BASELINE ENERGY AUDIT REPORT

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

Jagdish Prasad Hansraj

25/A, Industrial Area, Maksi Road
Ujjain
Madhya Pradesh

April 2016

Submitted to

BUREAU OF ENERGY EFFICIENCY

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Submitted by

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ACKNOWLEDGEMENT

DESL places on record its sincere thanks to Bureau of Energy Efficiency (BEE) for vesting confidence in DESL to carry out the assignment "Conducting Baseline energy audit in Indore SME food 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. Jitendra Rathi, Owner, for showing keen interest in the energy audit and also thankful to the management of Jagdish Prasad Hansraj Poha factory for their wholehearted support and cooperation for the preparation of this Base line energy audit report, without which the study would not have steered to its successful completion. Special thanks to other members of the unit for their diligent involvement and cooperation.

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

Last but not the least, the interaction and deliberation with Mr. Mayank Patel, Secretary, Poha Parmal, Nirmata Sangh, Ujjain, technology providers, and all those who were directly or indirectly involved throughout the study were exemplary. The entire exercise was thoroughly a rewarding experience for DESL.

DESL Team

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Team Members	Mr. Mithlesh Priya 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
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 in India.

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

The project awarded to DESL consists of 18 major tasks:

- Conducting pre–activity cluster workshop defining the agenda of this engagement
- Conducting initial walk through energy audits within 8 selected units of the cluster
- Identifying and proposing two energy efficient process technologies to BEE
- Identifying at least 5 local technology/service providers for above technologies in the cluster
- Identifying 20 SME units willing to implement and demonstrate the above two technologies
- Assistance to BEE for entering into contract with each of the 20 shortlisted SME units
- Conducting Comprehensive Energy Audits in 20 SME units
- Development of technology specific case studies (Audio, Visual and Print) for each technology
- Developing best operating practices(BOP) document for the top 5 energy equipment/processes in the industry cluster
- Enumeration of common regularly monitorable parameters at the process level which have impact on energy performance and listing of appropriate instrumentation for the same.
- Conducting post energy audit in each of the above 20 units to verify energy savings.
- Verification and submission of relevant documents (Evidence of implementation and Commissioning of EE technology)to the BEE
- Assisting BEE in conducting five post energy audits
- Submission of progress report in hard and soft versions (Word, presentation) to BEE
- Submission of draft document to BEE within seven days from issue of LOI by BEE

Brief Introduction of the Unit

Table 1: Details of Unit

Name of the Unit	Jagdish Prasad Hansraj
Constitution	Private Limited
MSME Classification	Small
No. of years in operation	NA
Address: Registered Office	Plot No:25/A, Industrial area Maksi road,Ujjain
Administrative Office	Plot No:25/A, Industrial area Maksi road,Ujjain
Factory	Plot No:25/A, Industrial area Maksi road,Ujjain
Industry-sector	Food
Products Manufactured	Poha (Rice flakes)
Name(s) of the Promoters / Directors	Mr. Jitendra Rathi

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. These rice flakes are then cleaned in cleaners and finally packed and dispatched.

Identified Energy Performance Improvement Actions (EPIA)

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 74% of the total energy cost of the unit. Major areas of electrical energy consumption in the unit are poha (press) machines. Measures proposed for the unit are:

1. Replacement of conveyor motors with energy efficient (EE) motors
2. Replacement of press (poha) machine motors with EE motors
3. Rebuilding the roaster with fire bricks and providing thermal insulation of glass wool
4. Optimization of roaster excess air and fuel feed control using oxygen sensors and VFD on feeder motor
5. Providing cast door of MS sheet and insulating body for ash removal door on roaster
6. Conversion of saw dust as a fuel into gas base fuel system

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

Table 2: Summary of EPIA

Sl. No.	Energy Performance Improvement Action (EPIA)	Annual energy savings	Annual energy savings	Investment	Monetary energy cost saving	Payback period
		kWh / y	Saw dust (kg / y)	Rs. Lakh	Rs. Lakh / y	y
1	Replacing Poha machine motors with smaller sized (7.5 HP X 7 numbers) EE motors	17,566		1.40	1.35	1.04
2	Replacing FD fan motor (1 HP X 1 number) of roaster with EE motor	278		0.10	0.02	4.70
3	Replacing elevator (1 HP X 5 number) motors with EE motors with gear box	1,104		0.40	0.08	4.73
4	Replacing other plant process motors with EE motors (Roaster motor, 1.5 HP; Dal chalna motor, 0.40 HP; Cyclone motor, 7.5 HP; Paddy cleaner motor, 1 HP X 2 numbers; Worm motor, 1 HP; Poha chalna motor, 1 HP; Poha cleaning chalna motor, 1.5 HP)	3,101		0.73	0.24	3.07
5	Reducing heat loss by covering the roaster inspection door with insulated MS plates		3,393	0.10	0.19	0.54
6	Reduction in radiation and convection loss from roaster by refurbishing refractory and insulation of surface		5,384	1.00	0.30	3.38
7	Fuel savings by waste heat recovery from flue gases from roaster-furnace		58,501	5.10	3.01	1.69
8	Fuel savings by controlling excess air supplied for combustion in roaster and controlling fuel feed		20,352	1.95	1.12	1.74
9	Energy cost savings by switching from saw dust to gas based fuel for roaster			7.00	3.28	2.14
	Total	**22,049**	**87,630**	**10.78**	**6.30**	**1.71**

- EPIA on fuel switch from saw dust to gas based system has not been considered for calculating total values
- With the implementation of these EPIAs, overall cost saving of Rs. 8.43 Lakh can be achieved
- Total estimated investment of Rs. 18.78 Lakh can incur with simple payback of nearly 2 years

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 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 to implement 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 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 for carrying out the project:

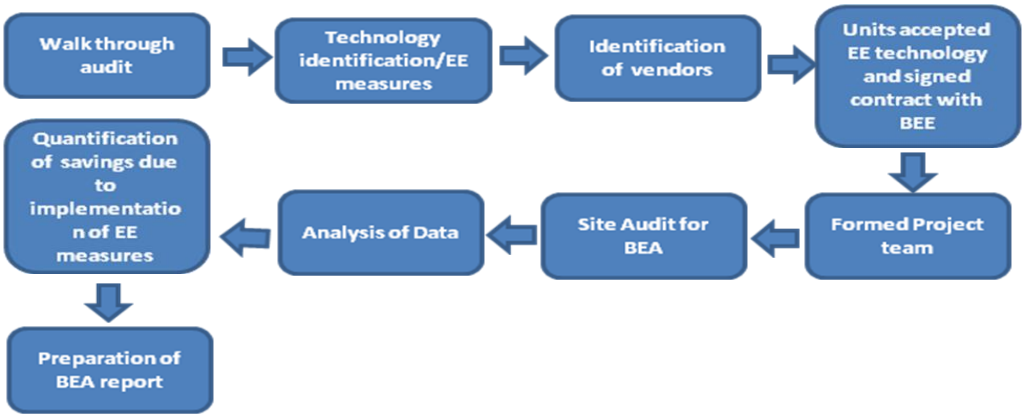


Figure 1 General Methodology

The study was conducted in following stages:

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

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

Stage 3: Formation of project team for conducting baseline energy audits (BEA) in the units that have signed MOUs with BEE; and conduct 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 equipments
- 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

Sl. No.	Instruments	Make	Model	Parameters Measured
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	Jagdish Prasad Hansraj Poha factory
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. Jitendra Rathi +91 – 9425332670 Jph.rajhans@yahoo.co.in
5	Address of the unit	Plot No: 25/A, Industrial area Maksi road,Ujjain
6	Industry / sector	Food
7	Products manufactured	Poha (Rice flakes)
8	No. of operational hours	10
9	No. of shifts / day	1
10	No. of days of operation / year	310

3 DETAILED TECHNICAL FEASIBILITY ASSESSMENT OF THE UNIT

3.1 Description of manufacturing process

3.1.1 Process & Energy flow diagram

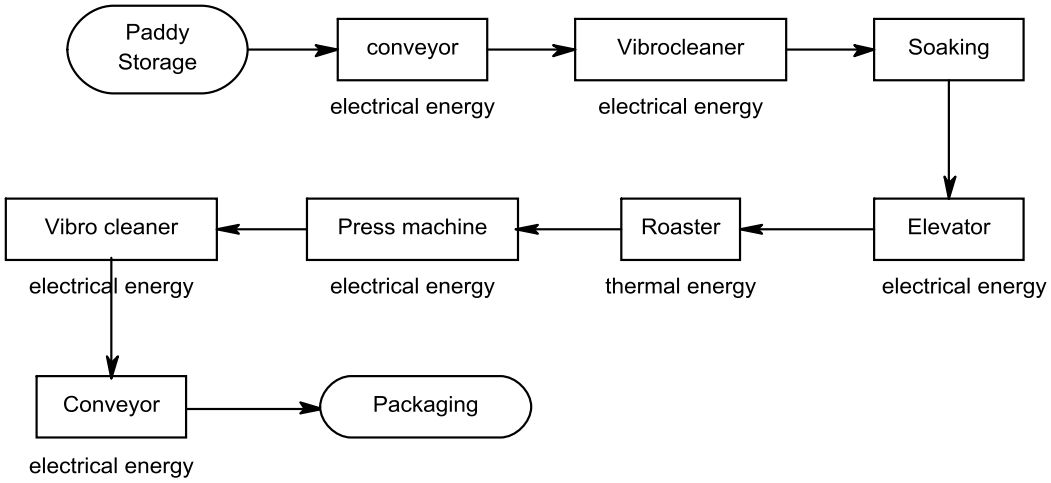


Figure 2: Production flow diagram

3.1.2 Process description

JP Hansraj Poha factory, Ujjain is a poha manufacturing unit. The process description is as follows:

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

3.2 Inventory of process machines / equipment and utilities

Major energy consuming equipment in the plant are:

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

- **Conveyor:** This 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 use pattern in the unit is as follows:

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

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

Table 5: Energy cost distribution

Particulars	Energy cost distribution		Energy use distribution	
	Rs. Lakh	% of Total	MTOE	% of Total
Grid –electricity	8.9	26	9.70	4.6
Thermal – Saw dust	25.3	74	201.63	95.4
Total	**34.2**	**100**	**211.33**	**100**

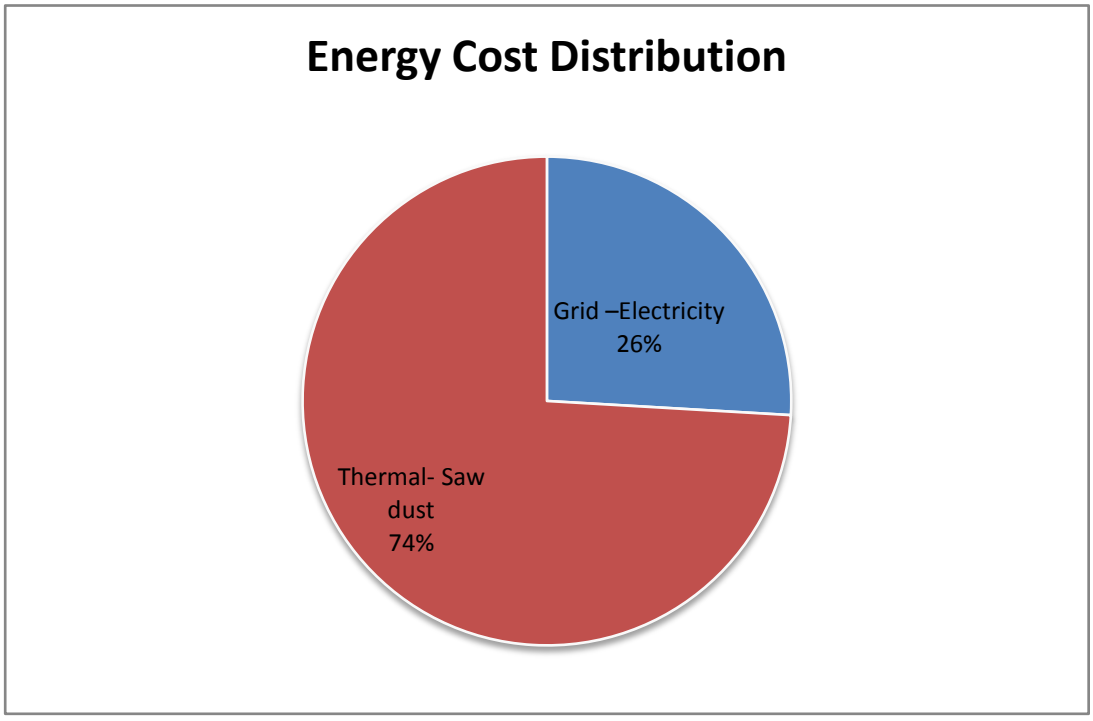


Figure 3: Energy cost share

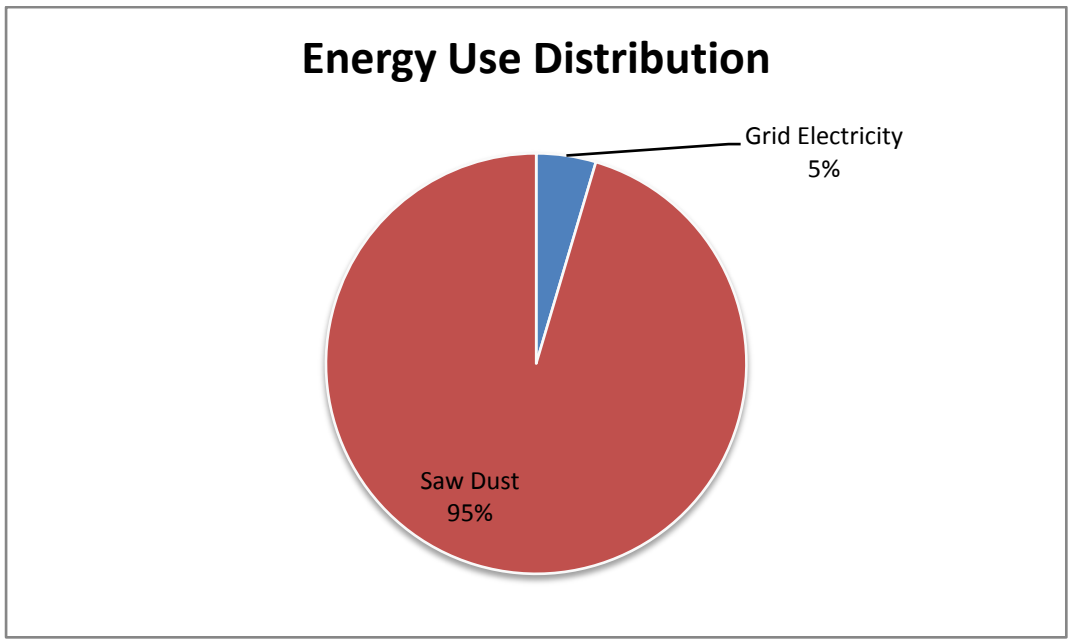


Figure 4: Energy use share

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 74% of the total energy cost and 95% of overall energy consumption.
- Electricity used in the process accounts for 26% of the energy cost and 5% 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 56.8 kW

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

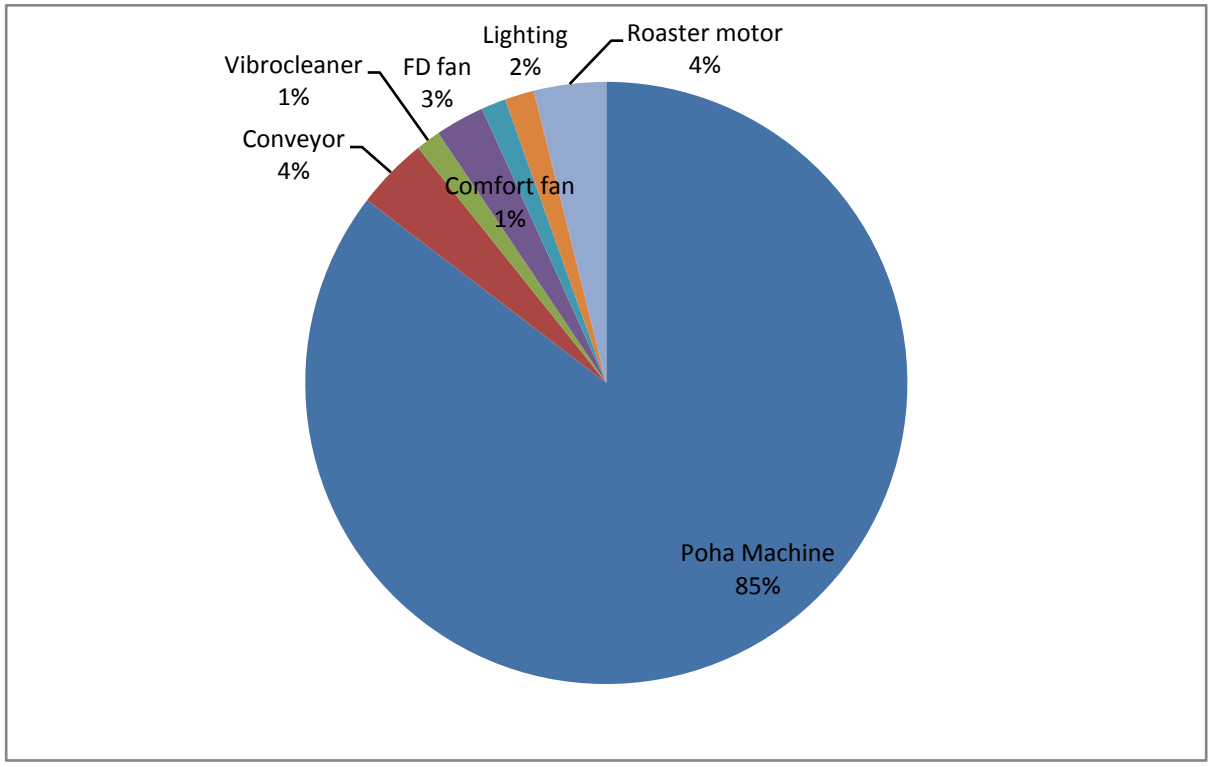


Figure 5: Details of connected load

As shown in the pie chart, the connected load is divided between poha machine – 85%, conveyor-4%, roaster motor – 4%, FD fan blower – 3%, vibrocleaner-1%, lighting-2% while the comfort fans 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 set in the unit

As there is no DG set in the unit, the share of grid is 100% in electricity cost. It is about Rs. 2.8 Lakh per annum.

3.3.3 Supply from utility

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

a)	Power Supply	:	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	5.7	Rs./kWh
Electricity duty	0.51	Rs./kWh
TOD rebate	0.0	Rs./kWh
TOD surcharge	0.0	Rs./kWh
FCA Charge	1.45	Rs./kWh
Weighted Average	7.66	Rs/kWh

(As per Dec-2015 bill)

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

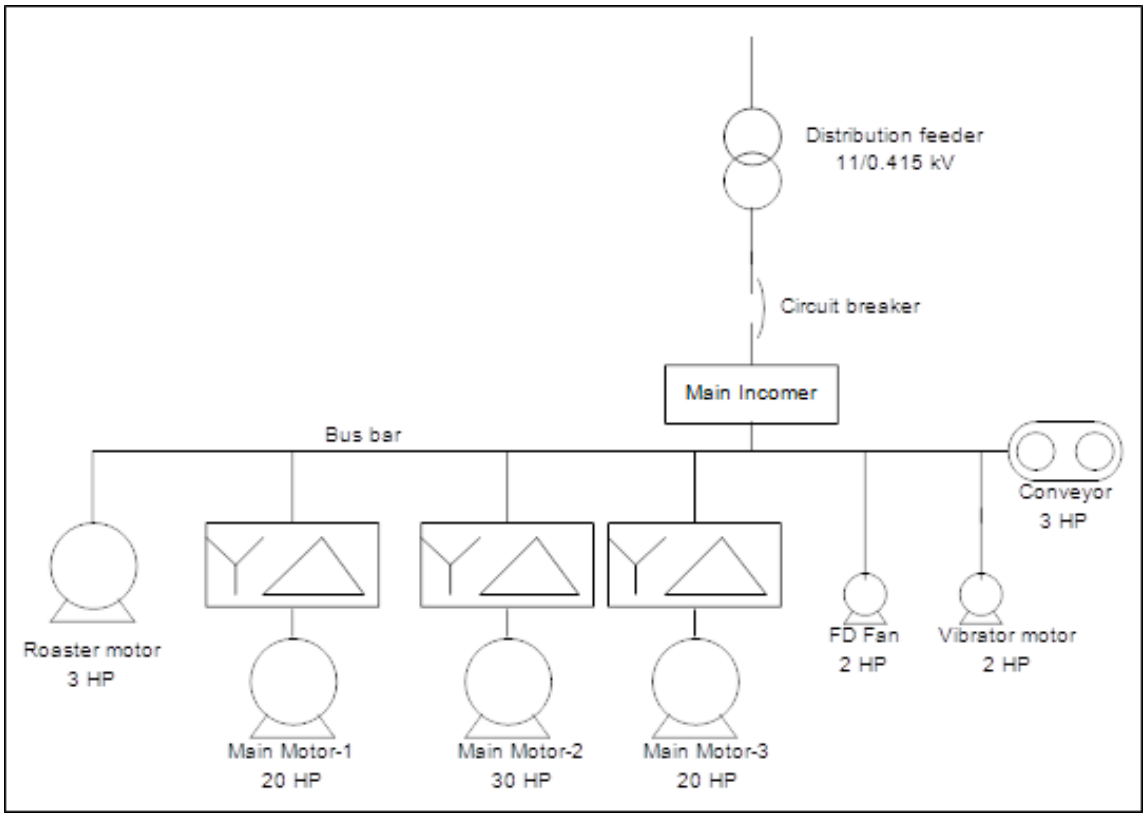


Figure 6: SLD of electrical load

Power factor

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

3.3.4 Electricity consumption

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

Table 7: Electricity consumption & cost

Months	Electricity	Cost
	Grid (kWh)	Grid (Rs.)
Feb-15	10,460	75,468
Mar-15	11,400	81,284
Apr-15	8,040	62,578
May-15	10,040	79,889
Jun-15	11,200	84,866
Jul-15	8,440	71,438
Aug-15	10,300	84,234
Sep-15	9,440	76,678
Oct-15	9,560	74,289
Nov-15	9,300	75,338
Dec-15	12,500	93.249
Jan-16	2,080	26,744
Total	**112,760**	**886,055**

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

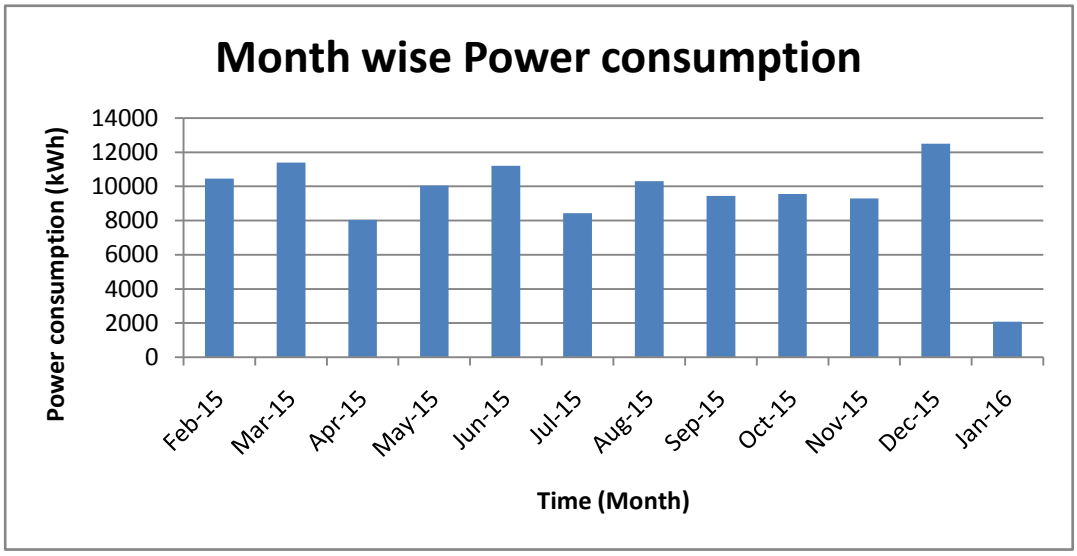


Figure 7: Month wise variation in electricity consumption from different sources

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/kg. There is no provision for measurement of saw dust consumption in the roaster. Annual saw dust consumption is 431 MT costing Rs. 2,219,069.45.

3.5 Specific energy consumption

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

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

Table 8: Overall specific energy consumption

Parameters	Unit	Value
Annual grid electricity consumption	kWh	112,760
Annual DG generation unit	kWh	0
Annual total electricity consumption	kWh	112,760
Annual thermal energy(saw dust) consumption	MT	460.35
Annual energy consumption; MTOE	MTOE	211.3
Annual energy cost	Lakh Rs.	34.2
Annual production	MT	2,670.60
SEC; Electrical	kWh/MT	42.2
SEC; Thermal	MT/MT	0.17
SEC; Overall	MTOE/MT	0.08
SEC; Cost Based	Rs./MT	1,280

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

- Conversion Factors
  - Electricity from the Grid : 860 kCal/KWh
  - 1koe : 10,000 kCal
- GCV of Saw dust : 4,380 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	Value	
Electricity rate	5.70	Rs. / kWh inclusive of taxes
Weighted average electricity cost	7.66	Rs. / kWh as per Dec-15 bill
Average cost of saw dust	5.50	Rs. / kg as per April 2015
Annual operating days per year	310	days/y
Annual operating hours per day	10	h/day

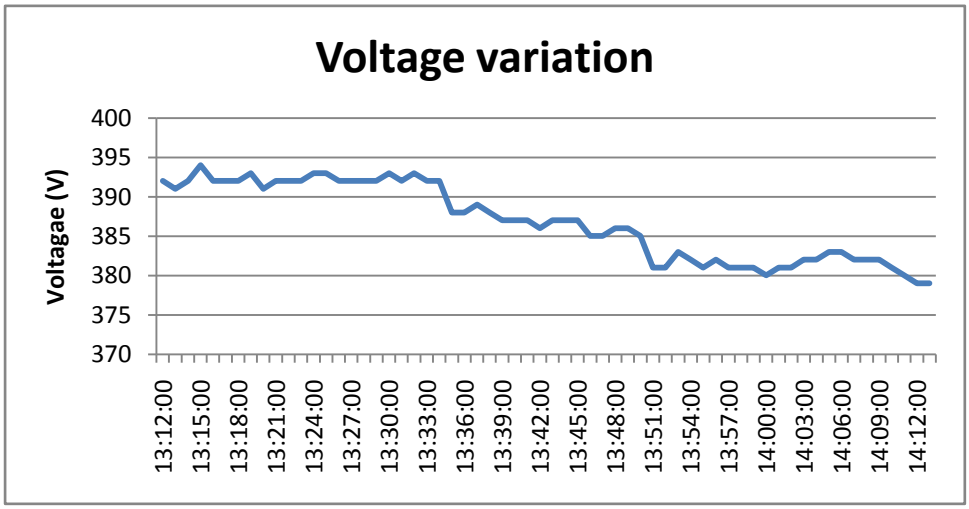
3.7 Identified energy conservation measures in the plant

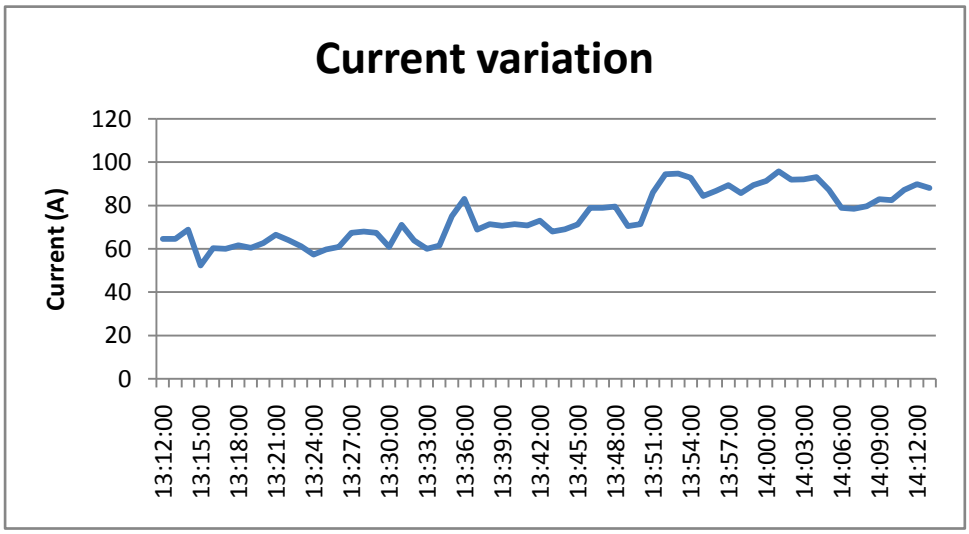
Diagnostic Study

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 which supplies power to the unit were recorded by using the portable power analyzer instrument.





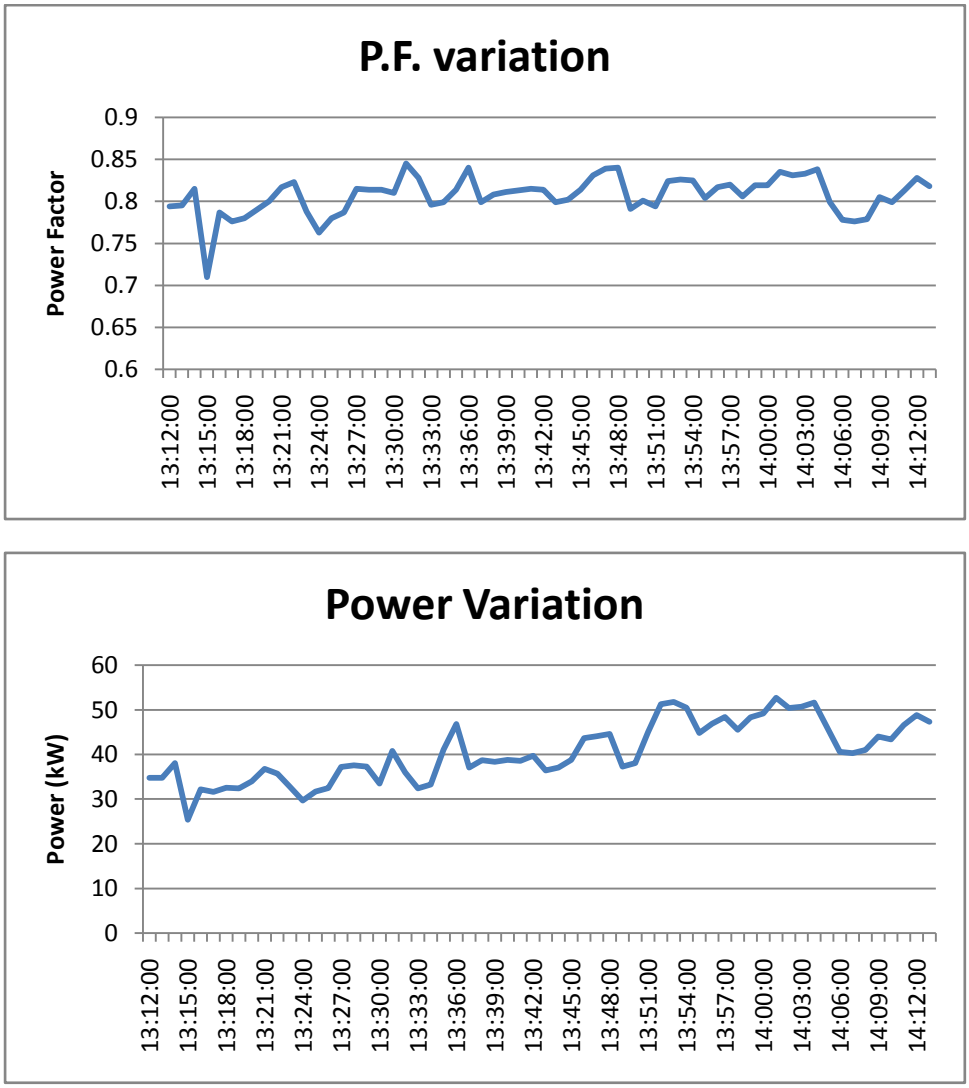


Figure 8: Variation in electric parameters on main incomer of plant

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 LT connection. The sanctioned load of the unit is 100 HP.	As per the electricity bill analysis, it was found that the electricity tariff was Rs.5.7/kWh, Weighted average electricity cost was Rs. 7.66/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 0.79 and maximum was measured as 0.84.	No EPIAs suggested.
Voltage variation	The unit has no separate lighting feeder and no servo stabilizer for the same.	The voltage profile of the unit was satisfactory and it is about 390V	No EPIAs suggested.

3.7.2 Electrical consumption areas

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

Electrical Motors

Following types of motors are present in the unit:

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

Table 11: Installed motor details

Description	Quantity	Power Rating
Elevator for paddy	5	3.73 kW
Cyclone	1	5.60 kW
Chalna - Poha	2	1.05 kW
Roaster motor	1	1.12 kW
Press machine	2	29.84 kW
	1	22.38 kW
Paddy cleaner	2	1.50 kW
FD fan with saw dust vibro hopper	1	0.75 kW
Total	**15**	**65.97 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</td><td>There are 7 poha (or press) machines. 3 motors of 20 HP, 30 HP and 20 HP respectively operate the poha machines using shaft and belt drives. Each motor of 20 HP operate 2 press machines whereas the 30 HP motor operates 3 poha machines</td><td>Study was conducted on both of the poha machines.
The results of the study are as below:
<table>
<tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr>
<tr><td>Motor-1
(M/C-1,2)
Motor-2
(M/C-3,4,5)
Motor-3
(M/C 6,7)</td><td>8.45
12.2
7.69</td><td>0.8
0.86
0.71</td></tr>
</table></td><td>Replacement of existing common motors of poha machines with smaller sized (7.5 HP X 7 numbers) EE motors</td></tr>
</table>

<table>
<tr>
<td>FD fan for roaster</td>
<td>There is a FD fan for supplying air for combustion of saw dust in roaster. FD fan motor was 1 HP</td>
<td>The study was conducted on FD fan. The results of the study are as below:
<table>
<tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr>
<tr><td>FD fan</td><td>0.65</td><td>0.69</td></tr>
</table>
</td>
<td>EPIA is suggested to replace existing fan motor with EE motor with VFD. Install feed controller for this motor and thermocouple on roaster. Based on roaster temperature, measured by the thermocouple, the feed controller will feed saw dust (fuel) to the furnace</td>
</tr>
<tr>
<td>Roaster motor (1.5 HP)</td>
<td>The roaster has a motor of 1.5 HP which is the prime mover of the roaster.</td>
<td>
<table>
<tr><th>Machine</th><th>Avg. kW</th><th>Avg PF</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Roaster motor</td><td>1.06</td><td>0.84</td></tr>
</table>
</td>
<td>EPIA is suggested to replace roaster motor with EE motor and gear control.</td>
</tr>
<tr>
<td>Elevator motors</td>
<td>There are in total 5 elevators, each having a prime mover (motor) of 1 HP rated capacity</td>
<td>The study was conducted on 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>Elevator, 1 HP</td><td>0.71</td><td>0.88</td></tr>
</table>
</td>
<td>Replacement of all 5 elevator motors with EE motors with gearbox is suggested</td>
</tr>
<tr>
<td>Other plant process motors</td>
<td>The plant has the following motors Poha chalna motor- 1 HP X 1; Cyclone motor – 7.5 HP X 1; Paddy cleaner motor – 1 HP X 2; Worm motor – 1 HP X 1; Poha cleaner chalna motor – 1.5 HP X 1</td>
<td>Study was conducted on all these motors as below
<table>
<tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr>
<tr><td>Poha chalna motor</td><td>0.71</td><td>0.88</td></tr>
<tr><td>Cyclone motor</td><td>5.32</td><td>0.89</td></tr>
<tr><td>Paddy cleaner</td><td>0.72</td><td>0.89</td></tr>
<tr><td>Worm motor</td><td>0.70</td><td>0.86</td></tr>
<tr><td>Poha cleaner</td><td>1.06</td><td>0.90</td></tr>
</table>
</td>
<td>Replacement of all the motors of process machines with EE motors of same capacity</td>
</tr>
</table>

3.7.3 Thermal consumption areas

As discussed in the earlier sections, about 89% of total energy cost of the plant and 89% of the total energy usage is in the roaster. The details of present set-up, key observations made and potential areas for energy cost reduction have been mentioned in the table below:

Name of Area	Present Set-up	Observations during field Study & measurements	Proposed Energy performance improvement actions
Roaster	The fuel used for roasting the paddy in Roaster is saw dust. The air supplied for combustion of saw dust in roaster is supplied by electrical driven blower (FD fan).	There was no metering system available for - measuring saw dust consumption, combustion air flow and pressure, flue gas parameters. The O_2 level in flue gases coming out of the roaster was about 9.60%. 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 was 457^0C The surface temperature of the roaster is very high varying from 59 to 117^oC. This results in high heat loss from surface of the roaster. There was an ash removal window of area of 0.46 m^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) 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 refractories and insulation on walls is proposed It is suggested to close the ash removal window for some periods of time using insulated MS plate door, when ash is not being removed. Fuel switch from saw dust based to gas based system to improve productivity and quality and ensure cost savings. 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.

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 section of this report. Based on the analysis, Energy Performance Improvement Actions (EPIAs) have been identified below:

4.1 EPIA 1: Replacement of press (poha) machine motors with EE motors

Technology description

Replacement of 3 press (poha) machine motors with 7 smaller-sized energy efficient motors of IE 3 class.

Study and investigation

The unit has three motors for seven poha machines which are run by using common shaft. Motor 1 of 20 HP is driving poha m/c 1 and 2, motor 2 of 30 HP driving m/c 3, 4 and 5 and motor-3 of 20 HP driving m/c 6 and 7. 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 depended on the production of dried poha from the roaster and also on the worker operating the poha machine – how fast or slow he operates during the entire shift. Some operators are faster than others and their machines are loaded for longer durations. A time-motion study was also conducted to note the loading on the eight poha machines. It was found that a fast worker manually transfers 5-6 baskets of roasted paddy from the roaster to the poha machine, while a slower worker transfers 4-5 baskets in 5 minutes. Based on the input to the poha machines, the production output also varies similarly (5-6 baskets of flakes output for the faster worker in a duration of 5 minutes). Each basket contains approximately 4.5 kg of roasted paddy by weight.

Recommended action

It is recommended to replace the present common motors (3 numbers) of poha machines with 7 smaller-sized (7.5 HP X 7) energy efficient motors for poha machines. 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 machine	#	7	7
No. of motors	#	3	7
Rated capacities of poha machine motors	HP	20 HP, 20 HP, 30 HP	7.5 HP X 7 numbers
Total Installed capacity of poha machine motors	kW	48.49	52.50
Avg. power consumption by poha machine motors	kW	28.33	22.67
Power savings by replacing poha machine motors with smaller sized EE motors	kW		5.67
Running hours per day	h / d	10	10

Operating days per year	d / y	310	310
Weighted avg. cost of electricity	Rs. / kWh	7.66	7.66
Annual energy savings by replacing poha machine motors with smaller sized EE motors	kWh / y		17,566
Annual monetory savings	Rs. Lakh / y		1.35
Estimated investment for new EE motors	Rs. Lakh		1.40
Simple payback period	y		1.04

4.2 EPIA 2: Replacement of FD fan motor of roaster with energy efficient motor and gearbox

Technology description

Replacing the present motor of FD fan of roaster with energy efficient motor of same rating with VFD control. It is also suggested to install feed controller for this motor and thermocouple on roaster. Based on roaster temperature, measured by the thermocouple, the feed controller will control saw dust (fuel) feeding to the furnace.

Study and investigation

The unit has 1 FD fan (blower). The rated capacity of FD fan motor is 1 HP. During BEA, it was found that this motor was old, several times re-wounded and was operating inefficiently. Further, the motor had low design efficiency of about 89%.

Recommended action

It is recommended to replace the present FD fan motor with energy efficient motor of same capacity. The cost benefit analysis for this energy conservation measure is given below:

Table 13: Cost benefit analysis (EPIA 2)

Replacing FD fan motor with EE motor and accessories (thermocouple, moisture meter)			
Parameters	**Unit**	**As is**	**To be**
Fuel feeder (fd fan) motor power rating	kW	0.746	0.746
Average running power	kW	0.71	0.62
Running hours per day	h / d	10	10
Operating days per year	d / y	310	310
Weighted avg. cost of electricity	Rs. / kWh	7.66	7.66
Power savings by replacing FD fan motor with EE motor	kW		0.09
Annual energy savings	kWh / y		277.51
Annual monetary savings	Rs. Lakh / y		0.021
Estimated investment for new EE motor with accessories	Rs Lakh		0.10
Payback	y		4.70

4.3 EPIA 3: Replacement of elevator motors with energy efficient motors and gearbox

Technology description

Installation of EE motor with gearbox reduces total power consumption of the motor to about 10% by reducing the power consumption.

Study and investigation

The unit has 5 elevators, each having a rated motor capacity of 1 HP. All the motors were installed during the time of unit's establishment. The efficiency of motors had degraded due to lack of preventive maintenance, and effects of several times of re-winding. Also, the motors have low design efficiency of about 89%.

Recommended action

It is recommended to replace these motors with EE motors with gearbox controls. 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
Number of elevator motor & power rating	#	1 HP X 5 nos.	1 HP X 5 nos.
Installed capacity of motors	kW	3.75	3.75
Average running power consumption	kW	3.56	3.21
Power saving using EE geared motors	kW		0.36
Running hours per day	h / day	10	10
Operating days per year	days / y	310	310
Weighted avg. cost of electricity	Rs. / kWh	7.66	7.66
Energy savings per year	kWh / y		1,104
Cost Saving per year	Rs. Lakh / y		0.085
Investment on new EE motor coupled with gears	Rs. Lakh		0.40
Payback	y		4.73

4.4 EPIA 4: Replacement of other plant process motor with EE motors (roaster motor, dhan chalna motor, cyclone motor, paddy cleaner motor, worm motor, poha chalna motor and poha cleaning chalna motor)

Technology description

The plant has one roaster motor of 1.5 HP rated capacity, one dhan chalna motor of 0.40 HP rated capacity, one cyclone motor of 7.5 HP rated capacity, two paddy cleaner motors of 1 HP rated capacity each, one worm motor of 1 HP capacity, one poha chalna of 1 HP and one poha cleaning chalna of 1.5 HP rated capacity. All 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 reducing power consumption.

Study and investigation

There are total of 8 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 15: Cost benefit analysis (EPIA 4)

Particulars	Units	As Is	To Be
Rated capacity of roaster motor	HP	1.50	1.50
Rated capacity of dhan chalna motor	HP	0.40	0.40
Rated capacity of cyclone motor	HP	7.50	7.50
Rated capacity of 2 numbers of Paddy cleaner motor (each 1 HP)	HP	2.00	2.00
Rated capacity of Warm motor	HP	1.00	1.00
Rated capacity of poha chalna motor	HP	1.00	1.00
Rated capacity of poha cleaning chalna motor	HP	1.50	1.50
Total rated capacity of the process motors	kW	11.12	11.12
Actual power consumption by the process motors	kW	10.56	
Power consumption by EE motors - projected	kW		9.56
Power savings by replacing process motors with EE motors and accessories (gear box)	kW		1.00
Running hours per day	h / d	10	10
Operating days per year	d / y	310	310
Weighted avg. cost of electricity	Rs. / kWh	7.66	7.66
Energy savings per year	KWh / y		3,101
Cost Saving per year	Rs. Lakh / y		0.24
Investment on new EE motor coupled with gears	Rs. Lakh		0.73
Payback	y		3.07

4.5 EPIA 5: Reduction in radiation losses by covering the ash removal openings of roaster with insulated MS plate doors

Technology description

There is 1 ash removal opening in the roaster which also doubles up as inspection hole. Plant operator uses this door to manually remove the bottom ash formed as a product of combustion. The operator also inspects the color of the firing chamber during combustion to judge the temperature level of the roaster combustion zone.

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

Figure 9: Ash removal opening in roaster

Study and investigation

At the time of BEA, it was found that area of ash chamber opening was 0.464 m^2. The average temperature inside the roaster-furnace was approximately 650^{0}C. Heat loss due to radiation from the ash removal openings was estimated to be 3,775 kCal/h. A portion of this heat loss can be prevented by installing a well-insulated metallic door on the opening and covering it while ash is not removed or when operators are not inspecting the roaster internal temperature.

Recommended action

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

Table 16: Cost benefit analysis (EPIA 5)

Particulars	Unit	As is	To be
Area of (ash removal) chamber opening	m^2	0.46	0.46
Average Temperature	^{o}C	450.00	60.00
Ambient temperature	^{o}C	40.00	40.00
Velocity of air	m / sec	1.00	1.00
Heat loss from the ash chamber opening	Watts / m^2	9,451	163
	kCal / m^2	8,128	140
	kCal / h	3,775	65
Savings in thermal energy	kCal/h	3,710	
GCV of fuel	kCal / kg	3,390	3,390
Savings in fuel	kg / h		1.09
Operating hours / day	h / day	10	10
Running days per year	days / y	310	310
Cost of saw dust	Rs. / kg	5.50	5.50
Annual savings	kCal/ y	11,501,168	

Annual savings in fuel	kg / y	3,393
Annual monetary savings	Rs. Lakh / y	0.19
Investment	Rs. Lakh	0.10
Payback years	y	0.5

4.6 EPIA 6: Rebuild rotating tunnel roaster with fire bricks and provide insulation on roaster walls

Technology description

Insulating the surface of roaster reduces the skin losses from the roaster which in turn helps in savings of fuel fired in the roaster. Fire bricks have low thermal conductivity than conventional furnace bricks, hence they provide better thermal insulation.

Study and investigation

The unit has a roaster for heating the moist paddy grains. The skin temperature of the roaster varies from 59 to 117^{o}C at various locations.

Recommended action

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

Table 17: Roaster measurements and proposed savings (EPIA 6)

Parameters	Units	As is	To be
Length of roaster	m	4.10	4.10
Width of roaster	m	2.14	2.14
Height of roaster	m	1.90	1.90
Average temp of front surface(material outlet)	^{0}C	69.00	50.00
Average temp of side surface(press-side)	^{0}C	59.40	50.00
Average temp of side surface (ash removal side)	^{0}C	74.67	50.00
Average temp of back surface(fuel feeding side)	^{0}C	117.55	50.00
Ambient temperature	^{0}C	40.00	40.00
Velocity of air	m / sec	1.00	1.00
Heat loss due to R&C - Front side	Watt / m^2	260	69
Heat loss due to R&C - Press machine side	Watt / m^2	157	69
Heat loss due to R&C - Ash removal side	Watt / m^2	325	69
Heat loss due to R&C - Back side	Watt / m^2	895	69
Heat loss due to R&C - Front side	kCal / m^2	223	59
Heat loss due to R&C - Press machine side	kCal / m^2	135	59
Heat loss due to R&C - Ash removal side	kCal / m^2	279	59
Heat loss due to R&C - Back side	kCal / m^2	770	59
Total area - Front side	m^2	4.07	4.07
Total area - Back side	m^2	4.07	4.07
Total area - Press machine side	m^2	7.79	7.79
Total area - Ash removal side	m^2	7.79	7.79

Heat loss due to R&C - Front side	kCal / h	908	240
Heat loss due to R&C - Press machine side	kCal / h	1,052	459
Heat loss due to R&C - Ash removal side	kCal / h	2,177	459
Heat loss due to R&C - Back side	kCal / h	3,131	240
Total heat loss due to R&C from furnace surface	kCal / h	7,268	1,398
Calorific value of fuel - saw dust	kCal / kg	3,380	3,380
Total energy savings by insulating the roaster-furnace	kCal / h		5,870
Total fuel savings per hour	kg / h		1.74
Operating hours / day	h / day	10	10
Running days per year	days / y	310	310
Cost of saw dust	Rs. / kg	5.50	5.50
Total fuel savings per year	kg / y		5,384
Monitory savings per year	Rs Lakh / y		0.30
Estimated Investment	Rs. Lakh		1.00
Simple payback period	y		3.38

4.7 EPIA 7: 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 457^{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 457^{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 7)

Parameters	Unit	Value
Temp of flue gas	^{0}C	457.30
Ambient temperature	^{0}C	29.40
Mass of flue gas generated	kg / h	1,662.15
Specific heat of flue gas	kCal / (kg-^{0}C)	0.26
Mass of air supplied	kg/h	377.51
Specific heat of air	kCal / (kg-^{0}C)	1.00
Efficiency of APH	%	50.00
Temp of flue gas after APH	^{0}C	180.00

Calculations		
Temp of air after APH	^{0}C	188.12
Energy savings	kCal / h	59,919
Annual energy savings	kCal / y	197,731,955
Annual fuel savings	Kg / y	58,501
Annual monetary saving	Rs. Lakh / y	3.01
Investment estimated	Rs. Lakh	5.10
Payback	y	1.69

4.8 EPIA 8: Controlling excess air and feed being supplied for fuel combustion in rotating tunnel roaster to desirable limits

Technology description

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

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

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 manually adjusting the air blower (FD fan) damper to control excess air being supplied for combustion.

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 9.6 % 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 19: Cost benefit analysis (EPIA 8)

Excess air control using in-line oxygen meter			
Parameters	**Unit**	**Present**	**Proposed**
Oxygen level in flue gas	%	9.60	6
Excess air level	%	84.21	40
Flue Gas temperature	^{0}C	457.30	457.30
Saving in fuel	With every 10% reduction in excess air leads to savings in fuel consumption by 1%		
fuel consumption	kg / y	460,350	439,997.68
Saving in fuel consumption	Kg / y		20352.32
Cost of fuel	Rs. / kg	5.5	5.5
Operating hours	h / y	3,100	3,100
Total savings	Rs. Lakh / y		1.12
Estimated investment	Rs. Lakh		1.95
Simple payback	y		1.74

4.9 EPIA 9: Replacing present roaster fuel system to Gas based burner system

Technology description

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

It results in very dusty environment inside the plant causing health problems for workers.

- This results in release of high quantity of un-burnts (CO in ppm) in flue gas creating higher pollution levels due to high amount of suspended particles.
- It results in un-even heating in the roaster which hampers final poha quantity.
- There is lot of storage space required for storing saw dust.
- During rainy season, the stored saw dust becomes wet thereby increasing its moisture contents.

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

Study and investigation

During the BEA, it was found that the air and fuel are supplied to the roaster together using the blower. The fuel was falling on the hearth of the roaster due to gravity and was in a suspended state for lesser time. Due to this and also due to high velocity of combustion air, the fuel gets lesser time for proper combustion. This results in formation of un-burnts in bottom and fly ash. The color of flue gas observed was black indicating high level of carbon mono-oxide (CO) in the flue gas which was measured (by flue gas analyzer) to be over 1600 ppm during BEA.

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

Recommended action

It is recommended to change the fuel system from saw dust to PNG based system thereby eliminating the demerits associated with saw dust based system (as discussed earlier) and also increasing the combustion efficiency of the roaster-furnace. It is recommended that till the unit does not receive PNG, they operate the roaster-furnace with LPG by installation of duel fuel burners.

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

Table 20: Cost benefit analysis (EPIA 9)

Parameters	Units	Value
Roaster efficiency	**%**	**45%**
GCV of saw dust	kCal / kg	3,380
Present saw dust consumption	kg / y	460,350
Annual heat requirement	kCal / y	700,192,350
Annual heat requirement cost (Saw Dust)	Rs. Lakh	25.32
Calculations		
Roaster efficiency	%	75%
GCV of LPG	kCal / kg	12,500
Mass of LPG required	kg / y	74,687
Annual cost of LPG	Rs. Lakh	48.55
Present energy consumption	MTOE	155.60
Post energy consumption	MTOE	93.36
Energy Saving	MTOE	62.24
Production enhancement	%	2.70
Present production	kg / h	791.60
Production enhancement	kg / h	21.37
Average selling price	Rs. / kg	40.00
Cost benefit through production	Rs. Lakh / y	26.50
Total cost savings	Rs. Lakh / y	3.28
Investment estimated	Rs. Lakh	7.00
Payback	y	2.14

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

Cost of LPG	Rs./kg	65
GCV of saw dust	kCal/kg	3,380
GCV of LPG	kCal/kg	12,500
Heat rate saw dust	Rs./kCal	0.001256
Heat rate LPG	Rs./kCal	0.0052

5 ANNEXURE

Roaster efficiency calculations

Input parameters

Input Data Sheet		
Type of Fuel	**Saw Dust**	
Source of fuel	**Local Vendor**	
Fuel Analysis	**Value**	**Units**
C	***48.98***	**%**
H	***4.89***	**%**
N	***0.32***	**%**
O	***36.01***	**%**
S	***0.18***	**%**
Moisture	***6.40***	**%**
Ash	***3.30***	**%**
GCV of fuel	***3380***	kCal/kg
Flue Gas Details		
Flue gas temp	**457.3**	^0C
O2 in flue gas	**9.6**	*%*
CO2 in flue gas	**6.0**	*%*
CO in flue gas	**903.0**	*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.	**29.4**	^0C
Relative Humidity	**48**	*%*
Humidity in ambient air	**0.0120**	*kg/kgdry air*
Mass flow rate of fuel	148.5	*kg/h*
Production of Roasted Paddy	900	*kg/h*

Efficiency calculations

Calculations	Values	Unit
Theoretical air required	5.82	*kg/kg of fuel*
Excess air supplied	84.21	*%*
Actual mass of supplied air	10.73	*kg/kg of fuel*
Mass of dry flue gas	11.19	*kg/kg of fuel*

Amount of water vapour in flue gas	-	*kg of H2O/kg of fuel*
Specific fuel consumption	0.17	*kg of fuel/kg of Paddy*
Heat loss in dry flue gas	184,920.62	*kCal/h*
Heat loss due to formation of water from H2 in fuel	50,751.64	*kCal /h*
Heat loss due to moisture in fuel	7,380.38	*kCal /h*
Heat loss due to moisture in air	3,681.78	*kCal /h*
Heat loss due to partial conversion of C to CO	6,137.79	*kCal /h*
Heat loss due to radiation and Convection losses	15,549.05	*kCal /h*
Heat loss from Unburnt in fly ash	1,470.15	*kCal /h*
Heat loss from bottom ash	6,615.68	*kCal /h*
Roaster Efficiency by indirect Method	45%	

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