HP	1 X 15 HP	1 X 15 HP
Rated power of conveyors (2 numbers)	HP	2 X 1.5 HP each	2 X 1.5 HP each
Rated power of elevators (2 numbers)	HP	2 X 2 HP each	2 X 2 HP each
Rating of FD fan (of roaster) motor	HP	1 X 1 HP	1 X 1 HP
Total rated power of process motors	HP	23.00	23.00
	kW	17.16	17.16
Average actual power consumption of motors - present	kW	16.30	
Average actual power consumption of motors - proposed	kW		14.58
Power savings by replacing existing plant motors with EE motors and accessories (gear box)	kW		1.72
No of operating hours per day	h / day	10	10
Operating days per year	days / y	280	280
Annual electricity savings per year	kWh / y	4,804	

W. average electricity tariff	Rs. / kWh	7.98
Annual monetary savings	Rs. Lakh / y	0.38
Estimated investment (ee motors & accessories - gear box)	Rs. Lakh	1.44
Simple payback period	y	3.75

4.4 EPIA 4: Reducing heat loss by covering the roaster inspection door with insulated MS plates

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.

These ash removal opening is kept open always, 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 13: Ash removal opening in roaster

Study and investigation

At the time of BEA, it was found that the area of the ash chamber opening was 0.77 m^2. The average temperature inside the roaster was approximately 650^0C. Heat loss due to radiation from the ash removal opening was estimated to be 6,281 kCal /h. A portion of this heat loss can be prevented by installing a well insulated metallic door on the opening and covering the opening 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 16: Cost benefit analysis (EPIA 4)

Particulars	Unit	As is	To be
Area of (ash removal) chamber opening	m^2	0.77	0.77
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 ash chamber opening	Watts / m^2	9,516	194
	kCal / m^2	8,183	167
	kCal / h	6,281	128
Savings in thermal energy	kCal/h	6,153	
GCV of fuel	kCal / kg	3,380	3,380
Saving in fuel	kg / h		1.82
Operating hours / day	h / day	10	10
Running days per year	days / y	280	280
Cost of saw dust	Rs. / kg	5.15	5.15
Annual savings	kCal/y	17,227,113	
Annual savings in fuel	kg/y	5,097	
Annual monetary savings	Rs. Lakh / y	0.26	
Investment	Rs. Lakh	0.10	
Payback period	y	0.38	

4.5 EPIA 5: 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 51 to 154^oC 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 17: Cost benefit analysis (EPIA 5)

Parameters	Units	Value	To Be
Length of roaster	m	3.50	3.50
Width of roaster	m	2.40	2.40
Height of roaster	m	3.14	3.14
Average temp. of front surface(material outlet)	^oC	148.00	47.00
Average temp. of side surface(press-side)	^oC	154.00	47.00
Average temp. of side surface(ash removal side)	^oC	66.33	47.00

Average temp. of back surface(fuel feeding side)	^{o}C	51.00	47.00
Ambient temperature	^{o}C	37.00	37.00
Velocity of air	m / sec	1.00	1.00
Heat loss due to R&C - Front side	Watt / m^2	1,412	69
Heat loss due to R&C - Press machine side	Watt / m^2	1,511	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	104	69
Heat loss due to R&C - Front side	kCal / m^2	1,215	59
Heat loss due to R&C - Press machine side	kCal / m^2	1,300	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	90	59
Total area - Front side	m^2	7.54	7.54
Total area - Back side	m^2	7.54	7.54
Total area - Press machine side	m^2	10.99	10.99
Total area - Ash removal side	m^2	10.99	10.99
Heat loss due to R&C - Front side	kCal / h	9,153	444
Heat loss due to R&C - Press machine side	kCal / h	14,283	648
Heat loss due to R&C - Ash removal side	kCal / h	2,489	648
Heat loss due to R&C - Back side	kCal / h	676	444
Total heat loss due to R&C from furnace surface	kCal / h	26,601	2,183
Calorific value of fuel - saw dust	kCal / kg	3,380	3,380
Total energy savings by insulating the roaster-furnace	kCal / h		24,418
Total fuel savings per hour	kg / h		7.22
Operating hours / day	h / day	10	10
Running days per year	days / y	280	280
Cost of saw dust	Rs. / kg	5.15	5.15
Total fuel savings per year	kg / y		20,228
Monitory savings per year	Rs. Lakh / y		1.04
Estimated investment	Rs. Lakh		1.00
Simple payback period	y		0.96

4.6 EPIA 6: Fuel saving by waste heat recovery from flue gases from roaster furnace

Technology description

Flue gases coming out from roaster are at very high temperature of 330^{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 330^{o}C, which indicated 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 18: Cost benefit analysis (EPIA 6)

Parameters	Unit	Value
Temp of flue gas	°C	330.00
Ambient Temperature	°C	40.00
Mass of flue gas supplied	kg / h	2,263.88
Specific heat of flue gas	kCal / (kg-°C)	0.26
Mass of Air supplied	kg / h	395.18
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	151.71
Energy savings per hour	kCal / h	44,146
Annual Energy savings	kCal / y	145,680,412
Annual Fuel savings	kg / y	43,101
Annual Monetary Saving	Rs. Lakh / y	2.22
Investment Estimated	Rs. Lakh	5.09
Payback	y	2.29

4.7 EPIA 7: Fuel saving by controlling excess air supplied for combustion in roaster and controlling fuel feed

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 13.20% which indicated 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 19: Cost benefit analysis (EPIA 7)

Parameters	UOM	Present	Proposed
Oxygen level in flue gas	%	13.20	5.00
Excess air levels in combustion air supplied	%	169.23	31.25
Flue Gas temperature	^{o}C	330.00	330.00
Saving in fuel	10% reduction in excess air leads to 1% fuel saving		
Annual fuel consumption	kg / y	392,616	338,443
Annual Saving in fuel consumption	kg / y		54,173
Cost of fuel	Rs. Kg	5.15	5.15
Savings in fuel cost	Rs. Lakh / y		2.79
Running load of blower	kW	0.70	0.63
Operating hours per year	h / y	2,800	2,800
Annual electrical energy consumed	kWh / y	1,960	1,764
Annual savings in electrical energy	kWh / y		196
Annual savings - cost of electrical energy	Rs. Lakh / y		0.02
Total annual monetary savings	Rs. Lakh / y		2.81
Estimated investment	Rs. Lakh		2.55
Simple payback period	y		0.91

4.8 EPIA 8: 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 are very high. Moreover, considerable amount of ash is being generated as a by-product of fuel combustion which needs to be disposed. Storage of saw dust (fuel) also requires a lot of plant space.

It is recommended to install gas based fuel firing system as PNG pipelines are 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 & quality and result in cost savings for the unit. The cost benefit analysis of this measure is given in the table below:

Table 20: Cost benefit analysis (EPIA 8)

Parameters	Units	Value
Roaster efficiency	#	33%
GCV of saw dust	kCal / kg	3,380.00
Present annual saw dust consumption	kg / y	392,616.00
Annual heat requirement	kCal / y	439,154,507.05
Annual heat requirement cost (saw dust)	Rs. Lakh / y	20.22
Calculations		
Roaster efficiency	#	75%
GCV of LPG	kCal / kg	12,500
Mass of LPG required per year	kg / y	46,843
Annual cost of LPG	Rs. Lakh / y	30.45
Present energy consumption	MTOE	132.70
Post implementation energy consumption	MTOE	58.55
Energy savings	MTOE	74.15
Production enhancement	%	2.00
Present poha production per hour	kg / h	791.60
Production enhancement	kg / h	15.83
Average selling price of poha	Rs. / kg	30.00
Cost benefit through enhanced production by fuel switch	Rs. Lakh / y	13.30
Total cost savings per year	Rs. Lakh / y	3.07
Estimated investment for gas based fuel firing system	Rs. Lakh	7.00
Simple payback period	y	2.28

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	**330**	^{o}C
O2 in flue gas	**13.2**	*%*
CO2 in flue gas	**2.6**	*%*
CO in flue gas	**3050.0**	*ppm*
Specific heat of flue gas	**0.26**	*Kcal/kg^{o}C*
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**	^{o}C
Relative Humidity	**48**	*%*
Humidity in ambient air	**0.0120**	*kg/kgdry air*
Mass flow rate of fuel	140.22	*kg/h*
Production of Roasted Paddy	998	*kg/h*

Efficiency calculations

Calculations	Values	Unit
Theoretical air required	5.82	*kg/kg of fuel*
Excess air supplied	169.23	*%*
Actual mass of supplied air	15.68	*kg/kg of fuel*
Mass of dry flue gas	16.15	*kg/kg of fuel*

Amount of water vapour in flue gas	-	*Kg of H2O/kg of fuel*
Specific fuel consumption	0.14	*kg of fuel/kg of Paddy*
Heat loss in dry flue gas	170,696.24	*kCal/h*
Heat loss due to formation of water from H_2 in fuel	44,092.38	*kCal /h*
Heat loss due to moisture in fuel	6,411.98	*kCal /h*
Heat loss due to moisture in air	3,443.56	*kCal /h*
Heat loss due to partial conversion of C to CO	40,769.77	*kCal /h*
Heat loss due to radiation and Convection losses	44,053.80	*kCal /h*
Heat loss from unburnt in fly ash	1,388.18	*kCal /h*
Heat loss from bottom ash	6,246.80	*kCal /h*
Roaster efficiency by indirect method	33%	

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 21 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