Energy Audit Report: Cattle Feed Plant-Katarva, Deesa

Conducting activities of energy audit & dissemination activities in Gujrat dairy cluster under GEF-UNIDO-BEE project

March 2016

pwc

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List of Abbreviations and Acronyms

A.C.	Air Conditioning
BTU	British Thermal Unit
CFL	Compact Fluorescent Lamp
CFM	Cubic Feet per Minute
COP	Coefficient of Performance
CO2	Carbon dioxide
DG	Diesel Generator
ECM	Energy Conservation Measure
EE	Energy Efficient
EER	Energy Efficiency Ratio
EPC	Engineering Procurement Construction
FAD	Free Air Delivery
FTL	Fluorescent Tube Light
GWh	Gigawatt Hour
IGEA	Investment Grade Energy Audit
kWh	Kilowatt Hour
LPG	Liquefied Petroleum Gas
LPM	Litre Per Minute
LT	Low Tension
Mkcal	Million Kilo Calories
Mt	Million Tonnes
M&E	Monitoring and Evaluation
O&M	Operation and Maintenance
PV	Photo Voltaic
RE	Renewable Energy
SEC	Specific Energy Consumption
SFC	Specific Fuel Consumption
SPC	Specific Power Consumption
SSE	Solar System Exploration
TOD	Time of Day
TR	Ton of refrigeration

Conversion Table

Unit	Conversion factor
1 kWh	860 kcal
1 Joule	0.24 Calorie
1 m^3	1,000 liters
1 TR	12,000 Btu
1 kWh	0.64 kg CO_2
1 Liter (Diesel)	2.7 kg CO_2
1 Liter (Furnace Oil)	2.9 kg CO_2
1 Liter (Kerosene)	2.5 kg CO_2
1 Kg (CNG)	2.8 kg CO_2
1 Kg (Coal)	2.93 kg CO_2

Acknowledgement

PwC sincerely thank GEF-UNIDO-BEE for associating us in its prestigious project "Energy efficiency and renewable energy in MSMEs" which involves developing and promoting market environment for introducing energy efficiencies in process applications in 12 selected energy-intensive MSME clusters in India. Gujarat dairy cluster is also one of these 12 clusters.

We express our sincere gratitude to all concerned officials of PMU of the project for their valuable support and guidance during execution of the project.

Our special thanks to following persons:

- Mr. Milind Deore, Energy Economist, BEE
- Mr. Abhishek Nath, National Project Manager, Energy efficiency and renewable energy in MSMEs
- Mr. Niranjan Rao Deevela, National Technology Coordinator, Energy efficiency and renewable energy in MSMEs
- Mr. Ashish Sharma, Project Engineer, GEF-UNIDO-BEE Project, BEE

PwC is thankful to Gujarat Cooperative Milk Marketing Federation Limited (GCMMF) for extending support for this assignment. We are also thankful to Mr. P. K. Sarkar and his team for giving full support during the energy audit. We would like to thank Mr. Falgun Pandya, Cluster Leader - Gujarat, GEF-UNIDO-BEE Project for providing on-field support during energy audit.

We would also like to acknowledge the support, valuable inputs, co-operation and guidance provided by Mr. Rajesh Bathol (Manager - Engineering) during field measurements at Cattle feed plant, Katarva - Deesa.

1. Executive Summary

1.1 Introduction

GEF-UNIDO-BEE is developing and promoting market environment for introducing energy efficiencies in process applications in 12 selected energy-intensive MSME clusters in India. Gujarat dairy cluster is one of them. The overall motive of this assignment is to improve the productivity and competitiveness of units as well as to reduce overall carbon emissions and improve the local environment. PwC was appointed by GEF-UNIDO-BEE for conducting activities under this assignment in the Gujarat Dairy cluster. The activities to be executed include conducting detailed energy audit in 6 plants under GCMMF. So, cattle feed plant of Banas Dairy was one of the plant wherein detailed energy audit was conducted.

1.2 Objective of the energy audit study

The objective of detailed energy audit is to review present energy consumption scenario, monitoring and analysis of use of energy and explore various energy conservation options. It includes submission of five best operating practices & common monitorable parameters in Gujarat dairy cluster. The project also includes submission of detailed energy audit report containing recommendations for improving energy efficiency with cost benefit analysis and technical specifications for any retrofit options, with list of suppliers/manufacturers of recommended energy efficient technologies. Extensive attention was given to understanding not only operating characteristics of all energy consuming systems but also situations which cause load profile variations on both annual and daily basis.

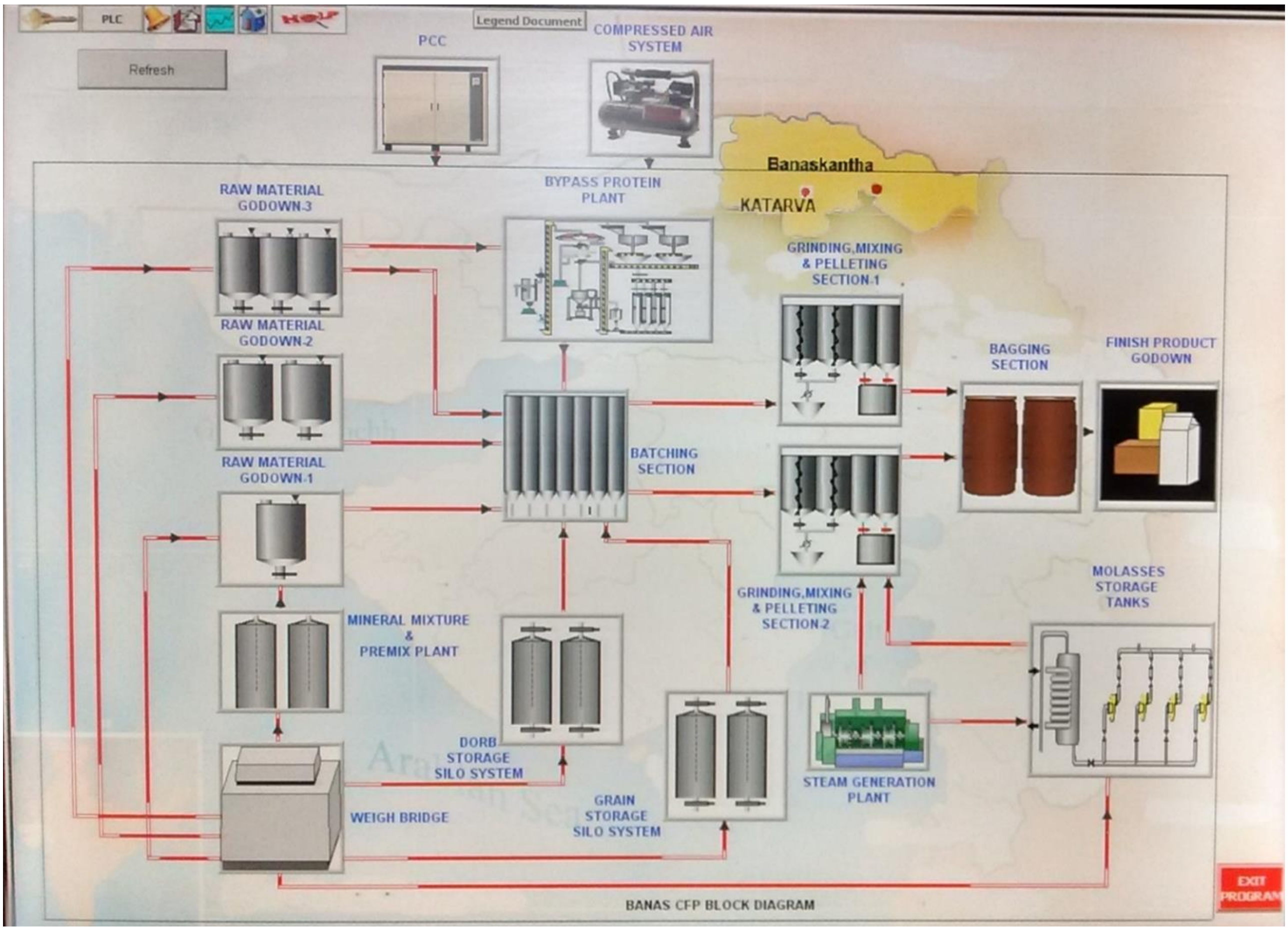
1.3 About Cattle feed plant

Cattle feed plant is under Banas Dairy of Amul group, located in Katarva – Deesa. The plant supplies nutritious food to the cattle-yards from where Banas dairy collects milk on daily basis. Plant manufactures feed of different types comprising of different grains and sells the same to farmers on discounted prices. The plant runs on no profit-no loss basis. The cattle feed plant has two production lines of 500 TPD capacity each. The manufacturing process of the cattle feed plant is discussed below.

Process flow:

The detailed process flow diagram for the Cattle Feed Manufacturing is provided below.

Figure 1: Process flow diagram



Cattle feed plant receives all raw materials through trucks and the same is stored in raw material godowns. There are three raw material godowns, RMG – 1, 2 and 3. Each of this godown has separate silos for each type of raw material. Thereafter, batching is done wherein different raw materials are mixed in a single batching silo as per the requirement of final feed quality. After batching, mixed raw material is taken to plant through conveyors belts for further processing in one of the two production lines.

Grinding, Mixing and pelleting: The batched raw material is first grinded in the Grinder to get a uniform mix and desired size. After grinding, uniform raw material is sent to Mixer, where material is mixed further to get uniform mixing and after this, raw material is forwarded to pelleting section, where steam is used to make pellets of required sizes.

After pelleting, cattle feed is ready and is then packed in packing section. After packing, the cattle feed packs are stored in storage final product godown before dispatching.

1.4 Present energy consumption scenario & specific energy consumption:

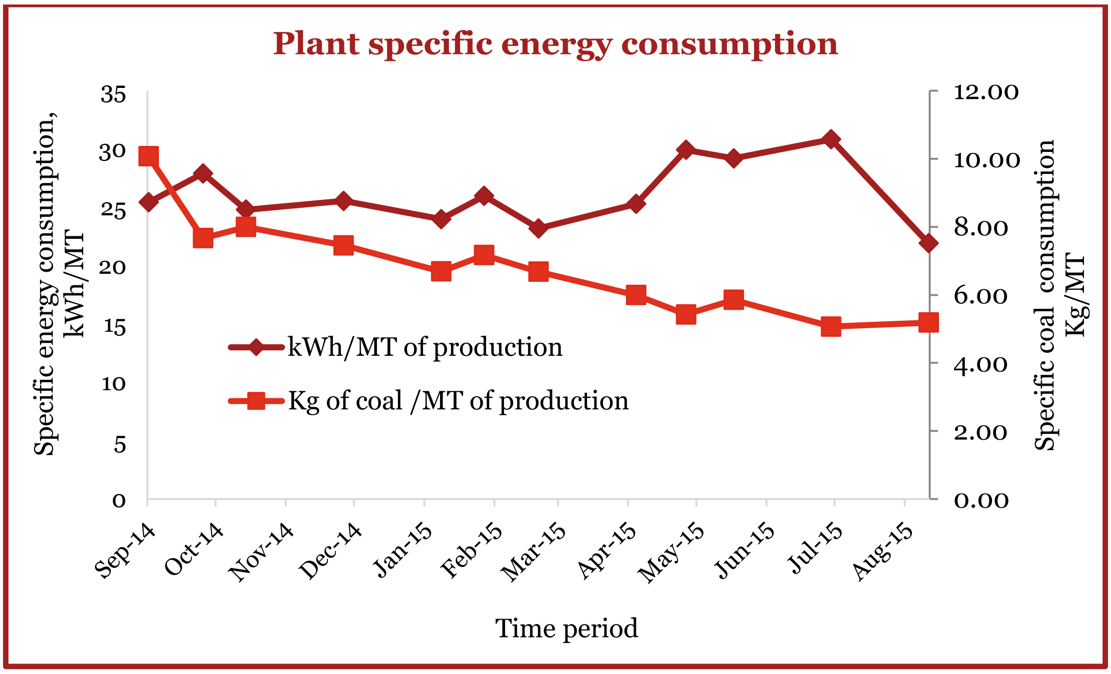
The cattle feed plant uses electricity and coal as its main energy input for operation. The electricity consumption and coal consumption of entire plant is tabulated and compared with quantity of Cattle feed manufactured to estimate electricity consumption and coal consumption for manufacturing each metric ton of cattle feed. This has been tabulated below for reference.

Table 1 : Present energy scenario and specific energy consumption

Month	Coal consumption (MT/month)	Electricity consumption (kWh/month)	Production (MT/month)	Specific energy consumption	
				(kWh/MT)	(Kg of coal /MT)
September-14	172	434,380	17,087	25.42	10.08
October-14	132	481,060	17,239	27.90	7.66
November-14	149	462,905	18,673	24.79	7.99
December-14	141	483,375	18,921	25.55	7.45
January-15	141	504,060	21,012	23.99	6.69
February-15	146	529,140	20,371	25.98	7.17
March-15	129	447,225	19,283	23.19	6.68
Apr-15	121	511,515	20,227	25.29	5.99
May-15	105	577,755	19,310	29.92	5.42
June-15	111	553,125	18,944	29.20	5.85
July-15	81	494,595	16,047	30.82	5.07
August-15	115	473,550	21,601	21.92	5.18
Average	**129**	**496,057**	**19,060**	**26.16**	**6.77**
Total	**1,543**	**5,952,685**	**2,28,715**		

The following figure captures variation in specific energy consumption in the plant.

Figure 2: Plant specific energy consumption variation



- The average specific energy consumption (Electrical) for cattle feed making is 26.16 kWh/MT of final product.
- The average specific coal consumption for cattle feed making is 6.77 kg/MT of final product.

1.5 *Plant energy consumption and energy savings*

A summary of plant energy consumption as well as savings is provided in the following table.

Table 2: Summary of plant energy consumption and energy savings

Particulars	Unit	Values
Annual electricity consumption	kWh/annum	**5,952,685**
Annual expense on electricity	Rs. Lakhs	**449.2**
Annual coal consumption	MT/annum	**1,543**
Annual expense on coal	Rs. Lakhs	**41.57**
Electricity saved annually through implementation of proposed energy conservation measures	kWh/annum	**381,725**
Coal saved annually through implementation of proposed energy conservation measures	MT/annum	**373.2**
Annual cost saved (as mentioned in section 1.6)	Rs. Lakhs	**34.92**
Investment required	Rs. Lakhs	**37.5**
Payback period	Months	**13**
Proposed percentage of electricity saved	%	**6.41**
Proposed percentage of coal saved	%	**24.23**
Proposed percentage of total energy cost saved	%	**7.1**

1.6 Summary of proposed energy conservation measures

Table 3: Summary of proposed energy conservation measures

S. No.	Suggested measure	Annual energy savings	Annual cost saving	Investment	Payback period
		kWh/annum Kg/annum	Rs. Lakhs	Rs. Lakhs	Months
1	Maintain unity power factor at main incomer to avail full incentive from electricity board	-	2.66	Negligible	Immediate
2	Arrest continuous steam wastage through boiler blowdown valve	360,640	9.73	Negligible	Immediate
3	Install back pressure turbine to generate power instead of wasting steam pressure energy in PRV	303,353	14	15	13
4	Recover heat from blowdown to pre heat boiler feed water	12,611	0.38	1	32
5	Install VFD in boiler ID & FD fans to avoid throttling and maintain correct O_2 in the flue gas	39,690	1.80	3.3	22
6	Install variable frequency drive to boiler feed water pump	7,182	0.32	0.6	22
7	Option -1 :Install lighting energy saver to lighting feeder	31,500	1.43	3.6	30
	Option -2 : Replace all lamps in the plant with appropriate rating LED lamps	1,01,500	4.6	14	36
Total		**381,725/373,251**	**34.92**	**37.5**	**13**

2 Introduction

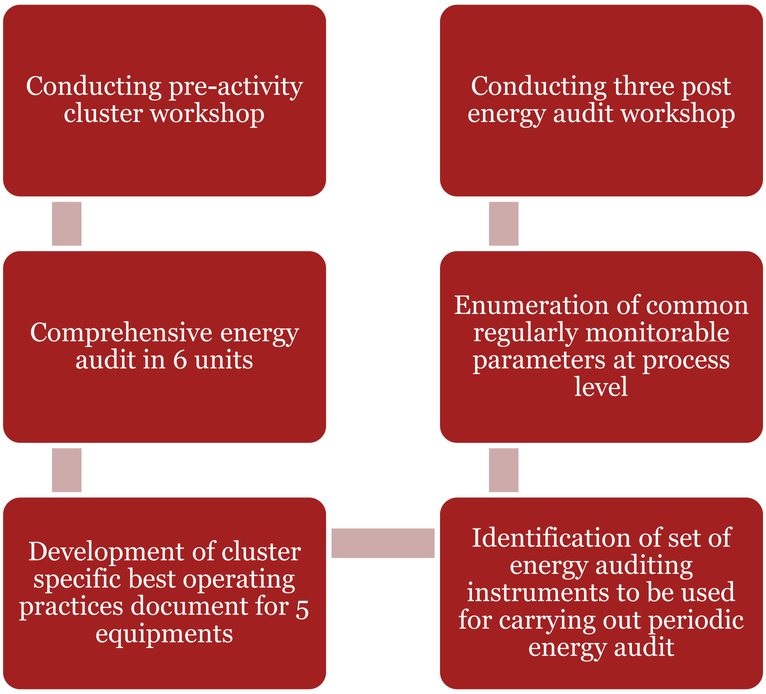
2.1 Introduction

GEF-UNIDO-BEE is developing and promoting market environment for introducing energy efficiencies in process applications in 12 selected energy-intensive MSME clusters in India. Gujarat dairy cluster is one of them. The overall motive of this assignment is to improve the productivity and competitiveness of units as well as to reduce overall carbon emissions and improve the local environment. PwC was appointed by GEF-UNIDO-BEE for conducting activities under this assignment in the Gujarat Dairy cluster. Carrying out energy audit in 6 dairy plants is one of the activities of the assignment. Energy audit of Cattle feed plant - Katarva was one of these 6 audits.

2.2 Scope of services

The scope of this assignment is shown at following figure.

Figure 3: Scope of services



This report has been prepared under the task 2 of our scope of services, which involves conducting comprehensive energy audits in six units in the cluster, where Cattle feed plant has been selected one of these six.

2.3 Energy audit scope and approach

A detailed energy audit was undertaken at Cattle feed plant – Katarva from 14 to 17 September 2015. The energy audit team from PwC comprised of thermal and electrical energy experts. During energy audit, a range of portable energy audit instruments were used to take various measurements of all energy consuming equipment/systems of the plant. In addition, design and operational data was collected from logbooks and equipment manuals. Also, discussions were held with technical personnel at the plant to fully understand its operations and energy requirements. The energy audit was focused on the study of cattle feed plant and evaluation of operational efficiency/performance of each equipment from energy conservation point of view.

The following areas were covered during the study:

- ***Cattle Feed plant***
  - ✓ Production Section/Equipment
    - Raw material godowns
    - Grinder
    - Mixer
    - Pelleting
    - Bagging section
  - ✓ Utilities
    - Air compressors
    - Cooling water system
    - Boiler and steam distribution
    - Water pumping system
- ***Renewable Energy***
  - ✓ Opportunities were identified for use of renewable energy

The study focused on identifying energy saving measures in cattle feed plant. The analyses included estimation of investment requirement, payback period and Internal Rate of Return (IRR) calculations to ascertain financial viability of investment intensive energy conservation measures. The energy audit involved carrying out various measurements and analysis, to assess losses and potential for energy savings in different sections of the plant. A wide array of latest, sophisticated, portable, diagnostic and measuring instruments were used to obtain primary information for energy audit investigations and analyses. The specialized instruments that were used during the energy audit included:

- Power analyzers (Three Phase and Single Phase)
- Digital manometer
- Digital hygrometers
- Temperature loggers
- Ultrasonic flow meter
- Digital pressure gauge
- Others

During the audit, team maintained continuous interaction with plant personnel to ensure that recommendations made were realistic, practical and implementable. On the last day of energy audit, discussion was held with plant management on site observations and preliminary findings, to enable management to take immediate action to conserve energy.

This report presents field measurements, design and operational data, data analysis, key observations and recommendations to achieve energy savings in each of the major areas that consumed energy and equipment. The recommendations are followed by cost-benefit analysis. Major emphasis was laid on short and medium-term measures. The ultimate aim of this exercise is to help plant management to understand and prioritize energy efficiency opportunities identified through the study.

2.4 Plant installed load details

The following table lists major energy consuming process equipment and auxiliaries in the plant.

Table 4 : List of energy consuming loads (Equipment) in the plant

Description	Motor H.P.
ID Fan(Boiler GT-7036)	25
ID Fan(Boiler GT-7037)	25
FD Fan(Boiler GT-7036)	30
FD Fan(Boiler GT-7037)	30
Air compressor motor-1	75
Air compressor motor-2	75
Main pump	75
Jockey pump	15
Hydra screw motor -1	30
Hydra screw motor -2	30
Hydra screw motor -3	30
Hydra screw motor -4	30
Batch mixer -1	75
Batch mixer-2	75
Pellet mill-1	425
Pellet mill-2	425
Conditioner number 2-1	30
Conditioner number 2 line-2	30
Conditioner number 1 line-1	30
Conditioner number 1 line-2	30
Hammer mill -1	340
Hammer mill -2	340
Main intake elevator-1	15
Main intake elevator -2	15
Main intake elevator -3	15
Batching main elevator line-1	15
Batching main elevator line -2	15
Motor for cooler cyclone-1	100
Motor for cooler cyclone -2	100
Motor for hammer mill blower fan-1	20
Motor for hammer mill blower fan -2	20
Batch Mixer -1	12.5
Batch Mixer -2	12.5
Bay pass intake elevator	12.5
Hammer mill	75
Boiler -1	
Boiler -2	
Air compressor – 1	67
Air compressor – 2	67

3 Observation and Analysis

Cattle feed plant is under Banas Dairy of Amul group, located in Katarva – Deesa. The plant supplies nutritious food to the cattle-yards from where Banas dairy collects milk on daily basis. Plant manufactures the feed of different types comprising of different grains and sells to the farmers on discounted prices. The plant runs on no profit-no loss basis. The cattle feed plant has two production lines of 500 TPD capacity each. The detailed energy audit was conducted at cattle feed plant to identify the energy saving opportunities, the observation part of the report is as below.

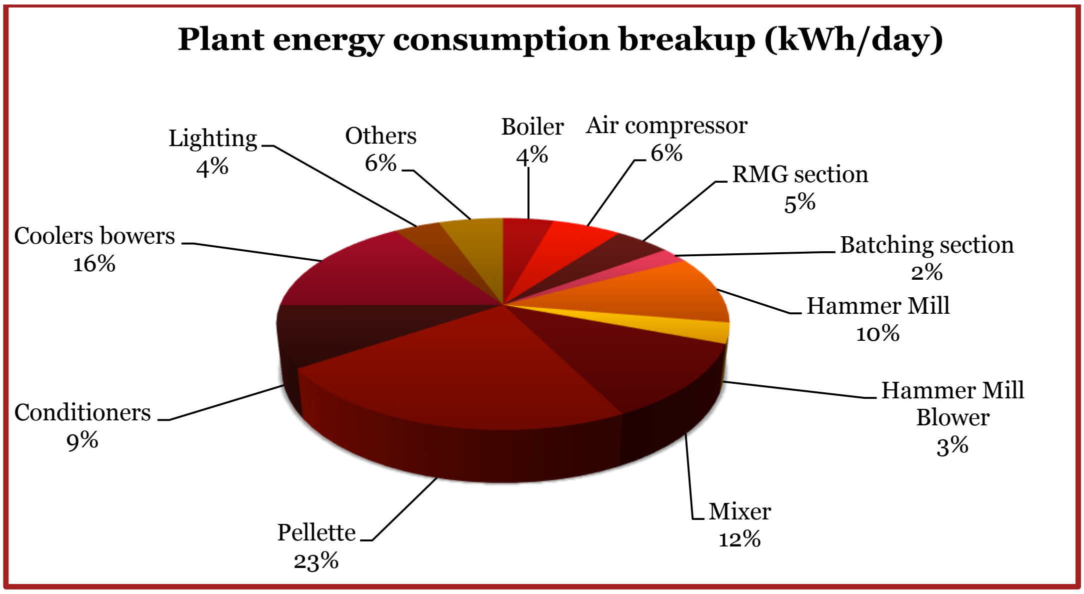
3.1 Electrical energy consumption breakup

Detailed electrical measurement was done on all energy consuming equipment in the plant and energy consumption breakup was derived and the same is tabulated below for reference.

Table 5 : Breakup of electricity consumption

Description	Operating load (kW)	Electricity consumption (kWh/day)	Share in total electricity consumption (%)
Boiler	41.25	990	4%
Air compressor	56.25	1350	6%
RMG section	45	1080	5%
Batching section	22.5	540	2%
Hammer Mill	100	2400	10%
Hammer Mill Blower	30	720	3%
Mixer	112.5	2700	12%
Pellette	220	5280	23%
Conditioners	90	2160	9%
Coolers bowers	150	3600	16%
Lighting	37.5	900	4%
Others	52.5	1260	5%
Total	**957.5**	**22,980**	**100%**

Figure 4: Plant electrical energy consumption breakup



- The major energy consumer in the cattle feed plant is the process equipment, which consumes, about 80.4 % of the energy consumption.
- Cattle feed plant is working 24 h in a day and manufacturers about 500 MT feed per day in one line.

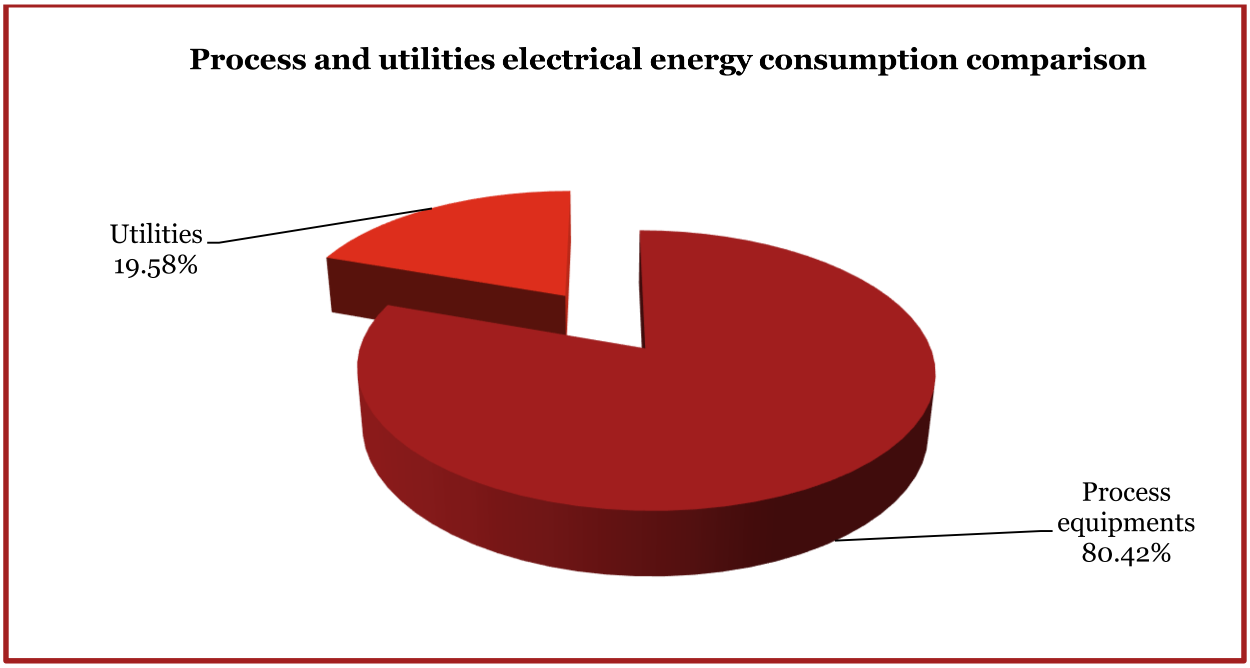
Process and utilities electricity consumption comparison:

Electricity consumption comparison between process equipment and utilities has been carried out and is tabulated below for reference.

Table 6 : Electricity consumption (process and utility electricity consumption comparison)

Description	Operating load (kW)	Electricity consumption (kWh/day)	Share in electricity energy Consumption (%)
Process equipment	770	18,480	80.4%
Utilities	187.5	4,500	19.5%
Total	957.5	22,980	**100%**

Figure 5: Process and utilities electrical energy consumption comparison



- Process equipment are the major energy consumer in the plant, this equipment's consumes about 80.4 % of total electrical energy.
- Utility like boiler, compressors and lighting consumes only 19.5 % of total electrical energy.

3.2 *Electricity bill analysis*

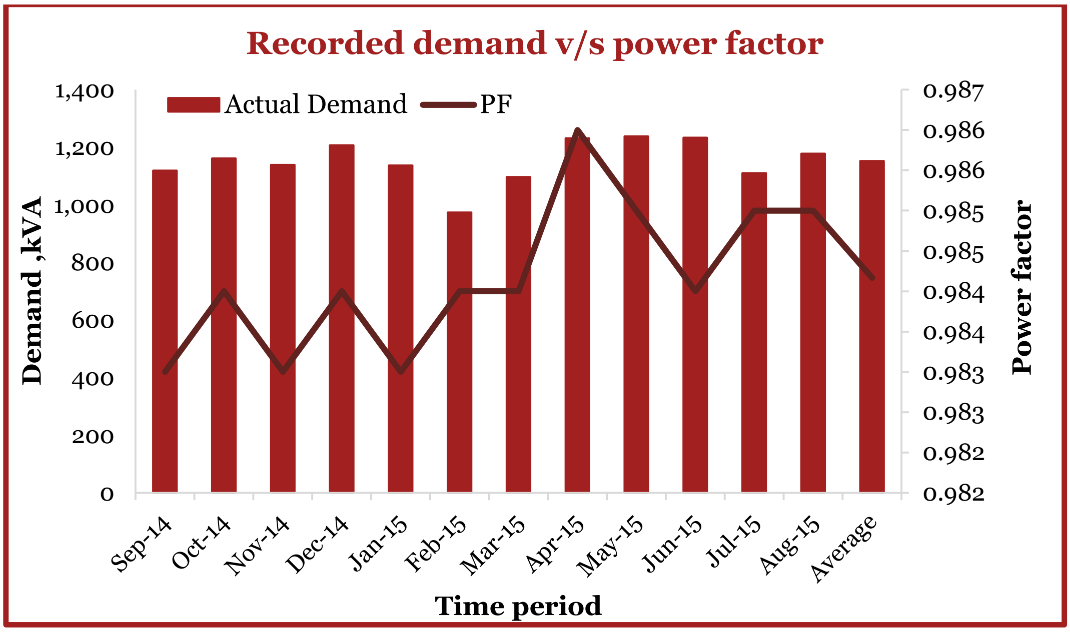
The plant receives power from Gujarat State Electricity Board at 11kV HT line. Two transformers of 1,600 kVA capacity each have been installed in plant to stepdown voltage from 11 KV to 440 Volts. The electricity bills from September 2014 till August 2015 were collected and analyzed. The findings are presented in following table.

Table 7 : Annual electricity bill analysis

Month	Actual demand (kVA)	Billing demand (kVA)	PF	Energy consumption (kWh)	Energy consumption during night hours (kWh)	TOD energy consumption (kWh)	Demand charges in (Rs.)	Energy charges in (Rs.)	PF incentive charges (Rs.)	Total electricity bill (Rs.)*
Sep-14	1,119	1,615	0.983	434,380	153,480	131,560	390,250	1,926,476	31,786	3,341,344
Oct-14	1,162	1,615	0.984	481,060	165,260	152,700	390,250	2,137,037	36,329	3,660,917
Nov-14	1,139	1,190	0.983	462,905	149,395	151,225	241,500	2,059,927	33,988	3,108,540
Dec-14	1,207	1,207	0.984	483,375	157,635	154,680	247,450	2,,151,019	36,567	3,059,806
Jan-15	1,137	1,190	0.983	504,060	178,155	161,085	241,500	2,235,466	36,885	3,703,218
Feb-15	974	1,190	0.984	529,140	175,440	168,420	241,500	2,354,673	40,029	4,181,243
Mar-15	1,097	1,190	0.984	447,225	152,160	136,665	241,500	1,987,838	33,793	3,492,108
Apr-15	1,231	1,231	0.986	511,515	176,745	160,245	255,850	2,271,562	40,888	3,969,063
May-15	1,238	1,238	0.985	577,755	208,875	181,230	286,150	2,616,568	45,789	4,578,988
Jun-15	1,234	1,234	0.984	553,125	206,040	168,225	284,450	2,498,304	42,471	4,334,264
Jul-15	1,111	1,190	0.985	494,595	183,600	155,835	265,750	2,234,483	39,103	3,909,880
Aug-15	1,178	1,190	0.985	473,550	165,075	149,085	265,750	2,148,511	37,598	3,587,070
Average	**1,152**	**1,273**	**0.984**	**496,057**	**172,655**	**155,913**	**279,325**	**2,218,489**	**37,936**	**3,743,870**
Total				**5,952,685**	**2,071,860**	**1,870,955**	**3,351,900**	**26,621,864**	**455,226**	**44,926,441**

* Total electricity bill also includes fuel adjustment charges and electricity duty.

Figure 6: Recorded demand and power factor variation profile



- Plant spends on an average INR 37.5 lakhs/month towards electricity bill and total electricity bill paid from September 2014 to August 2015 was around Rs. 449.26 Lakhs.
- Average power factor maintained by the plant from September 2014 to August 2015 is 0.984 lagging. Improving power factor up to unity will increase the power factor incentive from electricity board.

3.3 Main incomer power profile

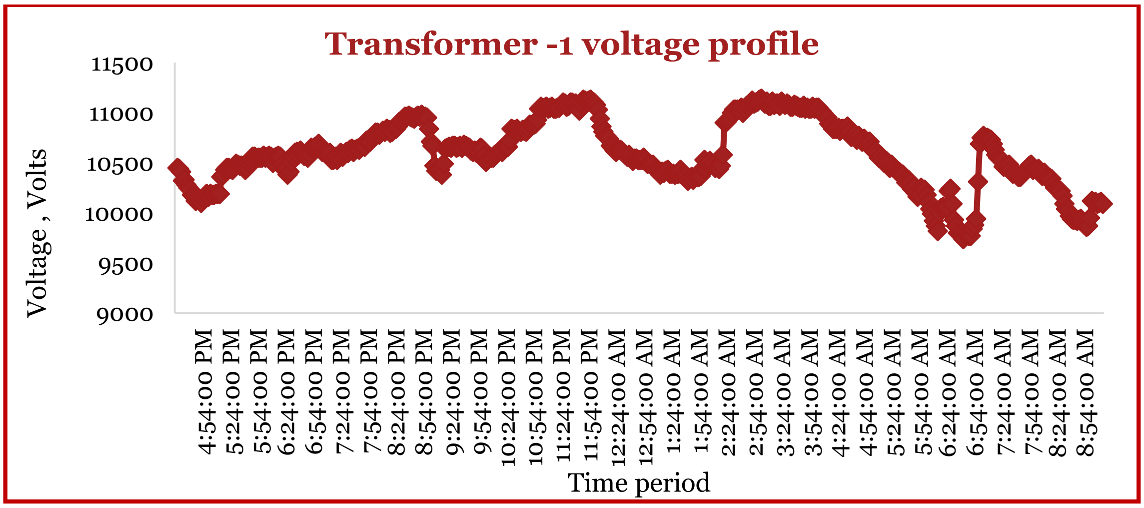
There are two transformers installed to feed power to entire plant, these transformers receives power from 11kV feeder. The voltage profile, current profile, power consumption profile, power factor profile and frequency profile were recorded for both transformers. The same has been presented next.

Transformer -1

Voltage profile:

The voltage profile was recorded for transformer -1 on HT side from 14-09-15 @04:56PM to 15-09-15 @ 9:00 AM. The profile obtained is present below.

Figure 7: Transformer -1 voltage profile



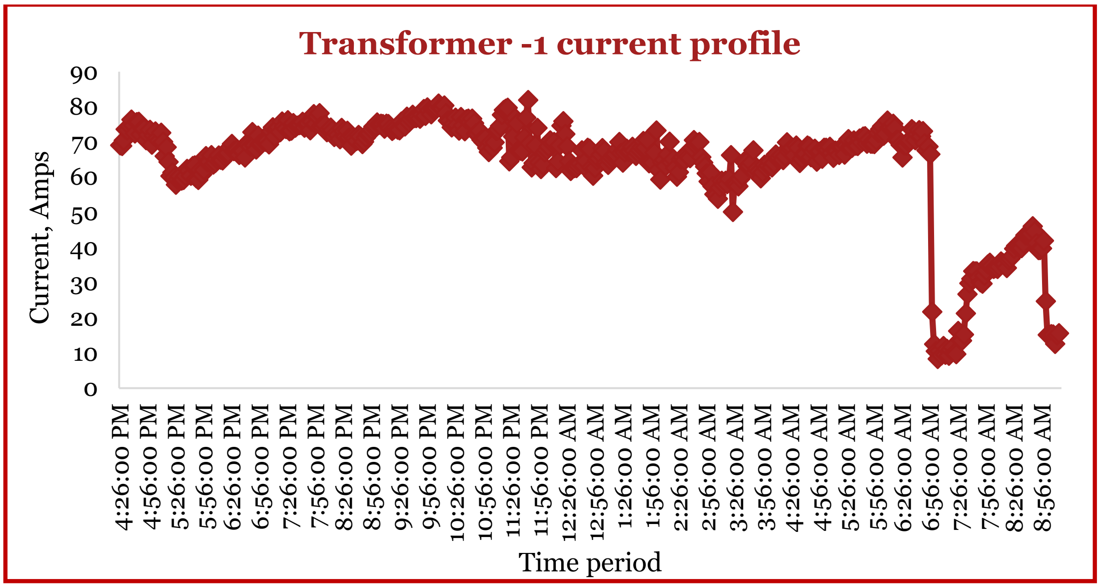
The maximum voltage recorded during this period = 11,370 volts

The minimum voltage recorded during this period = 9,500 volts

Current profile:

The current profile was recorded for transformer -1 on HT side from 14-09-15 @04:56PM to 15-09-15 @ 9:00 AM. The profile obtained is present below.

Figure 8: Transformer -1 current profile



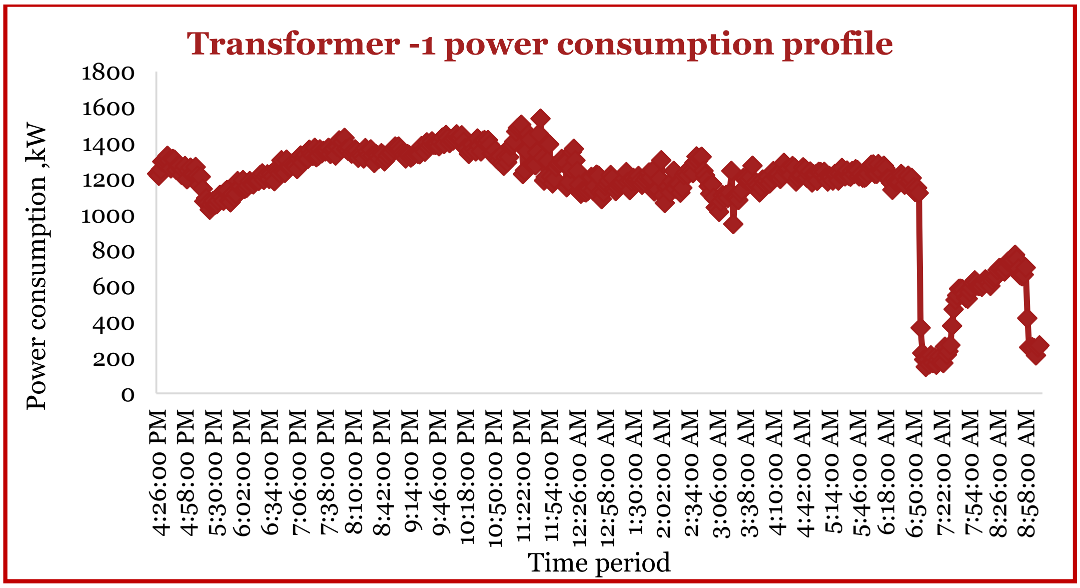
The maximum current recorded during this period = 82 amps

The minimum current recorded during this period = 9 amps

Actual power profile:

The power profile was recorded for transformer -1 on HT side from 14-09-15 @04:56PM to 15-09-15 @ 9:00 AM. The profile obtained is present below. s.

Figure 9: Transformer -1 power consumption profile



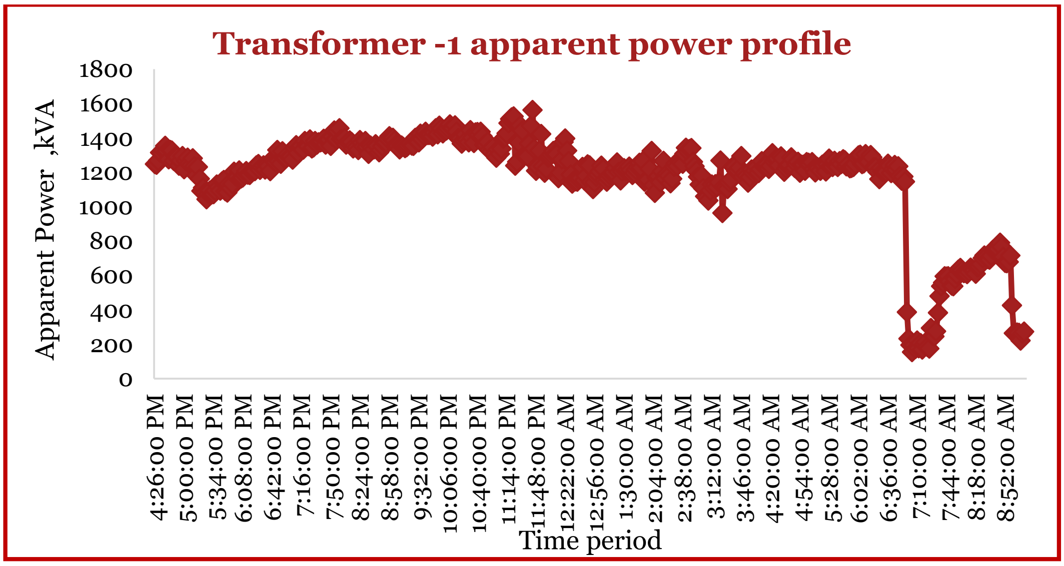
The maximum power consumption recorded during this period = 1,600kW

The minimum power consumption recorded during this period = 150 kW

Apparent power profile:

The apparent power profile was recorded for transformer -1 on HT side from 14-09-15 @04:56PM to 15-09-15 @ 9:00 AM. The profile obtained is present below.

Figure 10: Transformer -1 apparent power profile



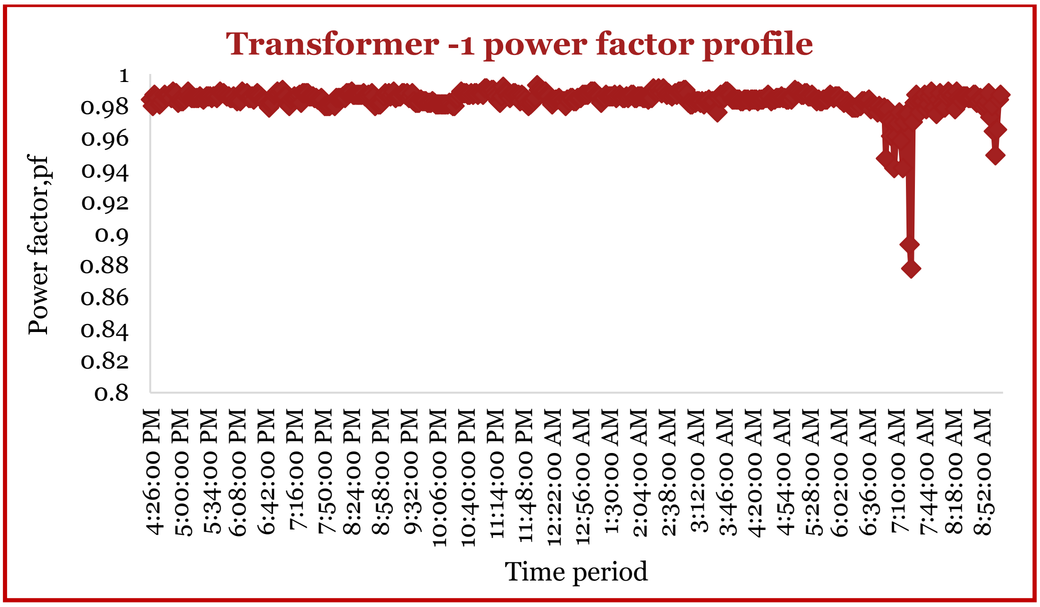
The maximum apparent power consumption recorded during this period = 1,600 kVA

The minimum apparent power consumption recorded during this period = 150 kVA

Power factor profile:

The power factor profile was recorded for transformer -1 on HT side from 14-09-15 @04:56 PM to 15-09-15 @ 9:00 AM. The profile obtained is present below.

Figure 11: Transformer -1 power factor profile



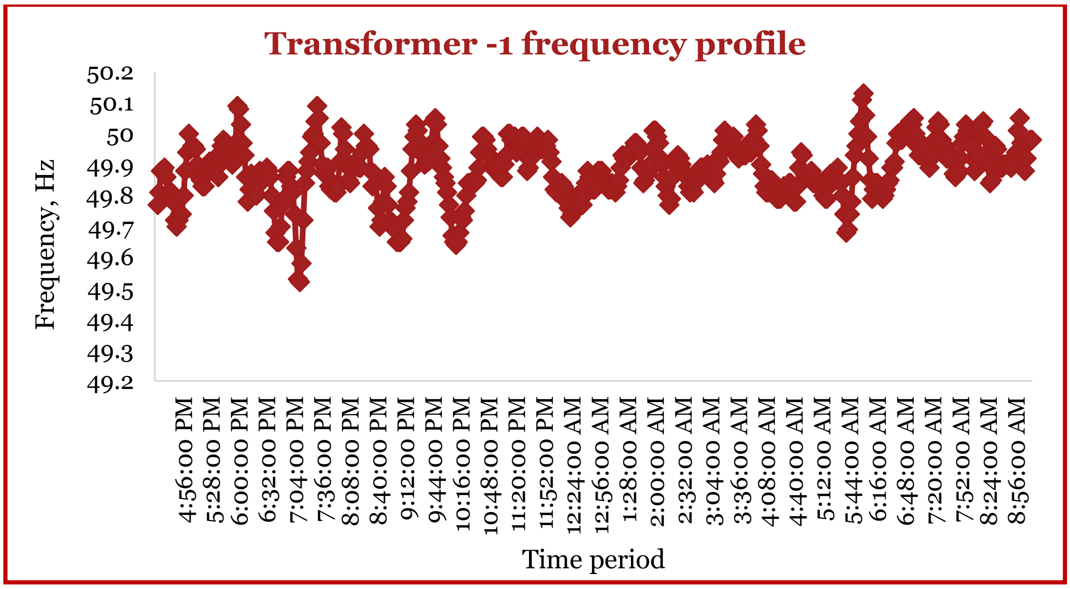
The maximum power factor recorded during this period = 0.98

The minimum power factor recorded during this period = 0.88

Frequency profile:

The frequency profile was recorded for transformer -1 on HT side from 14-09-15 @04:56 PM to 15-09-15 @ 9:00 AM. The profile obtained is present below.

Figure 12: Transformer -1 frequency profile



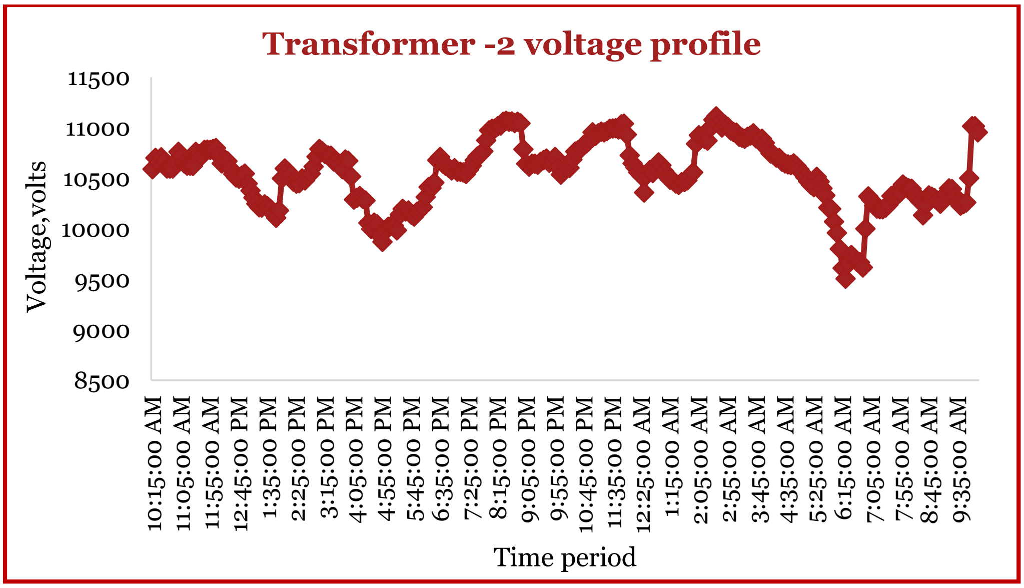
The maximum frequency recorded during this period = 50.1 Hz

The minimum frequency recorded during this period = 49.5Hz

Transformer -2 : Voltage profile:

The voltage profile was recorded for transformer -2 on HT side from 14-09-15 @ 10:15 AM to 15-09-15 @ 9:40 AM. The profile obtained is presented below.

Figure 13: Transformer -2 voltage profile

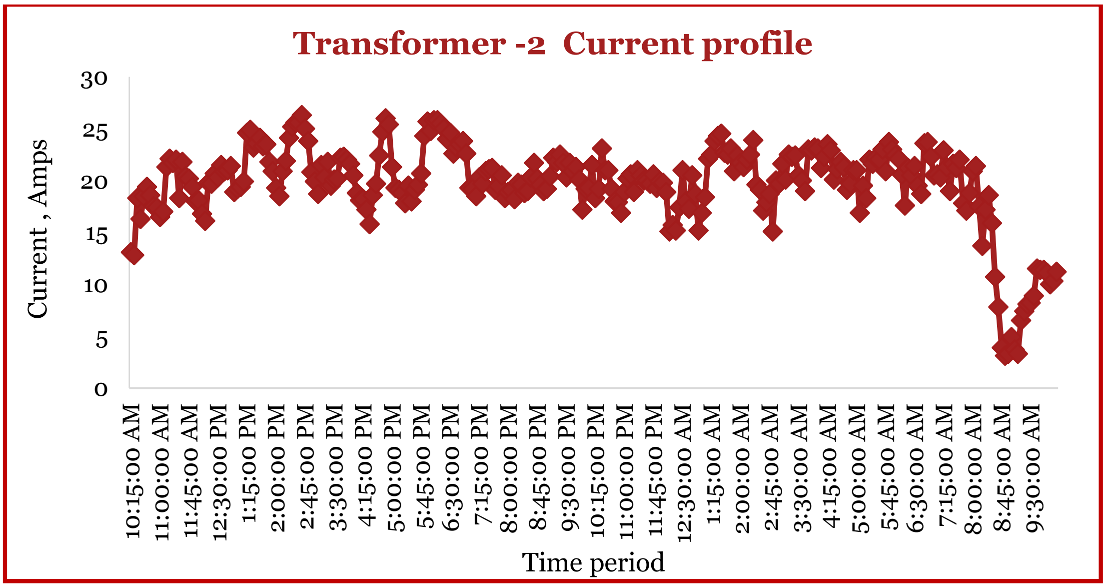


The maximum voltage recorded during this period	=	11,200 volts
The minimum voltage recorded during this period	=	9,500 volts

Current profile:

The current profile was recorded for transformer -2 on HT side from 14-09-15 @ 10:15 AM to 15-09-15 @ 9:40 AM. The profile obtained is presented below.

Figure 14: Transformer -2 current profile

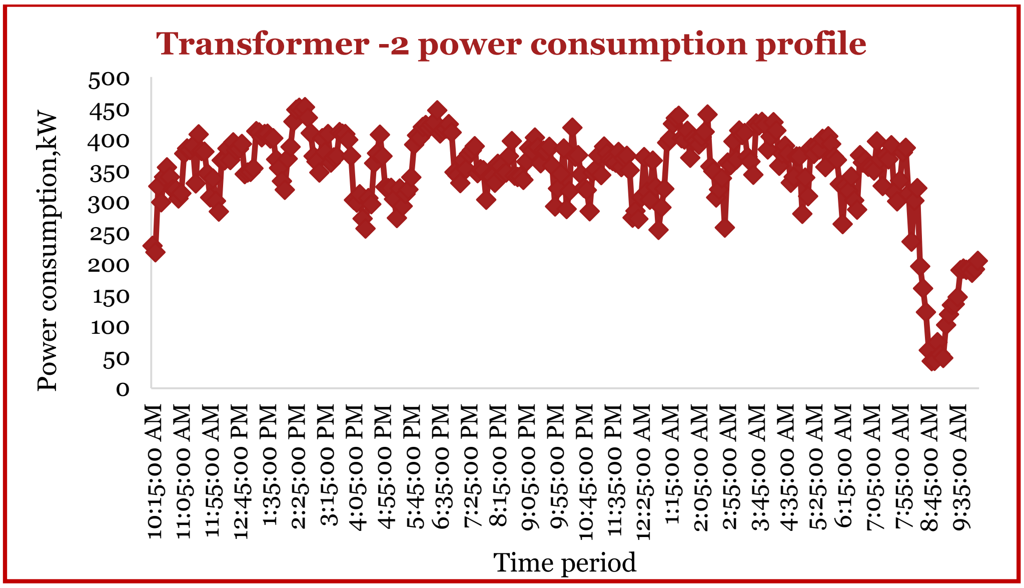


The maximum current recorded during this period	=	27 amps
The minimum current recorded during this period	=	4 amps

Actual power profile:

The actual power profile was recorded for transformer -2 on HT side from 14-09-15 @ 10:15 AM to 15-09-15 @ 9:40 AM. The profile obtained is presented below.

Figure 15: Transformer -2 current profile



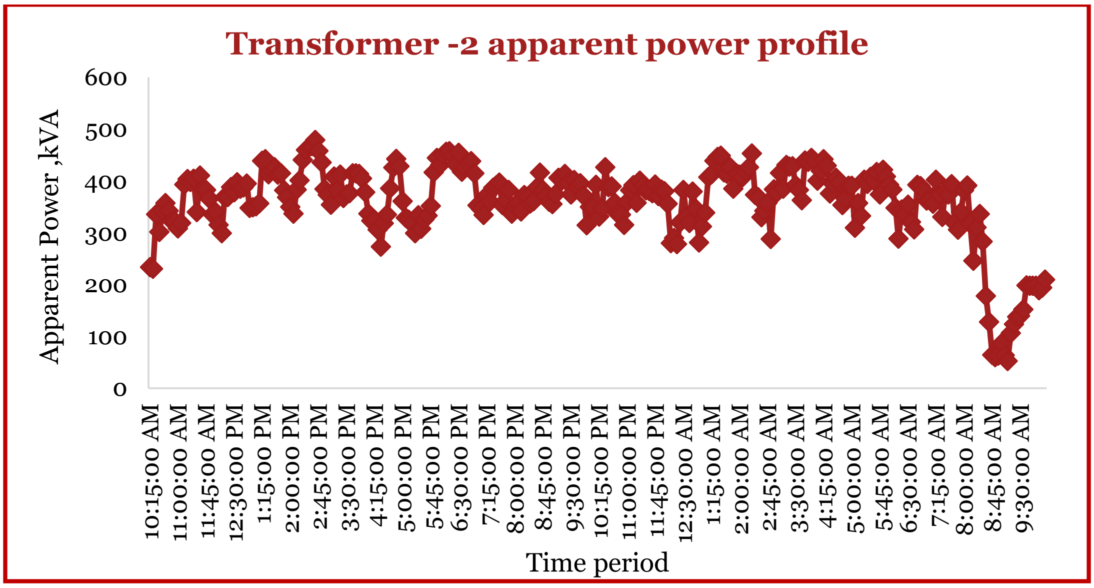
The maximum power consumption recorded during this period = 450 kW

The minimum power consumption recorded during this period = 50 kW

Apparent power profile:

The apparent power profile was recorded for transformer -2 on HT side from 14-09-15 @ 10:15 AM to 15-09-15 @ 9:40 AM. The profile obtained is presented below.

Figure 16: Transformer -2 apparent power profile



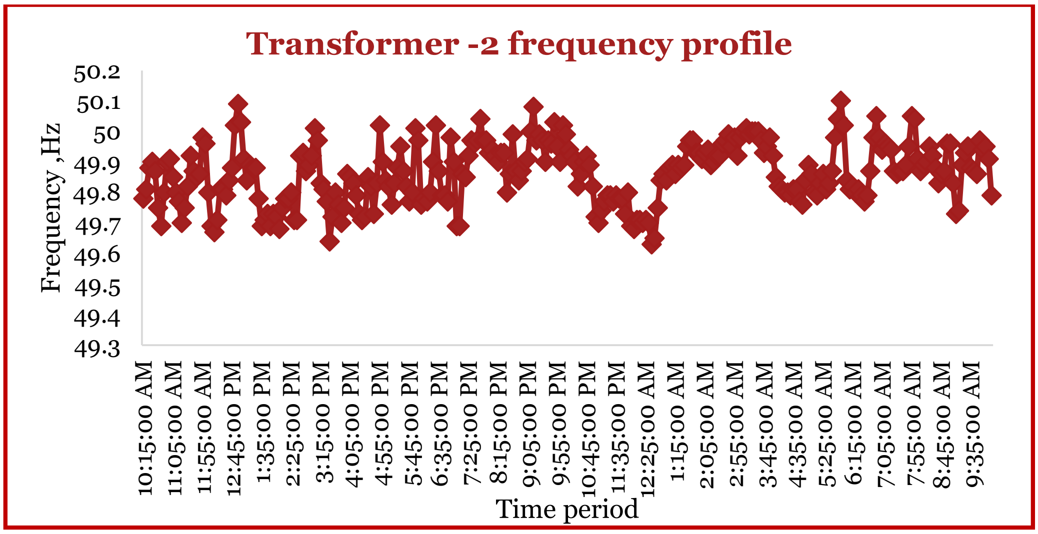
The maximum apparent power consumption recorded during this period = 500 kVA

The minimum apparent power consumption recorded during this period = 60 kVA

Frequency profile:

The frequency profile was recorded for transformer -2 on HT side from 14-09-15 @ 10:15 AM to 15-09-15 @ 9:40 AM. The profile obtained is presented below.

Figure 17: Transformer -2 frequency profile



The maximum frequency recorded during this period = 50.1 Hz

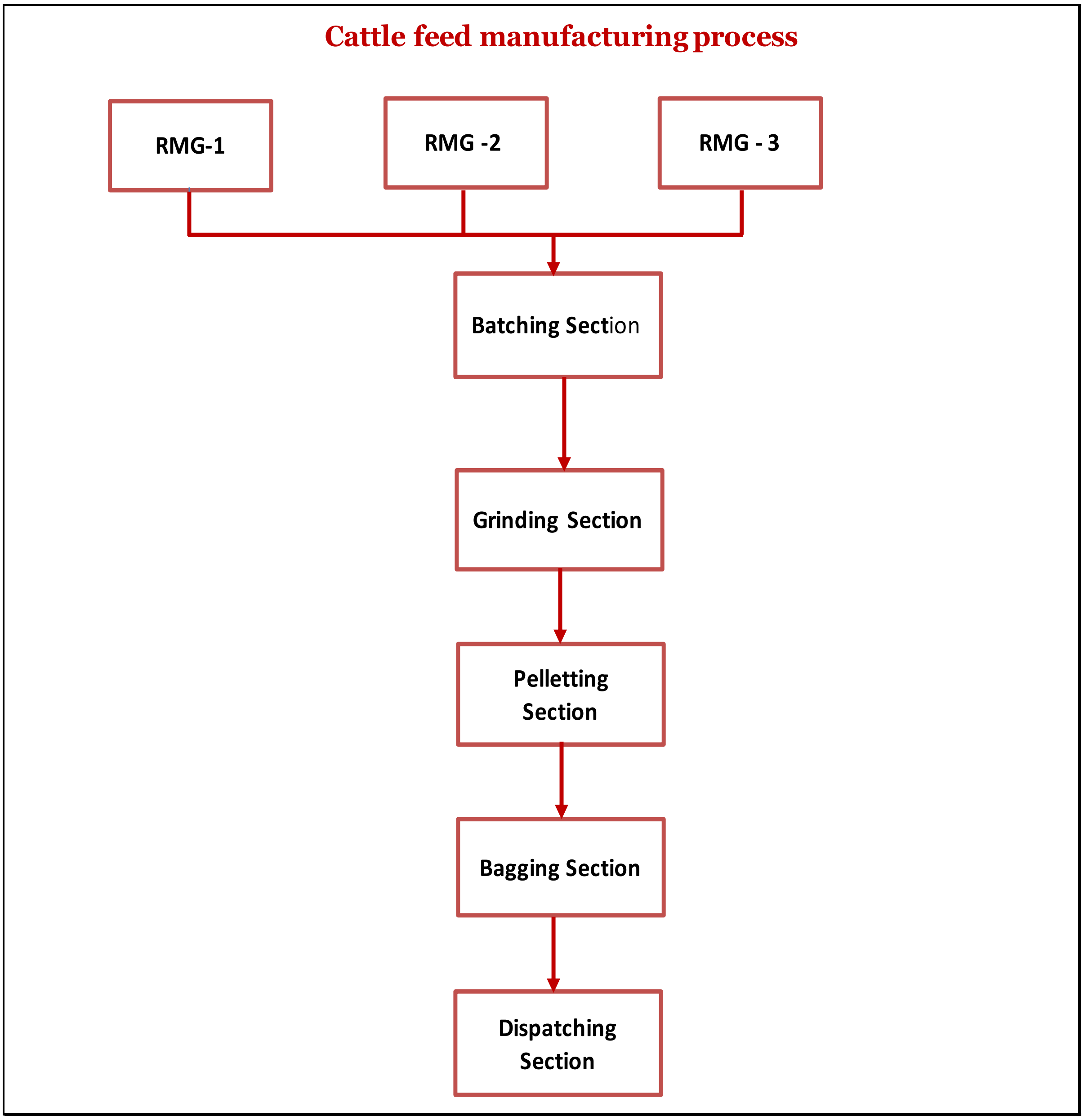
The minimum frequency recorded during this period = 49.6 Hz

The analysis of various power parameters given above indicates that the overall quality of power received by the plant is good and most of the parameters are within the desired range.

3.4 Process equipment

All energy consuming process equipment in the cattle feed plant were studied during the audit. The plant has two production lines having production capacity of 500 TPD each. During normal working days, both lines are operated to meet the requirements. The detailed process flow diagram for the cattle feed manufacturing is as follows.

Figure 18: Manufacturing process flow diagram



Cattle feed plant receives the all raw materials from outside through trucks, and stores it in raw material godowns located in the plant. There are there number of godowns namely RMG – 1, 2 and 3. Where there are separate silos are provided for each type of raw material. After storing it in the RMG there is a process called Batching. In batching different raw materials are mixed in a single batching silo according to the requirement of final feed quality. After mixing the raw material from batching silo, the mixed raw product will be taken to plant in any one line out of two (There are two line installed in the plant each having capacity of 500 TPD) and actual cattle feed making process starts from here.

Grinding, Mixing and pelleting: Raw material is first grinded in the grinder to get the uniform mix and required size. After grinding it is then sent to the Mixer, where the material is mixed again to get the uniform mixing and after this, raw material/product is forwarded to pelleting section, where steam is used to make the pellets of required sizes.

After the pelleting the cattle feed will be ready to feed cattle's, it is then packed in the packing section. After packing it is stored in the storage before dispatching.

Line -1:

Line -1 is having the production capacity of 500TPD, and for most of the time; this line works on full load. Major process equipments in this line are mentioned below.

- Hammer Mill
- Mixer
- Conditioner 1 & 2
- Palette
- Cooler blowers

Each of the above-mentioned equipments were studied during the energy audit to identify energy saving opportunities. The measured parameters and its analysis has been presented below.

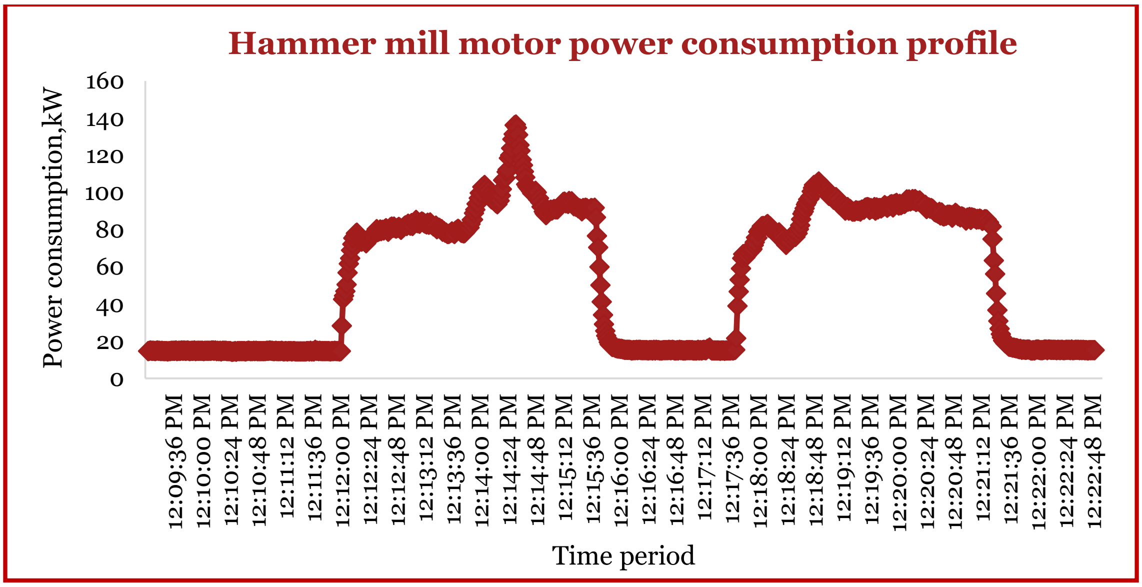
Hammer Mill:

Hammer mill is a major energy consuming equipment in whole production line and actual cattle feed manufacturing process starts from Hammer mill. Hammer mill grinds the raw material mixed and kept in batch silos. The measured parameters and its analysis have been presented below.

Mill Capacity	=	2.5 TPH
Running load during measurement	=	80%
Batch time	=	210 sec
Grinding temperature	=	41 ^{o}C

Power consumption profile recorded during energy audit for hammer mill motor is as follows.

Figure 19: Line -1 hammer mill motor power consumption profile

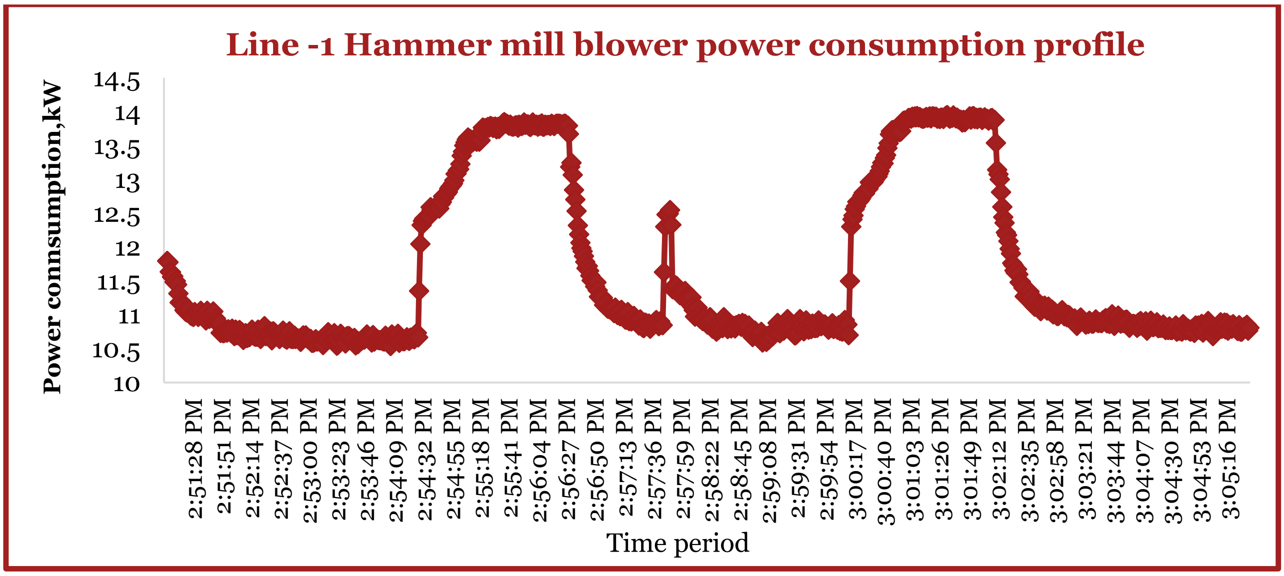


Rated capacity of the motor	=	255 kW
Actual power consumption during loading	=	100 - 140 kW @0.9 pf
Idle time power consumption	=	14 kW @ 0.11 pf
Average loading time in one batch	=	210 sec
Average idle time between the batch	=	90 sec

Hammer Mill blower:

Hammer mill blower has been installed to extract dust from hammer mill during operation. Two blowers have been installed, of which, one blower runs to meet the requirement and other blower is kept as standby. The power consumption measured at the blower is as follows

Figure 20: Line -1 hammer mill blower power consumption profile



Rated capacity of the blower	=	15 kW

Actual power consumption during loading	=	14 kW
Actual power consumption during unload	=	10.5 kW
VFD frequency	=	50 Hz always

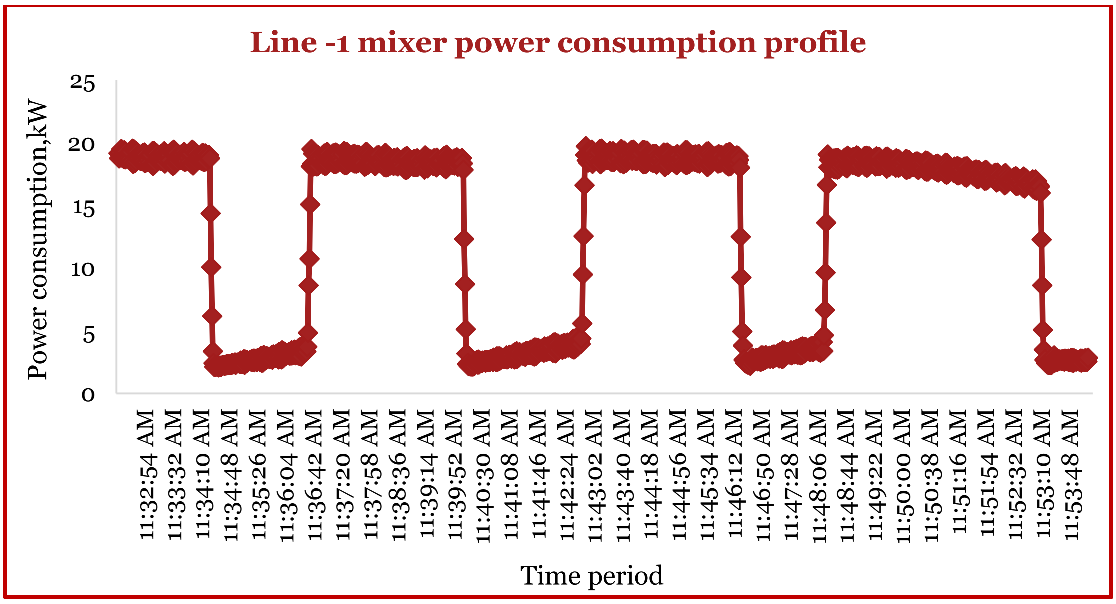
Mixer Motor:

Raw material processed in the hammer mill is then taken to mixer for mixing, where the product is further mixed to get uniform mixing of all raw materials. The parameters measured and analysis done on this mixer are presented below.

Mill Capacity	=	2.5 TPH
Running load during measurement	=	100 %
Batch time	=	210 sec

Power consumption profile recorded during the audit time for mixer motor is as follows.

Figure 21: Line -1 mixer motor power consumption profile

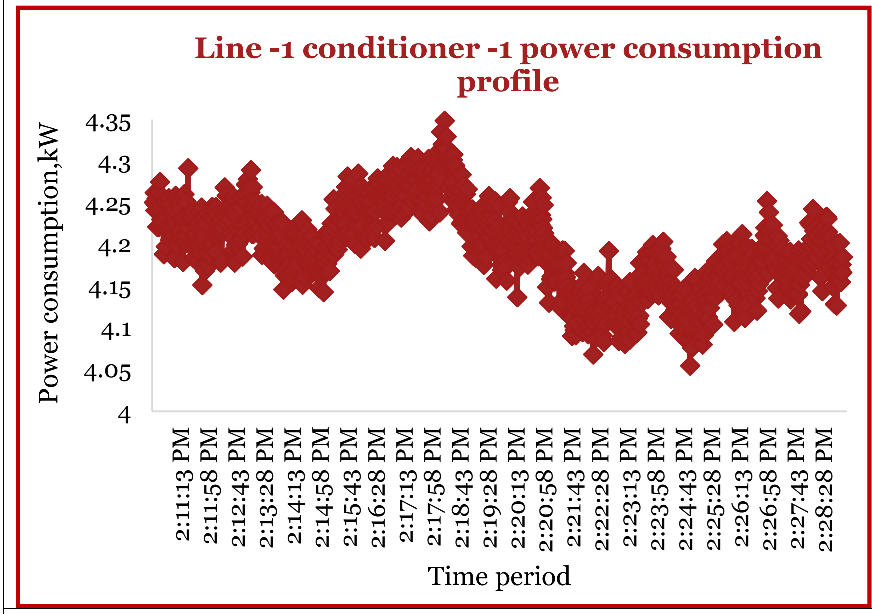


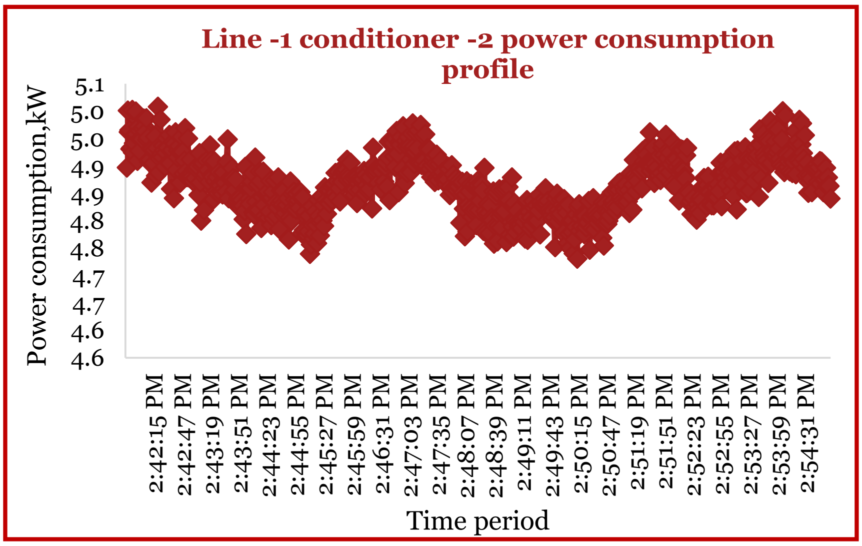
Rated capacity of the motor	=	55 kW
Actual power consumption during loading	=	20 kW @0.9 pf
Idle time power consumption	=	3.2 kW @ 0.2 pf
Average loading time in one batch	=	210 sec
Average idle time between the batch	=	180 sec

Conditioners:

Product mixed in the mixer is then sent to the conditioner, where steam is used as conditioner to condition the product. Conditioner is the only system that uses steam in the plant. Steam used in the conditioner is at 2.5 -3 kg/cm^2 pressure. The power consumption measurement done on the conditioner motor is presented next.

Figure 22: Line -1 - Conditioner power consumption profile

<table>
<tr><th>Power profile</th><th>Observations</th></tr>
<tr><td>
</td><td>Rated power consumption = 22.5kW

Actual power consumption = 4.1 to 4.3 kW</td></tr>
<tr><td>
</td><td>Rated power consumption = 22.5kW

Actual power consumption = 4.1 to 5.0 kW</td></tr>
</table>

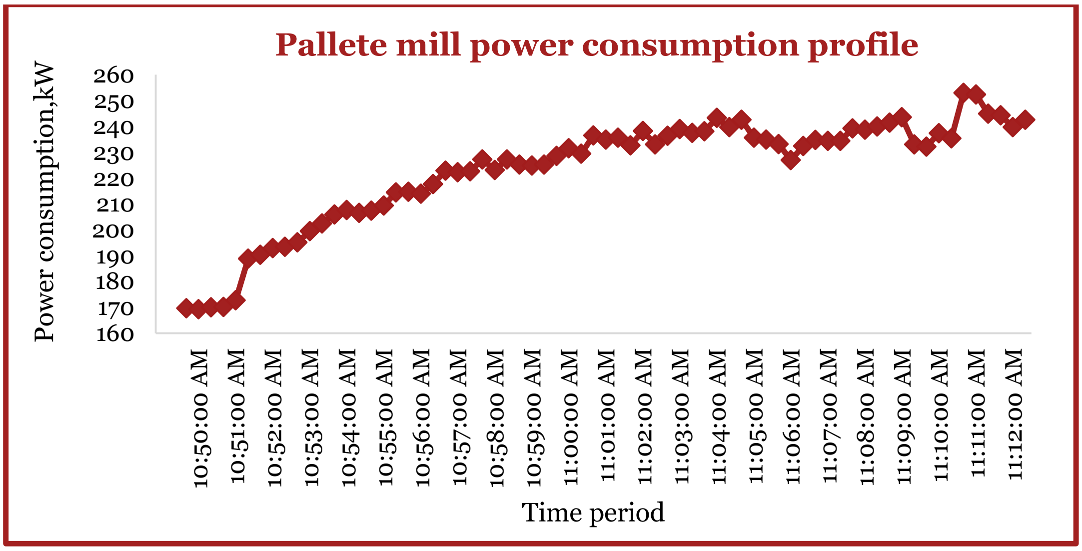
Pellette Mill:

The conditioned product from conditioners is converted to pellettes in this mill to prepare final cattle feed product. The parameters measured and the analysis done on the Pellette mill is presented next.

Rated capacity of the Mill	=	25TPH
Actual running load	=	16.3 TPH

Power consumption measurement done on the Pellette mill motor is as follows.

Figure 23: Line -1 Pellette mill power consumption profile

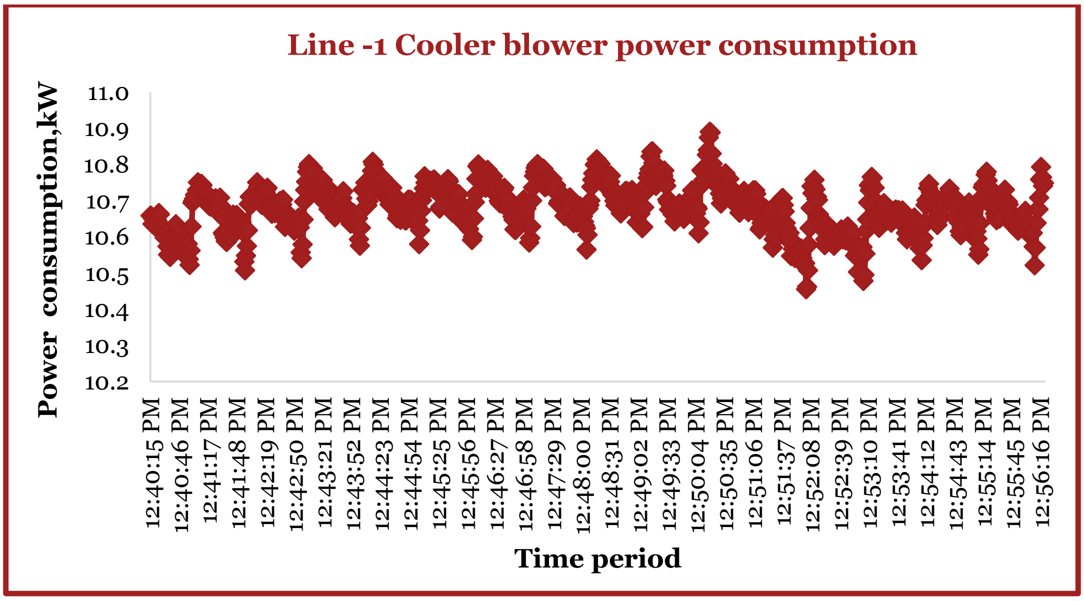


Rated capacity of the motor	=	320 kW
Actual power consumption	=	225 kW

Cooler blower:

Power consumption measurement done on the cyclone cooler blower is as follows

Figure 24: Line -1 Cooler blower power consumption profile



Rated power consumption	=	75 kW
Actual power consumption	=	10.9 kW
VFD frequency	=	25 Hz

Line -2:

Line -2 is having the production capacity of 500 TPD, and for most of the time; this line works on full load. Major process equipments in this line are mentioned below.

- Hammer Mill
- Mixer
- Conditioner 1 & 2
- Palette
- Cooler blowers

Each of the above-mentioned equipment was studied during the energy audit to identify energy saving opportunity. The measured parameters and its analysis has been presented below.

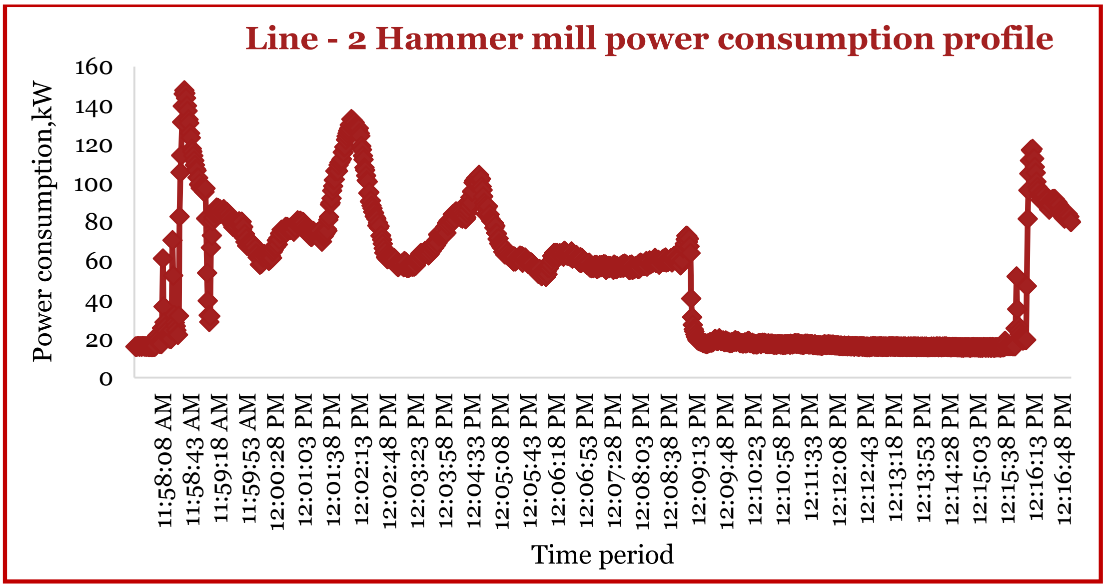
Hammer Mill:

Hammer mill is a major energy consuming equipment in whole production line and actual cattle feed manufacturing process starts from Hammer mill. Hammer mill grinds the raw material mixed and kept in batch silos. The measured parameters and its analysis has been presented below.

Mill Capacity	=	2.5 TPH
Running load during measurement	=	70%
Batch time	=	210 sec
Grinding temperature	=	44 °C

Power consumption profile recorded during the audit time for hammer mill motor is presented below.

Figure 25: Line -2 hammer mill power consumption profile

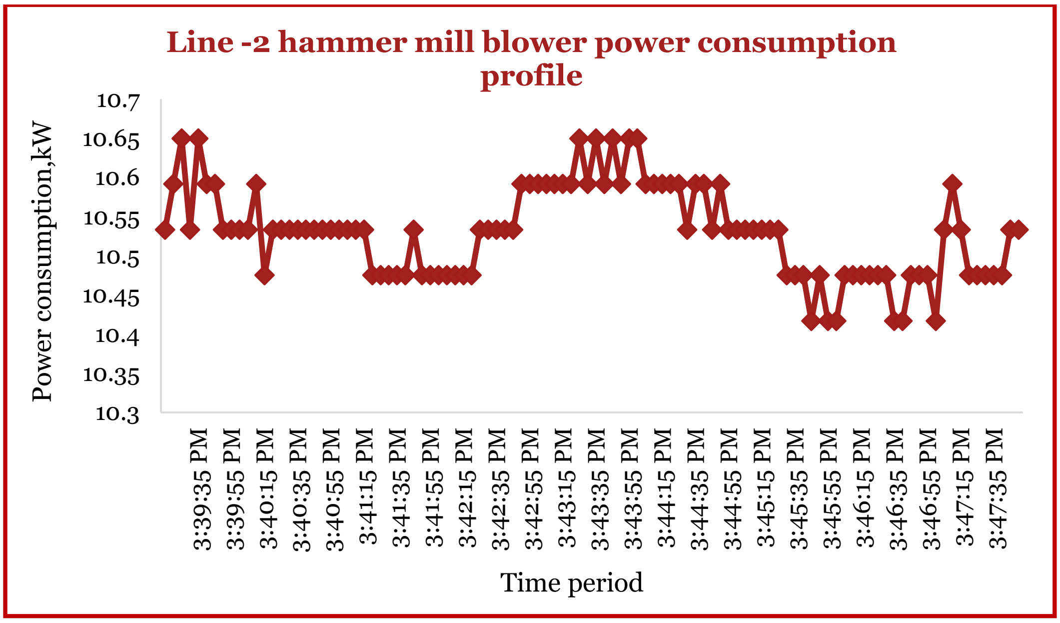


Rated capacity of the motor	=	255 kW
Actual power consumption during loading	=	150 kW @0.9 PF
Idle time power consumption	=	16 kW @ 0.11 PF
Average loading time in one batch	=	210 sec

Hammer Mill blower:

Hammer mill blower has been installed to extract dust from hammer mill during operation. Two blowers have been installed, of which, one blower runs to meet the requirement and other blower is kept as standby. The power consumption measured at the blower is as follows.

Figure 26: Line -2 hammer mill blower power consumption profile



Rated capacity of the blower	=	15 kW
Actual power consumption during loading	=	10.5 kW
VFD frequency	=	50 Hz always

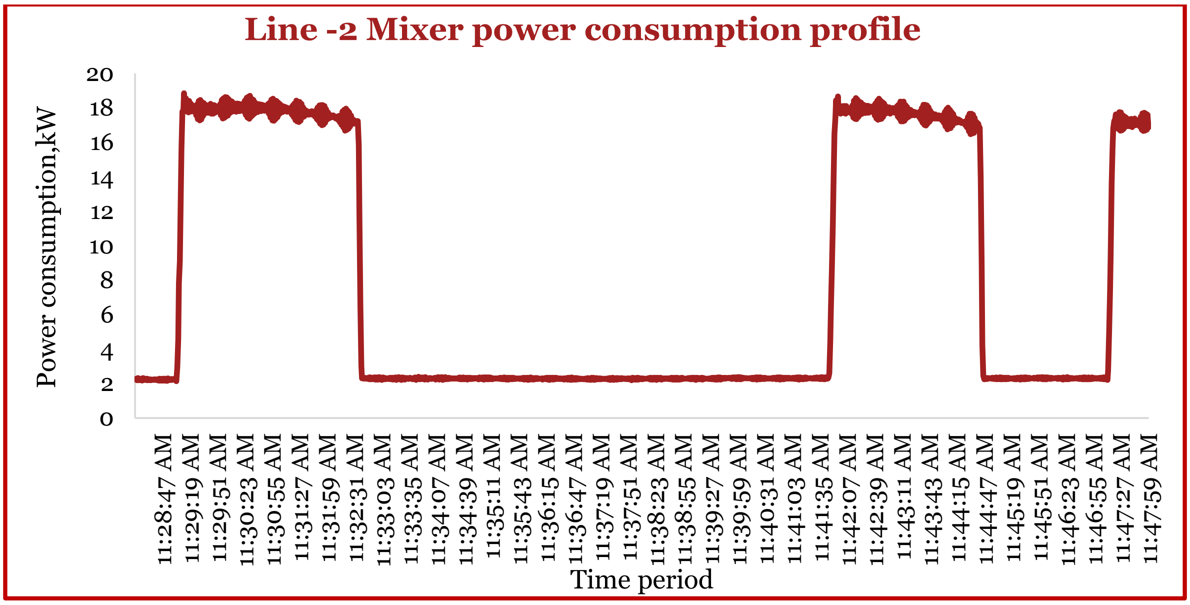
Mixer Motor:

Raw material processed in the hammer mill is then taken to mixer for mixing, where the product is further mixed to get uniform mixing of all raw materials. The parameters measured and analysis done on this mixer is presented below.

Mill Capacity	=	2.5 TPH
Running load during measurement	=	100%
Batch time	=	210 sec

Power consumption profile recorded during the audit time for hammer mill motor is as follows.

Figure 27: Line -2 mixer power consumption profile

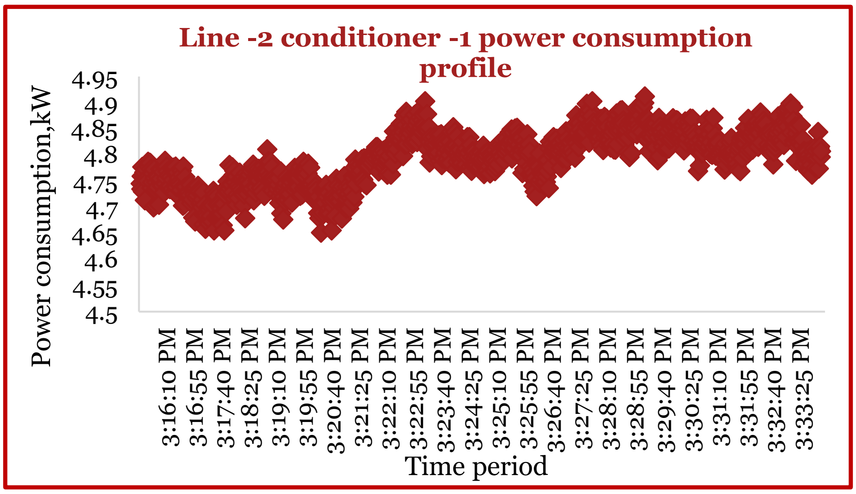


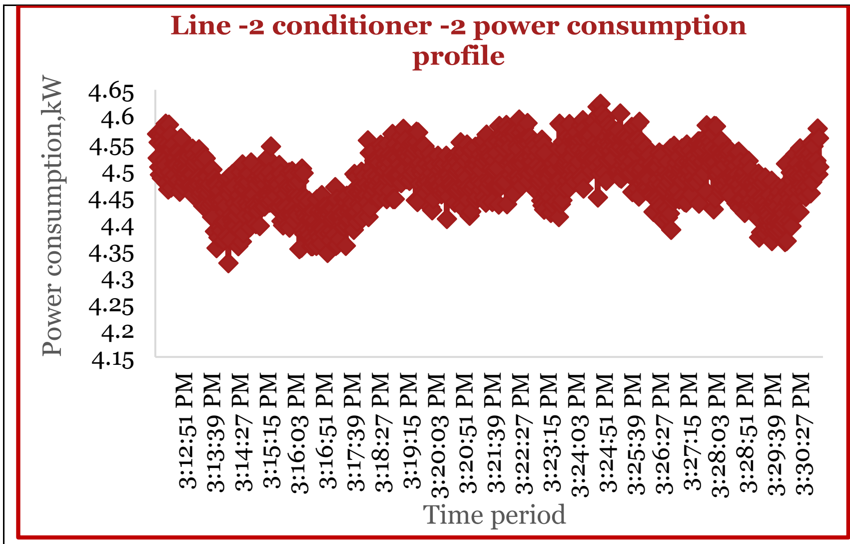
Rated capacity of the motor	=	55 kW
Actual power consumption during loading	=	19 kW @0.9 pf
Idle time power consumption	=	2.2 kW @ 0.2 pf
Average loading time in one batch	=	210 sec
Average idle time between the batch	=	180 sec

Conditioners:

Product mixed in the mixer is then sent to the conditioner where steam is used to condition the product. Conditioner is the only system that uses steam in the plant. Steam used in the conditioner at 2.5 -3 kg/cm² pressure, power consumption measurement done on the conditioner motor is as follows.

Figure 28: Line -2 Conditioner power consumption profile

Power profile	Observations
	Rated power consumption = 22.5kW Actual power consumption = 4.65 to 4.90 kW

	Rated power consumption = 22.5kW Actual power consumption = 4.35 to 4.6 kW

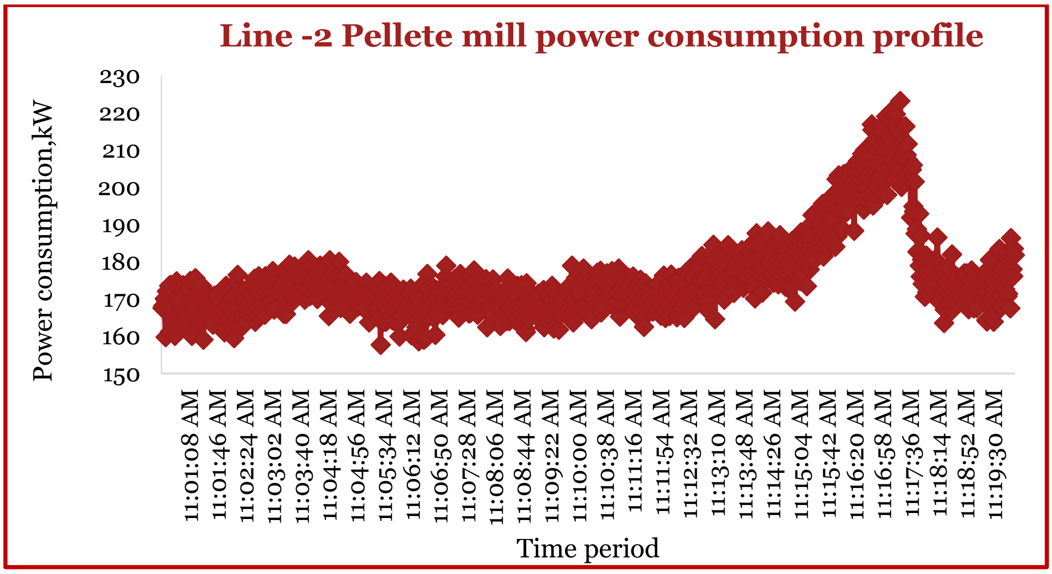
Pellette Mill:

The conditioned product from conditioners is converted to Pellettes in this mill to prepare final cattle feed product. The parameters measured and the analysis done on the Pellette mill is presented next.

Rated capacity of the Mill	=	25TPH
Actual running load	=	15.5 TPH

Power consumption measurement done on the Pellette mill motor is as follows.

Figure 29: Line -2 Pellette mill power consumption profile

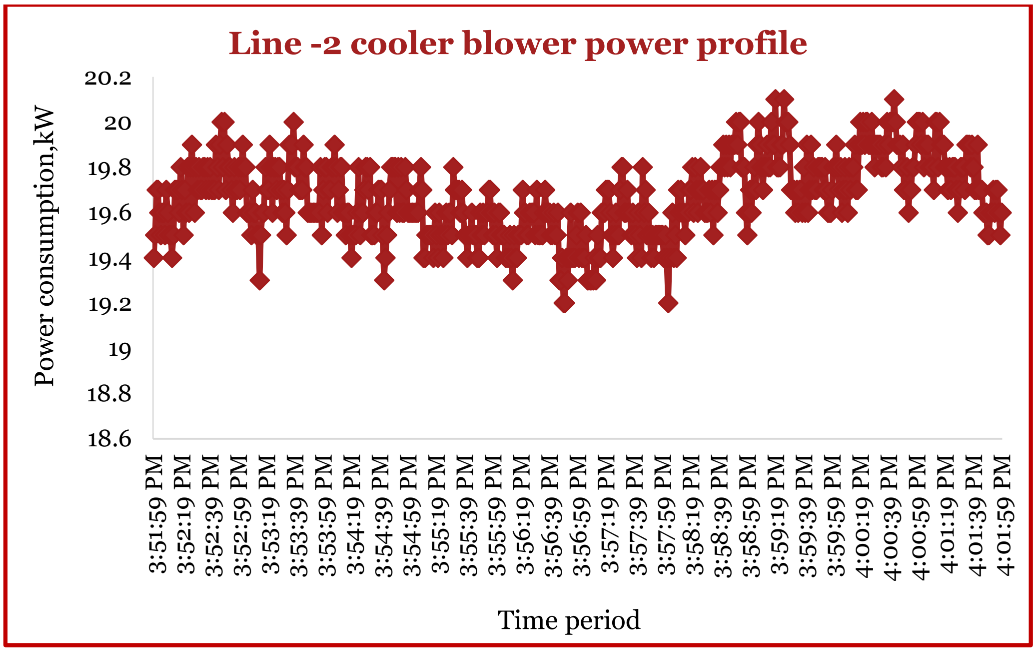


Rated capacity of the motor	=	320 kW
Average power consumption	=	180 kW
Peak power consumption	=	220 kW

Cooler blower:

Power consumption measurement done on the cooler blower is as follows

Figure 30: Line -2 cooler blower power consumption profile



Rated power consumption	=	75 kW
Actual power consumption	=	10.6 kW
VFD frequency	=	25 Hz

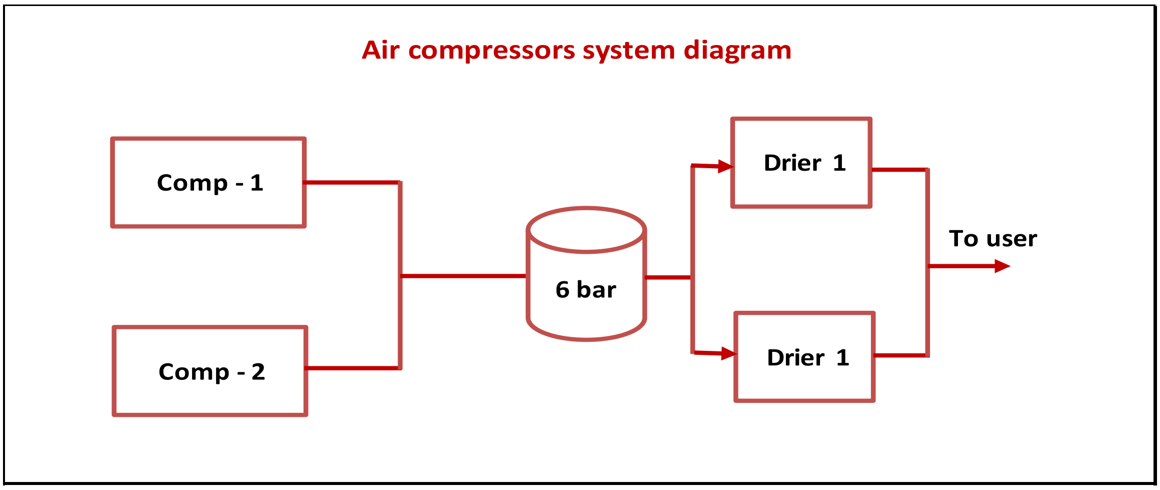
3.5 *Air compressors*

Two screw-type air compressors (both fitted with VFD) are installed in the plant to cater to compressed air requirement of entire plant. Usually, one compressor runs out of two to meet the plant's compressed air requirement and other compressor is standby.

The design details of the compressors are as follows.

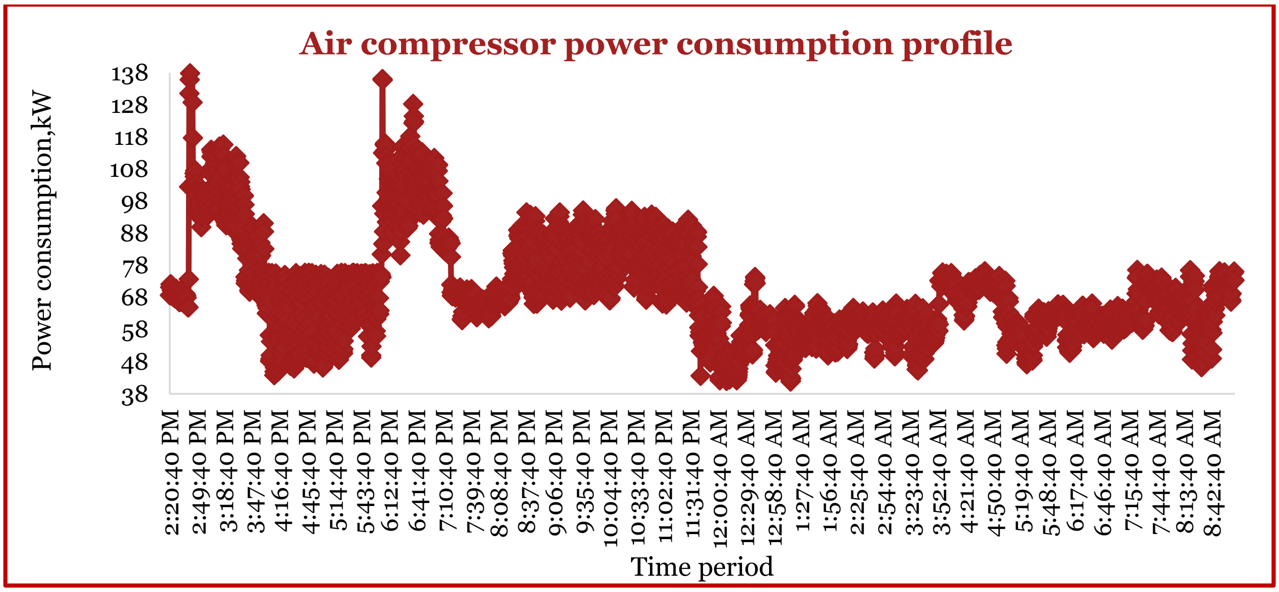
Make	=	Atlas Copco
Type	=	ZT55 VSD (Oil free compressor)
Maximum Pressure	=	8.6 kg/cm^2
Flow	=	309 cfm
Power consumption	=	55 kW

Figure 31: Plant air - compressor system diagram



Power consumption profile was measured at compressor motor during energy audit. The same has been presented below.

Figure 32: Air compressor power consumption profile



Note: Power consumption profile given in above figure includes drier power consumption as well.

Actual parameters measured at compressor

Running hours of compressor	=	16,943 Hours
Loaded hours	=	16,773 Hours
Set point-1	=	7 kg/cm²
Level -1	=	7.1 kg/cm²
Level -2	=	8 kg/cm²
Air pressure measured at receiver	=	6.5 kg/cm²
Power consumption during one compressor operation	=	55 kW

Power consumption during two compressor operation	=	108 kW
Loading percentage	=	100 %
Unloading percentage	=	0 %

Compressors are installed with VFD and running with lesser speed compared to rated. There is no unloading and compresses air pressure at user and generation end is found to be matching each other.

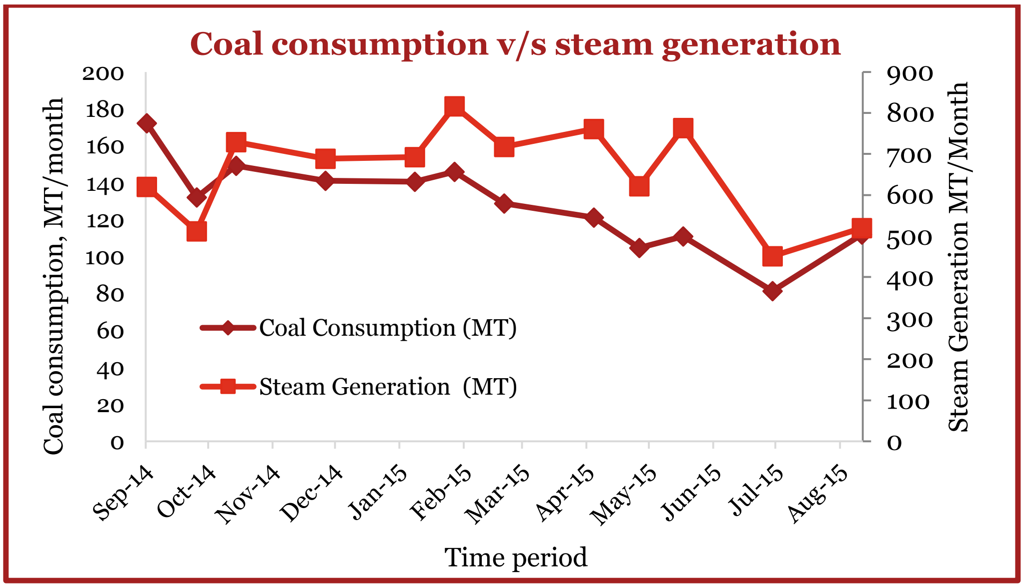
3.6 Boiler and steam distribution

The plant is installed with two boilers of 4TPH capacity each. Of which one boiler operates during working hours to meet the steam requirement of the plant and other boiler is kept as standby. Boiler uses coal as fuel to generate steam. Coal consumption and steam generated in the boiler for last one year is tabulated below.

Table 8 : Boiler steam generation and coal consumption details

Month	Coal consumption (MT/month)	Steam generation (MT/month)	Production (MT/month)
September-14	172	511	17,087
October-14	132	729	17,239
November-14	149	688	18,673
December-14	141	692	18,921
January-15	141	816	21,012
February-15	146	717	20,371
March-15	129	761	19,283
Apr-15	121	621	20,227
May-15	105	763	19,310
June-15	111	450	18,944
July-15	81	519	16,047
August-15	115	657.3	21,601
Average	**129**	**660**	**19,060**
Total	**1,543**	**7,924**	**228,715**

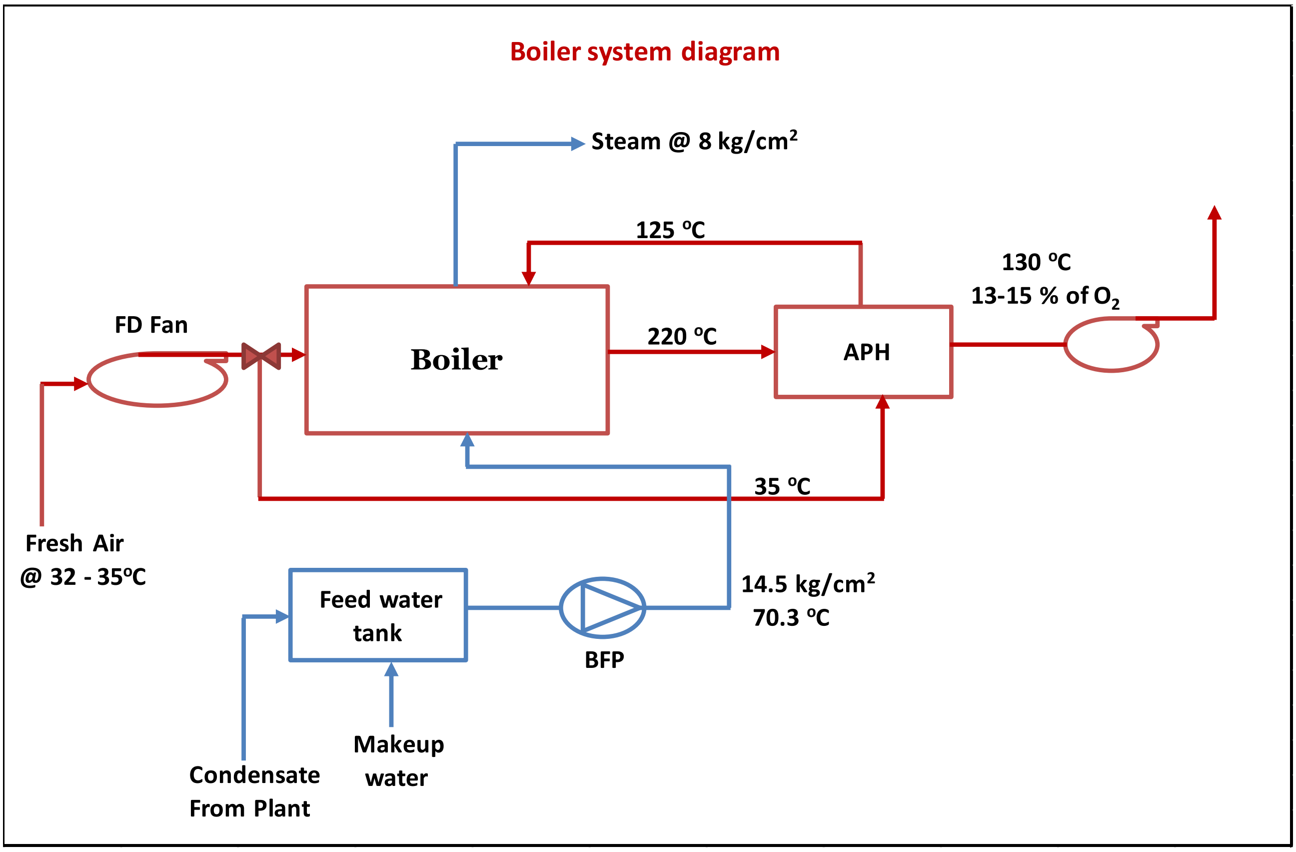
Figure 33: Boiler coal consumption and steam generation profile



- Annual coal consumption in the boiler from September 2014 to August 2015 was.1,543 MT with steam generation of 7,924 MT and during same time the production was at 228,715 MT.
- The average coal consumption in the boiler is 129 MT/month with average steam generation of 660 MT/month.

Boiler system diagram is as follows.

Figure 34: Boiler system diagram



Design details of the boiler and auxiliary equipment is as follows.

Boiler make	=	Thermax
Boiler capacity	=	4 TPH
Design pressure	=	10 kg/cm²
APH inlet flue gas temperature	=	260 – 280 °C
APH outlet flue gas temperature	=	160 – 180 °C
FD fan inlet temperature to APH	=	35 °C
Feed water outlet temperature from APH	=	140 °C
Furnace temperature (High)	=	850 °C
Furnace temperature (Low)	=	450 - 550 °C

Feed water specifications

TH	=	5 ppm (Max)

PH = 8.5 – 9.5 Max

TDS = 400 Max

Boiler water specification

TH = 5 ppm (Max)

PH = 10.54 to 11

TDS = < 3,500

Blow down vessel

Design pressure = 3.5 kg/cm^2

Temperature = 175 °C

Test pressure = 5.25 kg/cm^2

Actual parameters measured

Actual steam generation (During measurement) = 1.5 TPH

Furnace temperature = 605 °C

Furnace pressure = -2 mmWc

Flue gas temperature at the boiler outlet = 220 °C

Flue gas temperature at APH outlet = 130 °C

Oxygen at the flue gas outlet = 13 -15 %

APH outlet fresh air temperature = 126 °C

FD fan inlet fresh air temperature = 35 °C

Steam pressure at the main header = 8 kg/cm^2

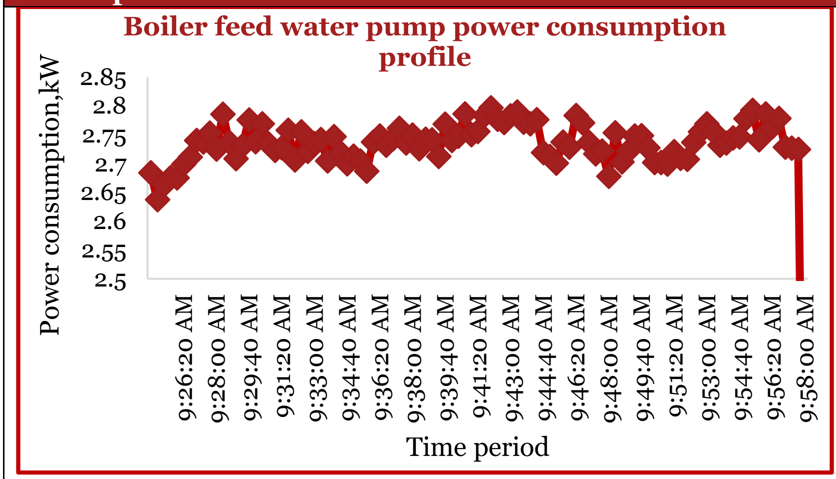
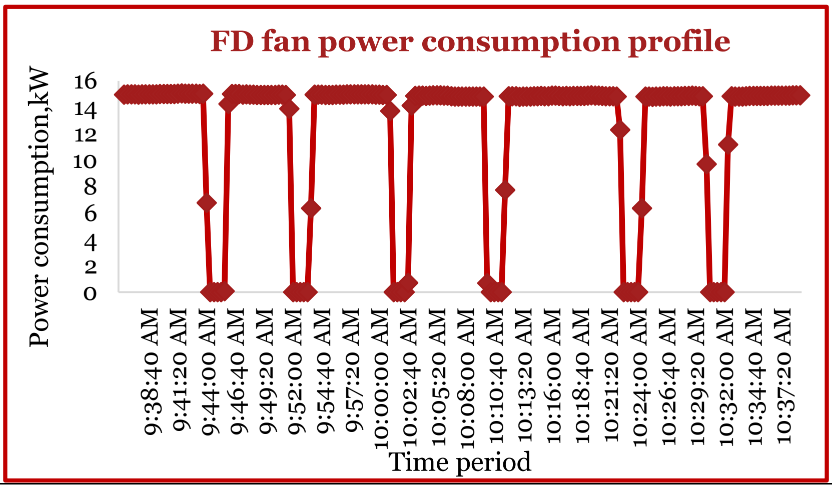
BFP out let water temperature = 70 °C

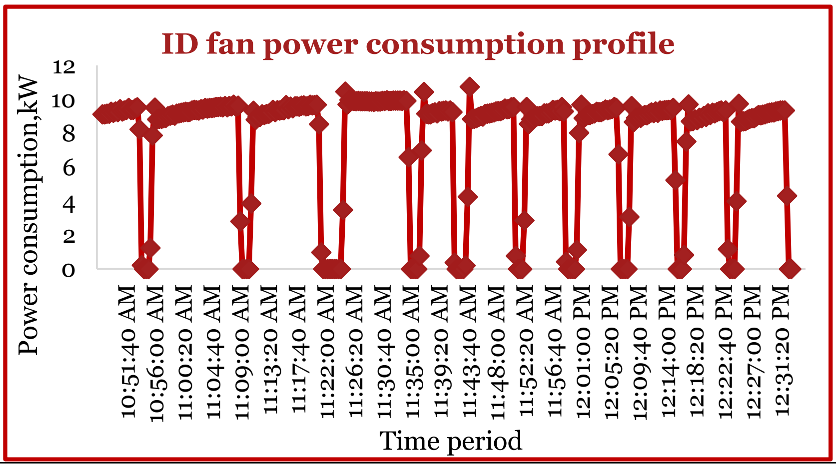
BFP discharge pressure = 14 kg/cm^2

Power consumption profile recorded at the BFP, FD and ID fan is as follows.

Figure 35: Boiler utilities power consumption profile

Power profile	Observations
	Rated power consumption of the pump= 3.7 kW Actual power consumption = 2.75 kW

<table>
<tr><th>Power profile</th><th>Observations</th></tr>
<tr><td>
</td><td></td></tr>
<tr><td>
</td><td>Rated power consumption of the pump= 22.5 kW

Actual power consumption = 15.5 kW</td></tr>
<tr><td>
</td><td>Actual power consumption = 10.5 kW</td></tr>
</table>

Boiler feed water pump:

There are two boiler feed water pumps installed in the boiler for pumping feed water to the boiler, these are multistage pumps and one pump will be working out of two to meet the water requirement. The design and operating details of the BFP is as follows.

Design details

Make = Grundfos

Model	=	CR 5-22
Speed	=	2,917 rpm
Flow rate	=	5.8 m^3/h
Pressure	=	115.3 m
Frequency	=	50 Hz
Power consumption	=	3.7 kW

Operating parameters

Flow rate	=	2.04 m^3/h
Head developed	=	14 kg/cm^2
Power consumption	=	3.3 kW

FD Fan

Design details

Make	=	Uni max
Model	=	BCA
Speed	=	2,910 rpm
Frequency	=	50 Hz
Power consumption	=	30 hp

Operating parameters

Suction side throttle	=	50%
Discharge pressure	=	400 mmWc
Power consumption	=	17.5 kW

3.6.1 Steam traps, Insulation and leakage:

Detailed study is done on the steam traps, steam insulation and steam leakage in the plant during the audit, same is discussed below.

Steam traps: Plant is installed with inverted bucket type of steam traps in most of the places in steam distribution network. Detailed physical inspection survey on sample basis is done on the steam traps in plant and it is found that, steam traps are working fine and there was no leakage is observed from it.

Insulation study: Detailed study is done on the steam insulation by physical inspection and temperature measurement of steam pipeline and it is found that steam insulation was proper and there was no insulation breakage is observed during the study.

Steam Leakage: There was no steam leakage in the plant through live steam lines, steam traps or some other equipment in the plant.

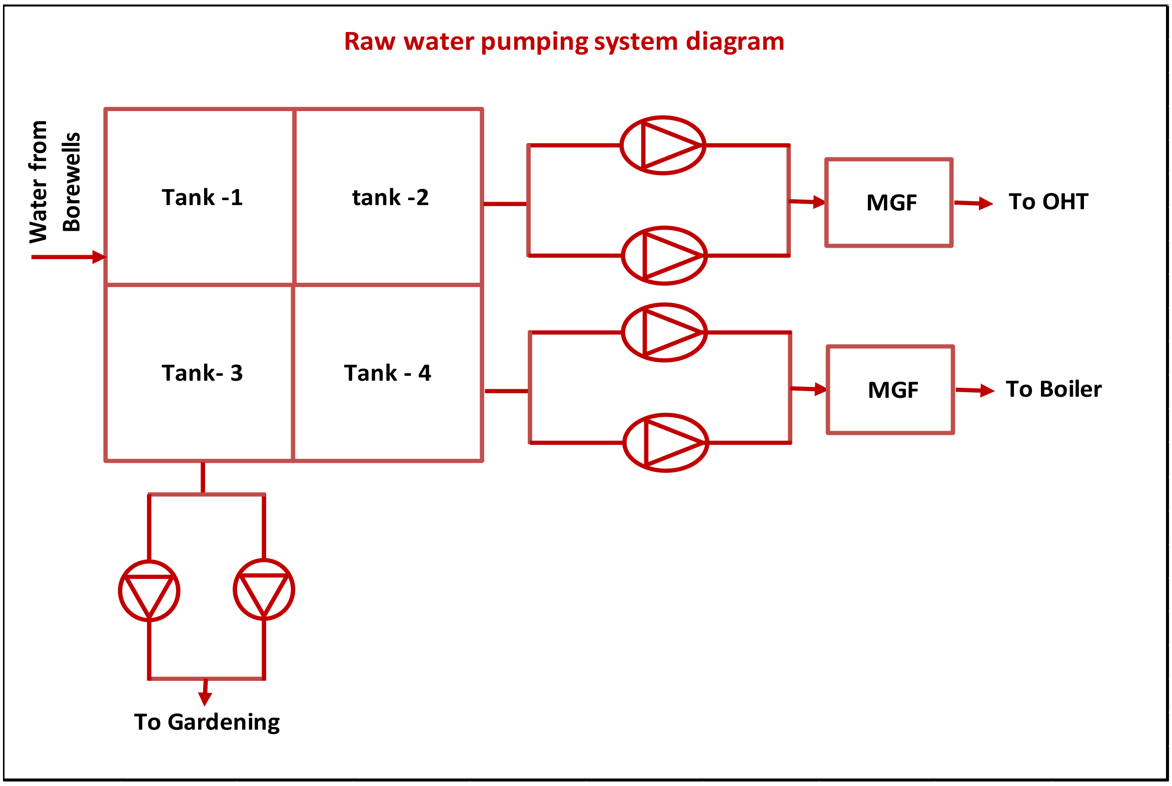
3.7 Raw water pumping system

Raw water pumping system is installed in plant to pump water for all plant users. Plant is getting water from bore wells drilled at different locations within the plant campus. There are three set of pumps installed for pumping raw water to raw water tank from where the water is pumped for different applications in the plant. The related details are mentioned below.

1. One set of pump is used for pumping water to OHT which is used for drinking water, toilets and washing usage
2. Second set of pump is used for pumping water to boiler feed water tank for boiler makeup
3. Third set of pump is used for pumping water for plant gardening purpose

Raw water pumping system diagram is shown below for reference.

Figure 36: Raw water pumping system diagram



The design and operating parameters of the pumps are as follows.

Boiler pumps:

<u>Design details</u>

Make	:	Grundfos
Model	:	CR – 20/03
Speed	:	2,917 rpm
Flow delivered	:	21 m^3/h
Head developed	:	34 m

Power consumption	:	4 kW

Actual parameters:

Actual head developed	=	35 m
Flow delivered	=	15 m^3/h
Power consumption	=	3.1 kW
Pump efficiency	=	46 %

OHT pumps:

Design details

Make	:	Grundfos
Model	:	CR – 32-03-2
Speed	:	2,919 rpm
Flow delivered	:	30 m^3/h
Head developed	:	38 m
Power consumption	:	5.5 kW

Actual parameters:

Actual head developed	=	40 m
Flow delivered	=	20 m^3/h
Power consumption	=	4.5 kW
Pump efficiency	=	48 %

Gardening pumps:

Design details

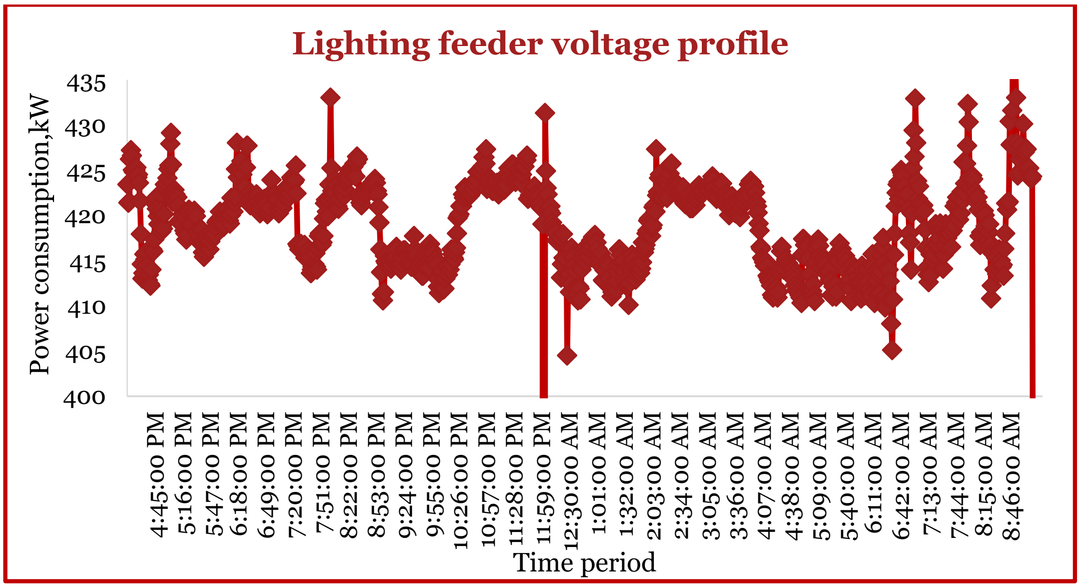
Make	:	Grundfos
Model	:	CR – 10/04
Speed	:	2,890 rpm
Flow delivered	:	10 m^3/h
Head developed	:	31.9 m
Power consumption	:	1.5 kW

3.8 Lighting

Lighting consumes around 2% of the total electricity consumption in the plant. There is a separate feeder installed for the lighting through which power supplied to all the lighting DB's.

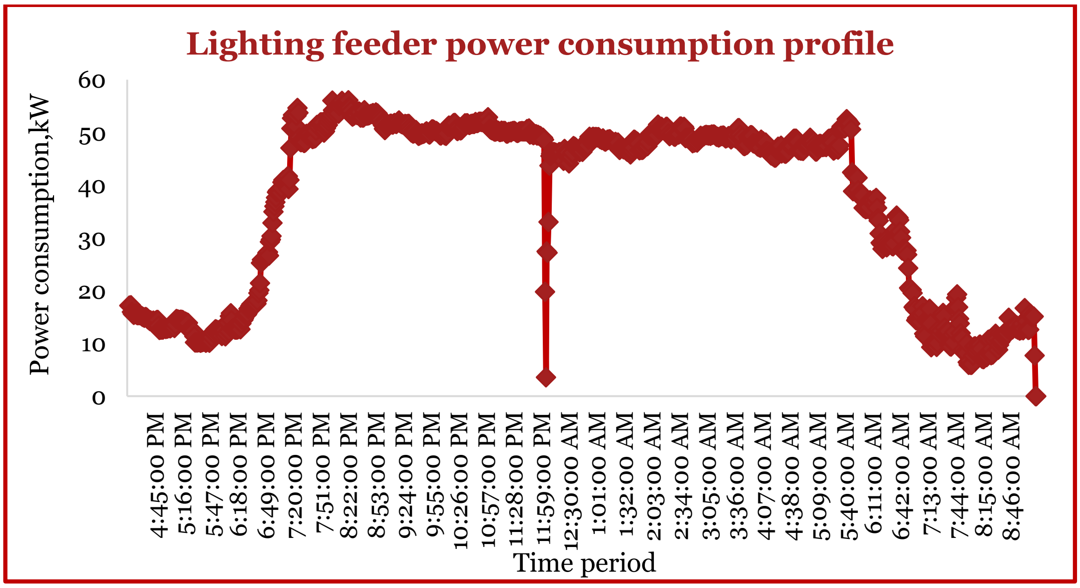
The voltage and power consumption measurement done on the lighting feeder during the energy audit is as follows.

Figure 37: Lighting feeder operating voltage profile



Maximum lighting voltage during the recording period	=	430 Volts
Minimum lighting voltage during the recording period	=	405 Volts
Average lighting voltage during the recording period	=	415 Volts

Figure 38: Lighting feeder power consumption profile



Maximum lighting consumption during the recording period	=	55 kW
Minimum lighting consumption during the recording period	=	8 kW

Average lighting consumption during the recording period = 50 kW

Lighting inventory:

The lighting inventory for the cattle feed plant is tabulated below.

Table 9 : Plant lighting fittings details

Type of lamp	Wattage	Quantity
T-8	1*36	88
T-8	2*36	373
T-5	28	106
CFL	18	54
MH	250	213
MH	500	20

Lux level:

The lighting lux levels measured during the audit at different places of the plant is as follows.

Table 10 : Plant lux level measurement

Area	Lux Measured
Utility area	
Stores	250,245,290,300,275,254
Substation	234,265,276,231,189,190
Compressors room	129,190,184,154
Boilers area	167,190,174,178,190,220,278,229
RMG - 1	124,189,154,190,222,321
RMG - 2	156,190,200,234,290,250
RMG - 3	213,222,290,300,190,186
Process area 8 m	234,290,300,320,290,125
Process area 16 m	231,290,300,178,156,190
Process area 36m	321,219,210,143,145,189,164
Process SCADA room	230,290,300,350
Canteen	234,289,290,300,310
Street light	
Utility area opposite road	123,65,75,89,80,120
Weighbridge opposite road	89,65,120,100,110,143,70,75
Process building front side road	67,90,120,150,125,130

- The lux level measured at the different places of the plant is found to be adequate as per the standards, except few places, where it was less than required.

4 Energy Conservation Measures

4.1 Power distribution

4.1.1 Improve power factor to unity to get maximum rebate from EB

Background

The plant receives power from Gujarat State Electricity Board at 11kV HT line. Two transformers of 1,600 kVA capacity each have been installed in plant to stepdown voltage from 11 KV to 440 Volts. The average power factor maintained at the HT side from last one-year electricity bill is 0.984 lagging. Month wise power factor maintained and incentive received from EB from last one year is tabulated below.

Table 11 : Annual power factor recorded and incentive received month wise

Month	Power factor (PF)	PF Adjustment Charges received (Rs./month)
September-14	0.983	31,786
October-14	0.984	36,329
November-14	0.983	33,988
December-14	0.984	36,567
January-15	0.983	36,885
February-15	0.984	40,029
March-15	0.984	33,793
April-15	0.986	40,888
May-15	0.985	45,789
June-15	0.984	42,471
July-15	0.985	39,103
August-15	0.985	37,598
Average	**0.984**	**37,936**
Total		**4,55,226**

The plant has 430 kVAR APFC panel on LT side of each transformer to maintain power factor. The set power factor at the APFC panel is 0.99 lagging.

Finding

EB is giving a maximum incentive of 2.5% percentage for maintaining unity power factor at the main incomer. However, the plant is maintaining power factor of 0.98 lagging only, even though its's having sufficient capacitor installed at LT side.

Recommendation

Maintain unity PF at the main incomer by

- Shifting power factor sensing CT to HT side from LT side of transformers
- Set unity power factor at the APFC control panel instead of 0.99
- Add smaller rating capacitor to APFC panel such as 5, 10 and 15 kVAR to compensate for smaller reactive power compensation when there is a small change in load

Energy & financial savings

Estimated energy and financial saving for the recommendation with payback period is as follows.

Table 12 : Power factor improvement saving and investment estimation

Description	Units	Parameters
Present operating parameters		
Average power factor maintained	Pf	0.98
Maximum incentive availed from state electricity board	%	1.75
Total power factor incentive amount from last one year	Rs.	4,55,226
Present APFC panel rating	kVAR	430 * 2
Proposed operating parameters		
Proposed power factor at main incomer	**pf**	**Unity**
Total incentive possible for unity power factor	%	2.5
Excess incentive availing possibility by unity PF	**Rs. Lakhs**	**2.66**
Investment required for small rating capacitor	**Rs. Lakhs**	**Negligible**
Payback period	**Months**	**Immediate**

4.2 Boiler and steam distribution

4.2.1 Install back pressure turbine to reduce steam pressure instead of PRV

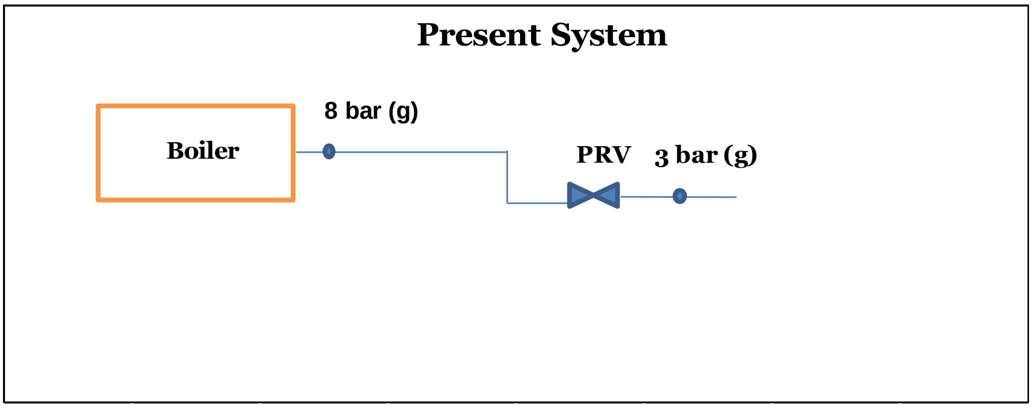
Background

The boiler serves the purpose of steam requirement in the plant and generates steam at a pressure of 8 kg/cm². Steam is used only in conditioner system.

The conditioner system requires LP steam for process, which is at 2.5-3 kg/cm² after PRV. Even though the steam pressure requirement is less than generation, still the plant is supplying steam at 8 kg/cm² and then reducing the pressure by PRV before serving conditioner system.

The present steam distribution system is as follow.

Figure 39: Present steam flow diagram



Finding

Plant is generating the steam at 8 kg/cm² but actual steam pressure required at the conditioner is 3 kg/cm². The plant has installed PRVs to reduce the steam pressure to around 2.5-3 kg/cm² which results in loss of pressure energy in steam.

Recommendation

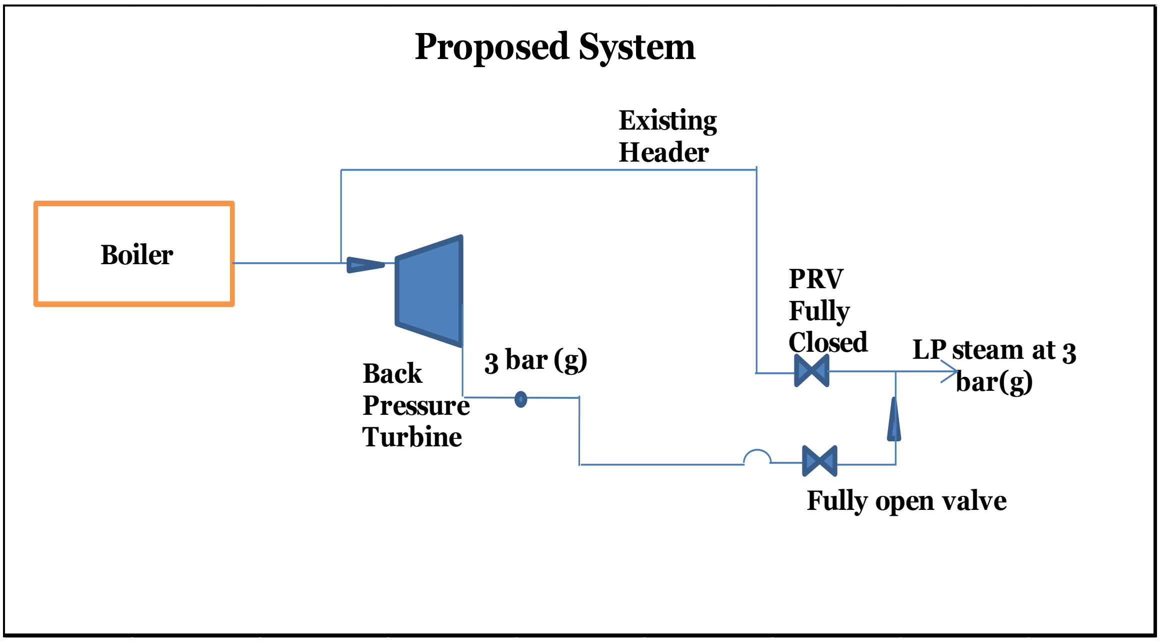
Instead of generating steam at higher pressure of 8 kg /cm² and reducing the pressure by PRV and then using in process, it is better to install a backpressure turbine to main the steam header to supply LP steam to process requirement. In the turbine steam, pressure energy is extracted and converted to electrical energy. There will be enthalpy drop also but it will be very minimal.

It is estimated that minimum possible power generation by the backpressure turbine is 40 kW.

Note: A similar set-up is operating at Sumul Dairy at Surat, Gujarat (India) which is a group company of Amul.

The proposed backpressure turbine and system configuration is as follows.

Figure 40: Proposed backpressure turbine system diagram



Energy & financial savings

Estimated energy and financial saving for the recommendation with payback period is as follows.

Table 13 : Backpressure turbine saving estimation

Description	Units	Parameters
Boiler Steam Pressure	kg/cm²	8
Average steam generation in boiler	kg/h	1,500
Steam pressure required at User end	kg/cm²	3
Saturation temperature of steam at 8 kg/cm²	°C	175
Enthalpy of inlet steam to turbine	kCal/kg	661.93
Enthalpy of outlet steam from turbine (Having dryness fraction of 93%)	kCal/kg	628.01
Enthalpy drop across turbine	kCal/kg	33.92
Efficiency of turbine, gears and alternator	%	75
Quantity of useful heat equivalent of power	kCal/kg	25.44
Specific steam consumption of turbine	kg/kWh	33.81
Estimated power generation	**kW**	**44**
Power generation considered for saving	%	90%
Estimated Power Generation	kW	40
Annual Operating Hours	Hours	7,920
Electrical energy generation	**kWh**	**3,51,427**
Auxiliaries power consumption		
Cooling water required	lpm	80
	m³/h	1.2
Pressure	kg/cm²	2
Power consumption	kW	0.37
Turbine auxiliary consumption	kW	3.5
Compressed air requirement	Nm³/h	20
Power consumption	kWh	2.2
Total Auxiliary power consumption	kWh	6
Annual operating Hours	Hours	7,920
Annual energy consumption	**kWh**	**48,074**
Annual energy generated (Deducting Aux con)	**kWh**	**3,03,353**
Energy cost	Rs./kWh	4.55
Annual cost saved	**Rs. Lakhs**	**14**
Investment required	**Rs. Lakhs**	**15**
Simple Payback period	**Months**	**13**

4.2.2 Arrest continuous steam flow through continuous blowdown line

Background & Finding

Steam generated in boiler is used in conditioner. Small amount of steam is also being used for jacket heating of molasses (molasses is used in the process). After the use of steam in the process, condensate is collected and is pumped back to the boiler feed water tank.

There is a water softening plant in the boiler premise and softening plant pumps soft water to boiler feed water tank as per the tank level.

The plant collects 90% of steam condensate from process, so ideally soft water required to be pumped to boiler is only 10% of steam generation.

Steam generation, coal consumption and soft water added to boiler for each day in one complete sample month is given below.

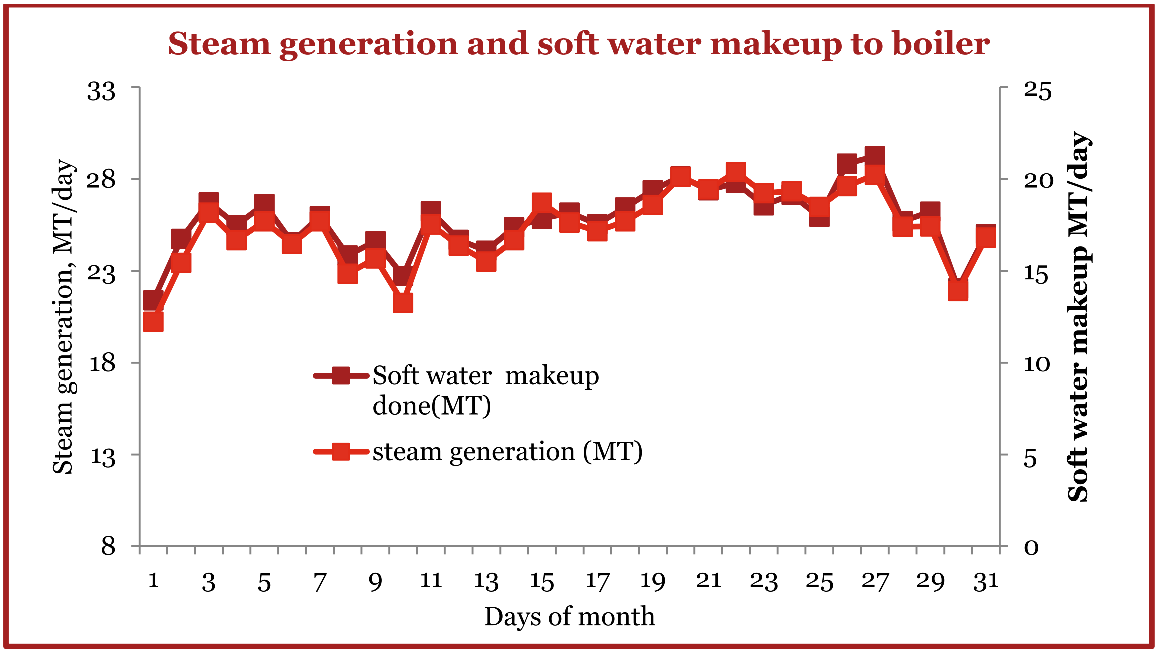
Table 14 : Steam generation and makeup water for every day in a one typical month

Day	Steam generation (MT)	Coal consumption (MT)	Soft water (MT)	Excess soft water pumped to boiler(@90 % condensate recovery (MT)
1	12.22	3.83	21.39	20.16
2	15.44	2.77	24.75	23.20
3	18.18	4.445	26.74	24.92
4	16.68	3.068	25.5	23.83
5	17.7	2.817	26.65	24.88
6	16.46	2.985	24.56	22.91
7	17.7	3.423	25.98	24.21
8	14.84	3.182	23.83	22.34
9	15.68	3.59	24.63	23.06
10	13.25	3.34	22.72	21.39
11	17.53	3.408	26.25	24.49
12	16.38	3.031	24.7	23.06
13	15.5	3.681	24.1	22.55
14	16.68	3.815	25.38	23.71
15	18.72	3.984	25.85	23.97
16	17.63	4.255	26.17	24.40
17	17.16	3.931	25.55	23.83
18	17.71	4.375	26.45	24.67
19	18.59	4.248	27.39	25.53
20	20.13	4.674	28.15	26.13
21	19.45	4.075	27.4	25.45
22	20.38	4.325	27.8	25.76
23	19.23	4.281	26.57	24.64
24	19.35	4.395	27.15	25.21
25	18.48	3.962	25.94	24.09

Day	Steam generation (MT)	Coal consumption (MT)	Soft water (MT)	Excess soft water pumped to boiler(@90 % condensate recovery (MT)
26	19.62	4.21	28.85	26.88
27	20.24	3.945	29.25	27.22
28	17.4	3.47	25.7	23.96
29	17.42	3.23	26.22	24.47
30	13.9	3.217	22.05	20.66
31	16.82	4.52	25	20.16

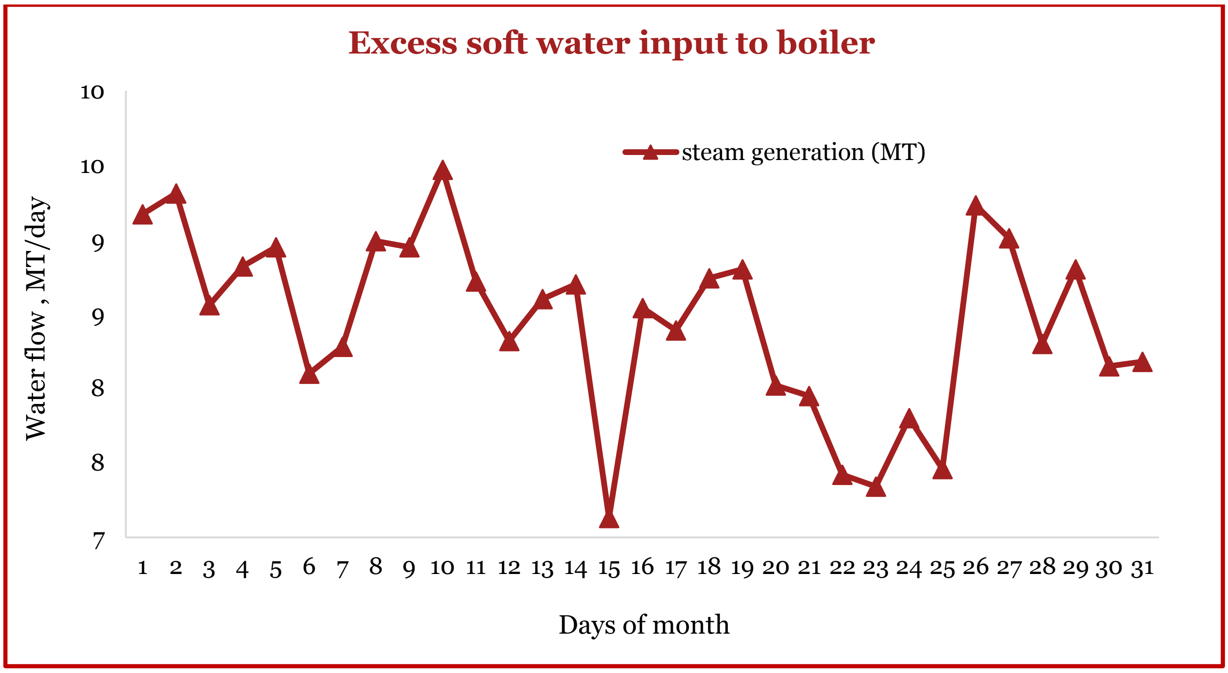
The actual quantity of soft water added to boiler is more than steam generation for every day in a sample month (from above table). This indicates that steam generated is being wasted in some areas.

Figure 41: Boiler steam generation and soft water makeup profile



Allowable TDS level in the boiler is 1500, and feed water is having average TDS of 550. Boiler is fitted with auto TDS sensor, where continuous blow down is taking place. TDS controller is given with the command to open the blowdown valve for TDS more than 1500. During energy audit, it was observed that continuous blow down valve is always open and steam is continuously going out. Since the continuous blowdown valve is open always, steam is going out of boiler to blow down tank the actual feed water flow, and steam generation from boiler is not matching with each other.

Figure 42: Excess soft water input to boiler



The quantity of soft water being wasted in the boiler room through continuous blow down is varying from 20 MT/day to 27 MT/day, which is very high. This much amount of water is getting heated in the boiler and dumped in blowdown tank (There is no heat recovery also from blowdown tank).

Recommendation

Following recommendations are made for addressing continuous blowdown:

- Check soft water flow meter for any error in the readings
- Check TDS controller & TDS range set in controller and continuous blow down valve in the boiler for any malfunction.
- Check steam flow meter for any malfunction.

Note: Plant is already having the advanced system for control and monitor of steam flow through continuous blow down system. The continuous steam flow through this line is happening may be due to malfunctioning of above said meters only. It is recommended to replace/calibrate the same immediately to arrest the steam flow.

Energy & Financial savings

Estimated energy and financial saving for the recommendation with payback period is as follows.

Table 15 : Soft water and steam wastage reduction saving estimation

Description	Units	Parameters
Design capacity of boiler	TPH	4
Steam pressure at boiler	kg/cm²	8
Actual steam generation during measurement period	TPH	2.8
Condensate recovery percentage in plant	%	90
Actual condensate recovered	TPH	2.52

Description	Units	Parameters
Actual makeup water flow measured during the audit	m^3/h	3.5
Actual makeup water flow required	m^3/h	0.28
Excess makeup water flow	m^3/h	3.22
Temperature of steam/hot water measured at blowdown pit	^oC	100
Actual heat loss due to excess blowdown	kCal/h	225,400
Calorific value of coal	kCal/h	4,200
Fuel consumption saved	kg	50
Average operating hours of boiler per day	Hours	24
Average load time of boiler per day	Hours	20
Boiler coal consumption saved per day	kg/day	1,002
Annual operating hours of boiler	Hours	360
Annual coal consumption saved	**kg/annum**	**360,640**
Cost of coal	Rs/kg	3
Annual coal cost saved	**Rs. Lakhs**	**9.73**
Investment	**Rs.**	**Negligible**
Payback period	**Months**	**Immediate**

Note: saving estimated on very conservative side, the actual saving will be more than the saving calculated in above table.

4.2.3 Recover heat from blowdown by installing blow down recovery system

Background

Boiler is equipped with continuous blow down and intermittent blow down to maintain the TDS and pH level of boiler feed water. The TDS level maintained at the different level of water in boiler is as follows.

		TH	pH	TDS
Soft water	=	1ppm	9.80	587
Feed water	=	2ppm	9.60	571
Blowdown	=	1ppm	12.50	1467

Finding

Intermittent blow down is done once in a shift, blow water from boiler is collected in a pit and then sent to ETP and subsequently used for the gardening purpose. There is a considerable amount of heat present in blowdown water which is being wasted.

Recommendation

It is recommended to install blowdown recovery system, to recover the heat from blowdown water and transfer the same to feed water tank. This will further increase the temperature of feed water thereby reduce coal consumption.

Energy & financial savings

Estimated energy and financial saving for the recommendation with payback period is as follows.

Table 16 : Boiler blowdown recovery saving and investment estimation

Boiler Blow Down Heat Recovery		
Description	**Units**	**Parameters**
Boiler pressure	kg/cm²	8
Boiler steam generation	kg/h	1,500
Maximum allowable TDS in boiler	ppm	1,500
Feed water TDS	ppm	571
Blowdown rate	kg/shift	921.96
Amount of energy in each kg of Blowdown	kJ/kg	740.0
Specific enthalpy of water at 0.2 kg/cm²	kJ/kg	440.5
Specific enthalpy of evaporation at 0.2 kg/cm²	kJ/kg	2,242
Percentage of flash steam generated	%	13.36
Rate of flash steam generation	kg/shift	123.16
Equivalent useful energy saved by flash steam generation	kCal/shift	66,059
Calorific value of coal	kCal/kg	4,200
Fuel savings per shift	kg/shift	12.0
Number of shifts per day	Numbers/day	3
Annual operating days	Days	350
Annual fuel savings	**kg**	**12,611**
Cost of coal	Rs/kg	3
Annual cost savings	**Rs. Lakhs**	**0.38**
Investment	**Rs. Lakhs**	**1**
Payback	**Months**	**32**

4.2.4 Install VFD to ID and FD fan to control O2 level and save the fans power consumption

Background

Boiler is equipped with FD fan to supply the fresh air for combustion and ID fan to extract flue gas from boiler. Both fans are provided with the damper control at the suction and discharge side to control the airflow as per the boiler load variation.

Presently, both fans are operating with the 50 % throttling condition at the suction side.

Finding

The average steam generation in the boiler during normal working hours is 1.5 TPH to 2 TPH as against the rated capacity of 4 TPH. It shows that boiler is working at 40 to 50 % load. In order to match the airflow requirement for this load in boiler, plant is controlling the FD and ID fans through dampers.

After controlling the ID and FD fans by dampers, oxygen level measured at the flue gas side is 13 %; it shows that there is 163% excess air present in the flue gas, which is very high.

Recommendation

It is recommended to install VFD with header pressure feedback control system to ID and FD fans and adjust VFD frequency as per boiler load and oxygen level at the flue gas. The oxygen percentage in the flue gas at the outlet of the boiler should be near to 3 %.

Energy & financial savings

Estimated energy and financial saving for the recommendation with payback period is as follows.

Table 17 : VFD for ID and FD fan saving and investment estimation

Description	Units	Parameters
Design details		
FD fan		
Make		Uni max
Model		BCA
Speed	rpm	2,910
Frequency	Hz	50
Rated power consumption	kW	22.5
ID Fans		
Rated power consumption	kW	18.5
Operating parameters		
Percentage of damper open for FD fan at the suction side	%	50
Percentage of damper open for FD fan at the dis charge side	%	100
Percentage of damper open for ID fan at the suction side	%	50
Percentage of damper open for ID fan at the dis charge side	%	100
Actual power consumption of ID fan	kW	14
Actual power consumption of FD fan	kW	17.5
Proposed parameters		
Percentage of damper open for FD fan at the suction side	%	100
Percentage of damper open for FD fan at the dis charge side	%	100
Percentage of damper open for ID fan at the suction side	%	100
Percentage of damper open for ID fan at the dis charge side	%	100
Expected energy consumption saving by VFD in FD fan	%	15
Expected energy consumption saving by VFD in ID fan	%	15
Expected power consumption saving in FD fan	kW	2.625
Expected power consumption saving in ID fan	kW	2.1
Total power consumption saving	kW	4.725
Annual operating hours	Hours	8,400
Annual energy consumption saving	**kWh**	**39,690**

Description	Units	Parameters
Power cost	Rs/kWh	4.55
Annual cost saved	**Rs. Lakhs**	**1.80**
Investment required for VFD	**Rs. Lakhs**	**3.28**
Payback period	**Months**	**22**

Note: Since there was no provision to measure the pressure drop across the dampers of ID and FD fans, savings given in the above table are calculated based on percentage of saving expected, so power consumption savings given above is indicative only.

Installing VFD on FD and ID fans will not only save electricity consumption of both fans but will also save coal consumption in boiler by controlling O_2 percentage in the flue gas.

4.2.5 Reduce the number of stages in the BFP to save pump power consumption

Background

Boiler is fitted with feed water pump to pump water to boiler at required pressure and flow rate, there are two pumps installed out of which one pump will be working to meet the requirement. The design details of the boiler are as follows.

Design details

Make = Grundfos
Model = CR 5-22
Speed = 2,917 rpm
Flow rate = 5.8 m^3/h
Head developed = 115.3 m
Frequency = 50 Hz
Power consumption = 3.7 kW

Operating parameters

Flow rate = 2.04 m^3/h
Head developed = 140 m
Power consumption = 3.3 kW

Finding

Boiler feed water pump is operating with the discharge pressure of 14 kg/cm^2 , whereas the steam pressure at the boiler outlet is 8 kg/cm^2 only. There is a control valve at the discharge side of the BFP to control the flow and pressure of pump as per the steam pressure and flow requirement. As per industrial good practice, feed water pump pressure should be 2 to 3 kg/cm^2 more than the actual steam pressure generated at the boiler.

Recommendation

Option -1: Reduce number stages in pump to reduce head developed (Since number of stages in the pump is not available, exact number stages need to be removed to match the steam pressure is not calculated)

Option – 2: Install VFD to boiler feed water pump with steam pressure and flow feedback control system to vary frequency as per the steam flow and pressure requirement.

Energy & Financial savings

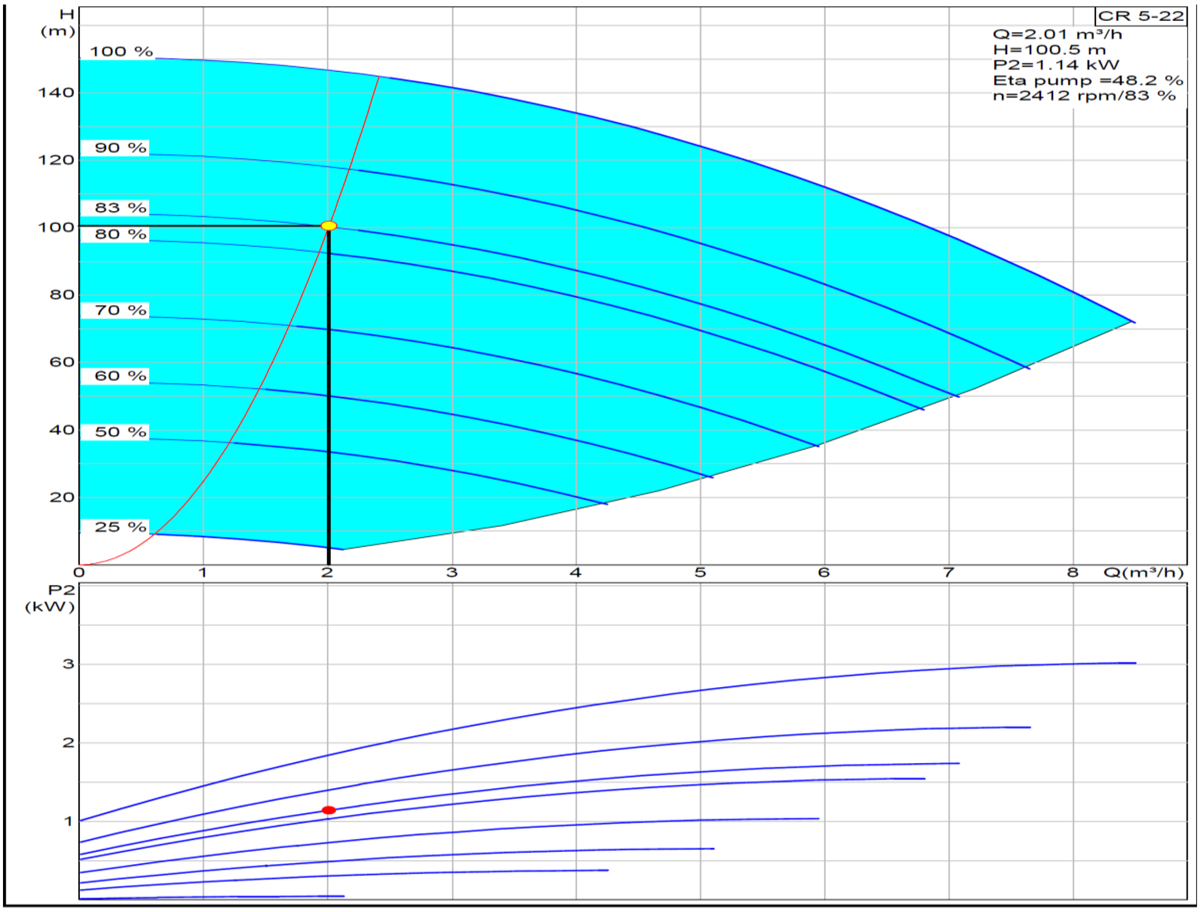
Estimated energy and financial saving for the recommendation with payback period is as follows.

Table 18 : Boiler feed water pump VFD installation

Description	Units	Parameters
Design details		
Make		Grundfos
Model		CR -5 - 22
Head developed	m	115.3
Flow delivered	m^3/h	5.8
Power consumption	kW	3.7
Operating parameters		
Head developed	m	140
Flow delivered	m^3/h	2.04
Power consumed by the pump	kW	3.3
Proposed parameters		
Head required	m	100
Flow rate	m^3/h	2.04
Proposed power consumption of pump	kW	1.14
Power consumption consider for saving calculation	kW	0.855
Annual operating days	Days	350
Operating hours	Hours	24
Annual operating hours	Hours	8,400
Annual energy saved	**kWh**	**7,182**
Energy cost	Rs./kWh	4.55
Annual cost saved	**Rs. Lakhs**	**0.32**
Investment required for VFD	**Rs. Lakhs**	**0.60**
Payback period	**Months**	**22**

Proposed parameter pump curve:

Figure 43: BFP proposed operating characteristic curve



4.3 *Process equipment's*

4.3.1 *Install VFD in hammer mill and batch mixer motor*

Background

There are hammer mill, batch mixer and pellette mill in the process, the energy consumption of these motors are higher compare to other motors in the plant. Rated capacities and rated power consumption of these motors are as follows.

Table 19 : Hammer mill and batch mixer motor operating details

Description	Units	Hammer Mill	Batch Mixer
Design details			
Motor power consumption	kW	255	55
Actual power consumption during running for line -1	kW	100	20
Actual power consumption during running for line -2	kW	80	19
Idle time power consumption for line -1 motors	kW	14	3.2
Idle time power consumption for line -2 motors	kW	16	2.2
Motors batch timing for line -1	Sec	210	210
Motors batch timing for line -2	Sec	210	210

Description	Units	Hammer Mill	Batch Mixer
Idle time observed during the audit between batch in line -1	Sec	90	180
Idle time observed during the audit between batch in line -2	Sec	90	180
Idle time energy consumption per hour for line -1	kWh	4.2	4.2
Idle time energy consumption per hour for line -2	kWh	4.8	0.96

Finding

These motors are running continuously in both lines, even though there is a variation production capacity from one day to other day these motors are running at constant speed at all production levels.

The standard time for the completion of one complete batch is 210 sec for both of these motors, from the end of one batch to the start of another batch there is idle time observed in these motors, during the idle time there will not be any load on the motor but motor will be running without any load.

Recommendation

It is recommended to install VFD to these motors to vary the motors speed according to the different production levels and to maintain the minimum possible motor speed during the idle time.

Energy & Financial savings

Installation of VFD to these motors will be having payback period of more than 3 years (Since motors are very big, VFD cost will be higher). Plant can consider this measure as a long-term investment plant.

Along with the installation of VFD to hammer mill motor and mixer motor, plant can also consider installation of VFD in Pellette mill motor as well.

4.4 Lighting

4.4.1 Option – 1: Install lighting energy saver to lighting feeder

Background

Lighting consumes around 2% of the total electricity consumption in the plant. There is a separate feeder installed for the lighting through which power supplied to all the lighting distribution boards.

The power consumption measurement done on the lighting feeder during the audit is as follows.

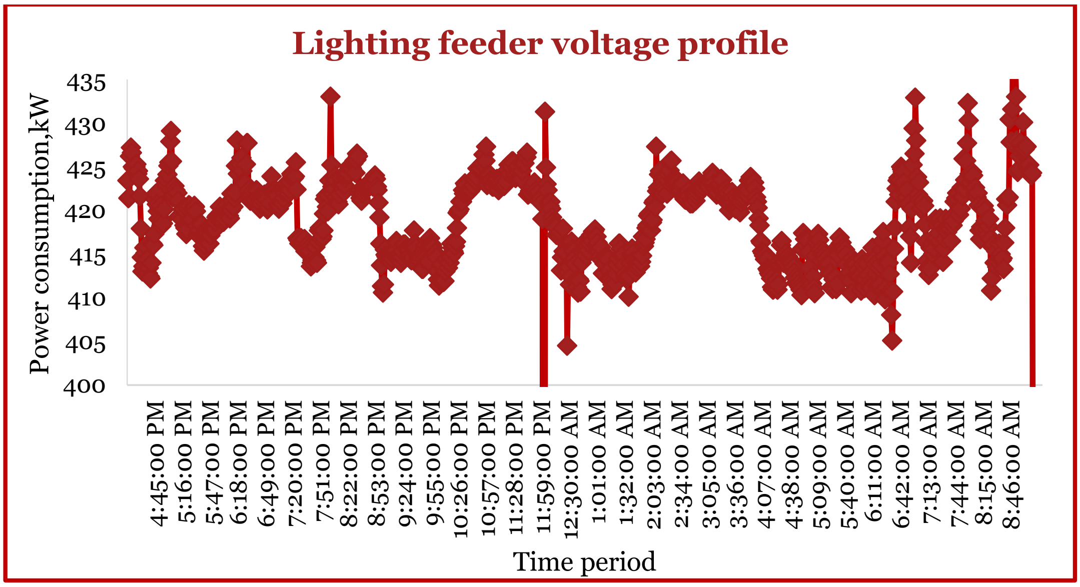
Maximum lighting consumption during the recording period	=	55 kW
Minimum lighting consumption during the recording period	=	8 kW
Average lighting consumption during the recording period	=	50 kW
Lighting energy consumption per day	=	450 kWh

Finding

The voltage profile recorded in the lighting feeder during the audit shows that lighting is operated with a voltage of 405 v to 430 v, which is very high.

The voltage measurement done on the lighting feeder during the audit is as follows.

Figure 44: Lighting feeder voltage profile



Recommendation

Install energy saver to lighting feeder and operate lighting at 370-380 volts instead of 405 – 425volts

Energy & Financial savings

Estimated energy and financial saving for the recommendation with payback period is as follows.

Table 20 : Lighting energy saver installation saving and investment estimation

Description	Units	Parameters
Actual parameters		
Actual voltage recorded in lighting feeder	Volts	405-425
Lighting energy consumption per day	kWh	450
Proposed parameters		
Proposed lighting voltage	Volts	370-380
Expected power saving by energy saver	%	20%
Actual energy consumption saved per day	kW	90
Operating days per year	Days	350
Annual energy consumption saved	**kWh**	**31,500**
Energy cost	Rs/kWh	4.55
Annual cost saved	**Rs. Lakhs**	**1.43**
Investment for 75 kVA lighting energy saver	**Rs. Lakhs**	**3.6**
Payback period	**Months**	**30**

4.4.2 Option -2: Replace all the lighting fittings with appropriate new LED fitting

Background

Plant is fitted with the following type of lamps to meet the lighting demand.

Table 21 : Lighting fitting details

Type of lamp	Wattage	Quantity
T-8	1*36	88
T-8	2*36	373
T-5	28	106
CFL	18	54
MH	250	213
MH	500	20

The average energy consumption of the lighting for a complete day is 450 kWh.

Finding

The power consumption of the present lamps can be reduced by the replacement of present lamps with the equivalent LED fittings. Replacement of present lamps with LED lamps will reduce the power consumption and maintain the same illumination level with higher life and less maintenance.

Recommendation

Replace present lamps with LED

36 W FTL Replace with 16 W LED

28W FTL Replace with 16 W LED

250W MH Replace with 125 W LED

500W MH Replace with 250 W LED

Energy & financial savings

Estimated energy and financial saving for the recommendation with payback period is as follows.

Table 22 : Replacement of all plant lamps with LED lamp saving and investment estimation

Description	Units	Parameters
Actual parameters		
Numbers of 36 W*1 FTL's working in plant	Numbers	88
Numbers of 36 W*2 FTL's lamps working in plant	Numbers	373
Numbers of 28W*1 FTL's lamp working in plant	Numbers	106
Numbers of 250 W MH lamps working in plant	Numbers	213
Numbers of 500 W MH lamps working in plant	Numbers	20

Description	Units	Parameters
Total power consumption of these lamps	kW	105
Average number of lamps working	%	55
Actual lighting power consumption	kW	58
Proposed parameters		
Power consumption of respective LED lamps	kW	53
Actual power consumption with 55% utilization	kW	29
Power consumption saved	kW	29
Operating hours per day	Hours	10
Operating day's per year	Days	350
Annual energy consumption saved	**kWh**	**1,01,500**
Energy cost	Rs/kWh	4.55
Annual cost saved	**Rs. Lakhs**	**4.61**
Investment for LED lamps	**Rs. Lakhs**	**14.00**
Payback period	**Months**	**36**

4.5 Use of Renewable Energy Sources

The plant depends only on the conventional energy sources for meeting its energy demands. Electricity and diesel, natural gas and coal are the dominant sources of energy and contributor to the total energy costs. During detailed energy audit, the possibilities of renewable energy options like solar energy were explored to meet the energy demand of the plant. Based on the observations and collected data, the solar photovoltaic (PV) system seems to be a feasible renewable energy option.

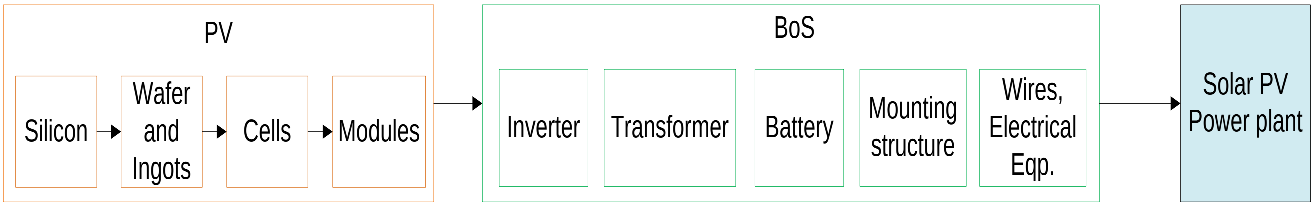
4.5.1 Solar PV system

The possibility of electricity generation through a solar photovoltaic (PV) system in the plant exists because of the availability of free roof space and a good amount of solar irradiation in the area. The roof area of around 2,500 m^2 available on the shop floor building is concrete, shadow free and clear of any restrictions like trees, overhead water tank, shadow from adjoining building, etc. The roof space available at the plant can support a solar PV system to generate electricity to meet the load requirement of the administrative building i.e. lighting, fans and air conditioning which is fairly constant.

PV modules are the primary components of Solar PV power plant and may comprise as high as 70 % of the project cost. Solar PV power plants are based on modules prepared through crystalline or thin film cells.

The PV module is the major component of the solar power plants and is the major cost proponent for the project but a number of additional components are required for a rooftop PV project to operate. These components are inverters, charge controllers, transformers, civil structure, mounting structure for modules, batteries (optional), wires, switches etc. The layout of a PV plant is shown below (considering c-Si modules).

Figure 45: Layout of solar PV plant



Choice of mounting structure will depend on the positioning and type of solar array, strength of the structure, area free from shading, obstructions on the roof like vents, pillars etc. Mounting structures may be fixed or tracking.

4.5.2 Solar assessment in Cattle feed plant - Katarva

Solar radiation data for Cattle feed plant in Katarva area is as follows:

Table 23: Physical features of the Cattle feed plant –Katarva

Parameters	Unit	Climate data location
Latitude	˚N	23.3
Longitude	˚E	72.63
Elevation	m	129
Heating design temperature	ºC	15.39
Cooling design temperature	ºC	37.09

The radiation information will be of immense help for providing solar planners, designers, engineers and renewable energy analysts in providing an initial assessment of a site and estimated returns from a solar project.

For cattle feed plant area, the details of monthly daily solar radiation horizontal kWh/m²/d, air temperature, wind speed and relative humidity as provided by NASA are tabulated below.

Table 24: Average monthly insolation data

Month	Daily solar radiation horizontal (kWh/m²/d)	Air temperature, (°C)	Winds speed (m/s)	Relative humidity (%)
January	4.5	21.1	3.5	34.30%
February	5.12	23.3	3.6	29.60%
March	5.96	28.3	3.6	25.50%
April	6.41	31.4	4	29.60%
May	6.59	32.3	4.6	40.80%
June	5.93	30.4	4.2	61.40%
July	4.73	28.1	3.7	75.20%
Aug.	4.49	27.7	3.3	73.70%
September	5.14	28.6	3	60.80%
October	5.12	28.8	2.8	39.70%
November	4.55	25.9	3	29.70%
December	4.15	22.4	3.3	33.00%
Annual	**5.22**	**27.4**	**3.6**	**44.40**

4.5.2.1 Energy and cost parameters for installation of crystalline and thin film solar PV modules

On the basis of availability of 2,500 m² roof top area in the plant, a comparison of energy and cost parameters for both the crystalline and thin film solar PV modules that can be installed in the plant is provided below:

Table 25: Energy and cost parameters for solar PV modules

Parameters	Units	Solar PV system with crystalline modules	Solar PV system with thin film modules
Installed Power Generation Capacity	kWp	208	166
Capacity Utilization Factor	%	18%	18%
Useful Life	Years	20	20
Net Electricity Generation	MWh/year	323	261.75
Tentative capital cost of project (after 15% MNRE capital cost subsidy)	Rs. Lakhs	141.7	113.33
Net monetary electricity savings	Rs. Lakhs/year	14.9	11.90
Simple payback period	Months	113.9	114.19

The above analysis from both the methods indicates that the thin-film is less efficient and hence occupies more space, because of which the actual generation from the solar rooftop installation reduces. Thin-film may produce more power for a fixed capacity of plant size but the area requirement for a thin-film plant is substantially higher than for crystalline modules. This translates to reduced plant size for a thin-film power plant compared to crystalline modules.

There is hardly any difference between large solar systems or small solar systems in terms of Solar PV modules/arrays. However, due to consideration of space requirements and fixed axis (without tracking systems), the small solar systems predominantly uses crystalline PV modules.

This must be stated that the energy and cost estimation is merely indicative of the performance of crystalline and thin film modules but the actual generation will be different and will depend upon the technologies and the type of configuration selected by the project developer. The power delivered by an SPV power source will depend on PV module rating and insolation level of the location and environmental factors like dust, wind, velocity and temperature of the location. Some of the features of SPV technology & environmental factors which influence the performance of the power plant are irradiance or light intensity, temperature of the cells, response of the light spectrum, and orientation of the panel/array, sun hours per day etc.

5 Annexure

5.1 List of Energy Audit Instruments

PwC has multiple energy audit instruments kits. All the instruments are of have high quality, precision and are periodically calibrated. The instruments are capable to cover all electrical and thermal measurements required in the plants. A list of instruments used by PwC during the audit are shown below

Table 26: List of energy audit instruments

S. No.	Name of the Instrument	Make	Quantity
Thermal Instruments			
1	Flue Gas Analyzer (KANE 900+)	Kane (UK)	2
2	Non-contact Infrared Thermometer (Testo-845 and Extech)	Testo (USA),	3
3	Contact type Thermometer (Testo-845 and Extech)	Extech (USA)	3
4	Digital Manometer (Testo-510)	Testo (USA)	1
5	Vane Anemometer (Testo-416)	Testo (USA)	2
Electrical Instruments			
6	3-phase Power Analyzer	Krykard	3
7	1-phase Power Analyzer		3
8	Digital Tachometer (Extech-461995)	Extech (USA)	1
9	Lux Meter (Extech and Testo)	Extech and Text	5
10	Pressure Gauge	Comark (UK)	2
Others			
11	Precision Hygrometer (Testo-625)	Testo (USA)	2
12	Ultra Sonic Water Flow meter - Transit Time type	GE, Micronics	2
13	Ultra Sonic Water Flow meter - Doppler type	Micronics	1

5.2 *List of suppliers*

The objective of the mapping of suppliers is to provide guidance to the factory management in understanding the supplier base for the recommended energy efficient technologies and equipment in the energy conservation measures in the report.

PwC team with their experience as well as during the fieldwork stage of the energy audits collected a very wide range of energy consumption related data and gained a thorough understanding of related technologies and practices adopted at dairy plants. These interactions enabled the PwC to understand the current level of awareness among factories about energy efficient equipment and the suppliers of such equipment.

By analyzing, the energy consumption related data collected at the fieldwork stage, the PwC team identified the appropriate energy efficient equipment for each of the audited dairy plants. Following the identification of the most appropriate energy efficient technologies and equipment, the energy audit team gathered information on the suppliers of such technologies and equipment mainly through following steps:

- Names and addresses of the suppliers, who have supplied energy efficient equipment's and technologies to the factories, which were visiting during field studies, were collected.
- Desk Research (internet search etc.) was carried out to identify the established international and local suppliers of energy efficient equipment to dairy plants.
- When additional technical and pricing information was required, the suppliers (or agents or representatives in India) were directly contacted by the PwC team, to obtain the required information.

Based on the above-mentioned approach, the following table provides insights into the composition of the current supplier base and identifies preferred suppliers of energy efficient technologies/ equipment's to the Gujarat dairy sector.

Table 27 : Vendor details for recommended saving solution

Equipment/ Technology	Product	Manufacture/ Brand	Available location and address
Variable Frequency Drive (VFD)	VFD	Danfoss	**Danfos India Private Limited** No. 502, Abhijeet IV, Behind Pantaloon Showroom , Near Law Garden Ahmedabad - 380009
	VFD	Schneider	**Schneider electric India Private Limited** No. 42A, 4th Floor, Space House, Mithakali Six Roads , Opp. Sri Krishna Centre Ahmedabad - 380009
	VFD	Siemens	**Siemens Ltd** 3rd Floor, Prerna arbour, Opp. Singapore Airlines, Near Girish Cold drinks cross roads, Off. C. G. Road, Ahmedabad - 380009 Tel.: +91 (079) 30927600/40207600
Blowdown recovery system	Blowdown recovery system	Thermax	**Thermax India Private Limited** 403, Mihir Tower, Mani Nagar Near Jawahar Chowk, Mani Nagar Ahmedabad, Gujarat 380008
		Forbes Marshal	**Forbes Marshal India Private Limited** 35, Punitnagar Society, Old Padra road Vadodara - 390015
APFC	Capacitors	Schneider	**Schneider electric India Private Limited** No. 42A, 4th Floor, Space House, Mithakali Six road, Opp. Sri Krishna centre Ahmedabad – 380009

Equipment/ Technology	Product	Manufacture/ Brand	Available location and address
Backpressure turbine	Turbine	Turbo Tech	**Turbo Tech Precision Engineering private limited** Survey No. 8/2, Honnasandra village kasab Hobli, Nelamangala Taluk, Bangalore
Lighting	Lighting energy saver	Schneider	**Schneider electric India Private Limited** No. 42A, 4th Floor, Space House, Mithakali Six Roads, Opp. Sri Krishna Centre Ahmedabad – 380009
		Beblac	**Beblec Energy Systems Pvt Ltd** N3 Part, 1st Floor, 3rd Phase SIDCO Industrial estate, Hosur - 635 126 Tamil Nadu Phone: +91-4344-276358 / 278658 Mobile: +91-9443376558
	LED lamps	Philips	**Philips India Private Limited** Star House, Near Relief Cinema, Relief Rd, Bhadra, Ahmedabad - 380001 Phone:079 2535 4833
		Syska	**Syska Lighting** 6th floor, Shiromani complex Nehru Nagar, Opposite to Ocean park satellite Ahmedabad

* *Please note neither PwC nor UNIDO recommends any particular vendor/supplier. The list provided is not comprehensive and is only suggestive to facilitate the unit. If unit has its own vendor /supplier, those can also be contacted for the same.*