Energy Audit Report-Packaging film plant (PFP) - Amul Fed Dairy, Gandhinagar

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 CO2
1 Liter (Diesel)	2.7 kg CO2
1 Liter (Furnace Oil)	2.9 kg CO2
1 Liter (Kerosene)	2.5 kg CO2
1 Kg (CNG)	2.8 kg CO2

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, which includes Gujarat dairy cluster.

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

We would also like to acknowledge the support, valuable inputs, co-operation and guidance provided by Mr. N. R. Sheth (AGM – PFP Plant) during field measurements at Packaging film plant (PFP), Gandhinagar.

1. Background of the project

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, which includes Gujarat dairy cluster also.

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.

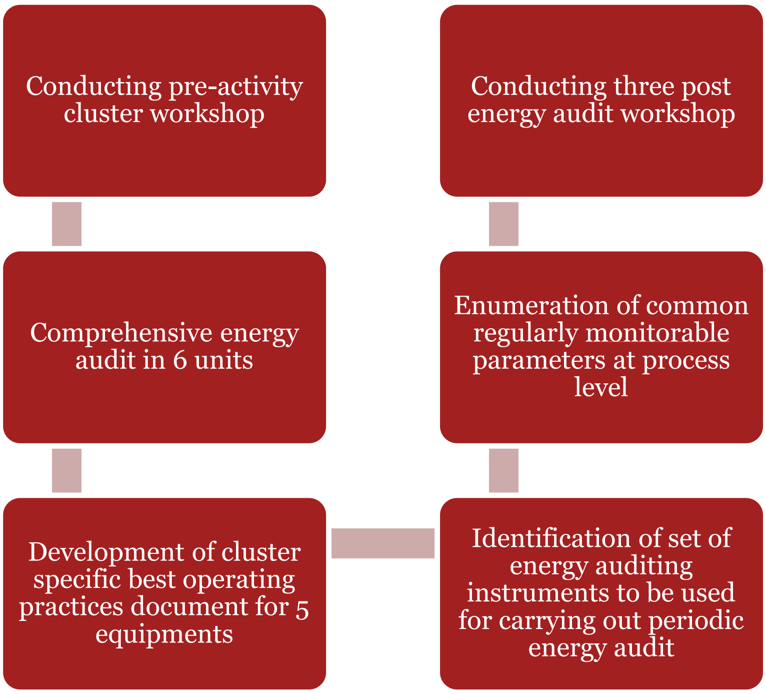
Introduction to project

PwC has been appointed by GEF-UNIDO-BEE for 'Conducting activities of energy audit and dissemination in the Gujarat Dairy Cluster under GEF funded UNIDO project 'Promoting energy efficiency and renewable energy in selected MSME clusters in India'.

Scope of services

The scope of this assignment is shown at following figure.

Figure 1: Scope of services



This report has been prepared under the task 2 of our scope of services with involves conducting comprehensive energy audits in six units in the cluster.

2. Executive Summary

2.1 Objective of the energy audit study

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

2.2 About Packaging film plant (PFP)

Mother dairy has its packing film plant in the Gandhinagar for manufacturing of plastic film for packing its various products. PFP plant manufactures all types of films for milk, buttermilk and curd. Plant uses LDP (Low density plastic) and LLDP (Linear low-density plastic) granules in Blow film plant (BFP) machines to manufacture plastic films of 50, 60 and 120 microns thickness.

Plant is having six BFP machines for manufacturing different sizes of plastic films. All machines are working during normal working hours to meet demand of plastic films from dairies. The capacity details of each machine is given below.

Machine -1	=	150 kg/h, manufactures 50 Micron plastic film
Machine -2	=	150 kg/h, manufactures 50 Micron plastic film
Machine -3	=	400 kg/h, manufactures 60 Micron plastic film
Machine -4	=	270 kg/h, manufactures 50 Micron plastic film
Machine -5	=	650 kg/h, manufactures 120 Micron plastic film
Machine -6	=	650 kg/h, manufactures 120 Micron plastic film

Plastic films manufactured in the PFP plant are transported to all nearby dairies and is being used directly for packing of milk products. The thickness of films used for different size of packings are mentioned below for reference.

500 ml	=	50 micron
1 Liter	=	60 micron
5 to 6 Liter	=	120 micron

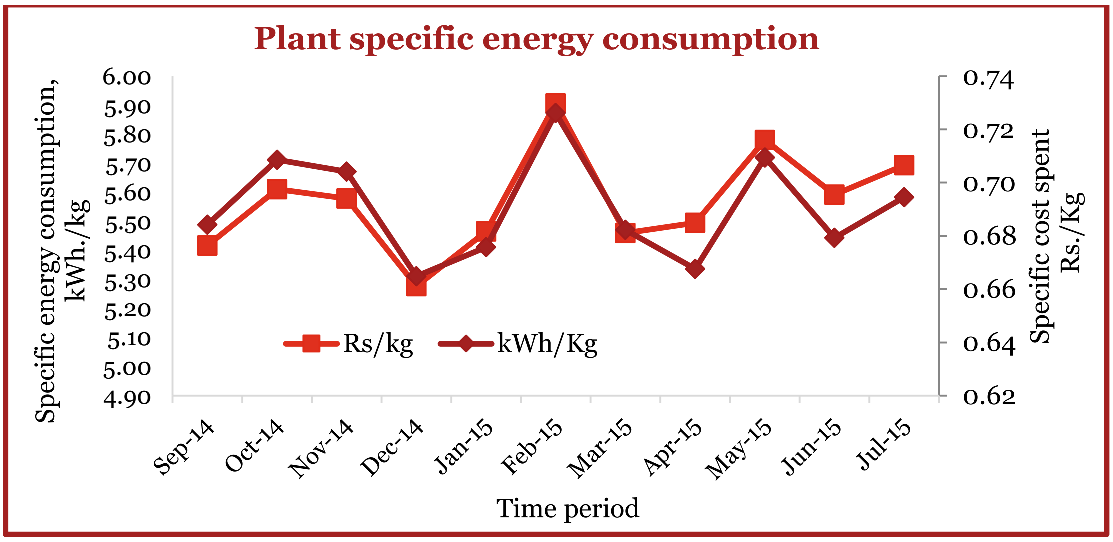
2.3 Present energy scenario & specific energy consumption

Plant uses electricity as main energy inputs to operate. The electricity consumption of entire plant is compared with quantity of plastic films manufactured to estimate the average electricity spent on manufacturing of each kg of plastic film. This is tabulated below for reference.

Table 1 : Present energy scenario and specific energy consumption

Month	Electricity consumption (kWh/month)	Electricity cost (Rs.)	Total production (MT/month)	Specific energy consumption (kWh/Kg)	Cost spent on each kg of plastic (Rs./kg)
Septmeber-14	990,180	7,839,177	1,447.16	0.68	5.42
October-14	1,016,880	8,050,614	1,434.98	0.71	5.61
November-14	992,390	7,863,167	1,409.38	0.70	5.58
December-14	922,200	7,319,093	1,387.01	0.66	5.28
January-15	849,330	6,869,489	1,256.84	0.68	5.47
February-15	796,520	6,479,290	1,096.99	0.73	5.91
March-15	1,013,250	8,107,560	1,485.00	0.68	5.46
April-15	98,270	7,558,380	1,375.51	0.67	5.49
May-15	983,918	8,016,730	1,387.00	0.71	5.78
June-15	969,168	7,979,020	1,426.87	0.68	5.59
July-15	1,025,316	8,404,990	1,476.24	0.69	5.69
Average	**952,492**	**7,680,682**	**1,380**	**0.69**	**5.57**
Total	**10,477,422**	**84,487,510**	**15,182**		

Graph 1 : Plant specific energy consumption



- The average specific energy consumption for plastic film making is 0.69 kWh/kg of plastic film manufactured.

- The average money spent for plastic film making is Rs. 5.57 per kg of film manufactured.

2.4 Plant energy consumption and saving summary

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 plant electrical energy consumption	kWh/annum	**14,437,902**
Annual plant electrical energy cost	Rs. Lakhs	**930**
Proposed energy consumption saved	kWh/annum	**9,51,914**
Proposed cost saved annually	Rs. Lakhs	**54.71**
Investment required	Rs. Lakhs	**43.6**
Payback period	Months	**9.5**
Internal rate of return(IRR)	%	**95.53**
Proposed percentage of plant electrical energy saved	%	**6.5**
Proposed percentage of plant electricity cost saved	%	**5.88**

2.5 Summary of proposed energy conservation measures

Table 3: Summary of energy conservation measures

S. No.	Suggested measure	Annual energy savings	Annual cost saving	Investment	Payback period
		kWh/annum	Rs. Lakhs	Rs. Lakhs	Months
1	Replace cooling water pumps of BFP – 5 & 6 with energy efficient pump	2,83,920	16.32	16	11.7
2	Install VFD in all fresh air fans to reduce numbers of air changes as per ASHRAE standard	4,18,320	24.05	15.6	7.7
3	Replace old inefficient reciprocating chillers in BFP -3 machine with new energy efficient screw chiller	1,95,844	11.26	8	8.5
4	Arrest CW water flow in to non- operating air compressors and install common CW system for machines, air compressor and other utilities	15,120	0.86	1	14
5	Install lighting energy saver in lighting feeder to save the lighting energy consumption	38,710	2.22	3	16
Total		**9,51,914**	**54.71**	**43.6**	**9.5**

3. Introduction

3.1. Energy audit scope and approach

A detailed energy audit was undertaken at Mother Dairy – PFP plant, Gandhinagar from September 07 -10, 2015. The energy audit team of PwC comprised of mechanical and electrical energy experts. During the energy audit, a range of portable energy audit instruments were used to take various measurements at all major energy consuming equipments/systems of the plant. In addition, design and operational data was collected from logbooks and equipment manuals. 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 PFP plant and the evaluation of operational efficiency/performance of such equipment from energy conservation point of view.

The following areas were covered during the study:

- ***Packing film plant***
  - ✓ Blow film plant
    - o Machines
    - o Chillers
    - o Cooling water system
  - ✓ Cooling water system
    - o Pumps
    - o CT
  - ✓ Fresh air fans
  - ✓ Electrical distribution
  - ✓ Air compressors
- ***Renewable Energy***
  - ✓ Opportunities were identified for use of renewable energy

The study focused on PFP plant to identify opportunities to save energy at the plant. The analyses included payback and Internal Rate of Return (IRR) calculations to ascertain the 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, there was continuous interaction between the audit team and plant personnel to ensure that the recommendations made were realistic, practical and implementable as well as to facilitate possible concurrent implementation measures. On the last day of the field visit, a discussion was held with the plant management on site observations and preliminary findings, to enable the 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 is laid on short and medium-term measures. The ultimate aim of this exercise is to help the plant management to understand and prioritize energy efficiency opportunities identified through the study.

3.2. Plant installed load details

A list of major energy consuming equipment and auxiliaries in the plant is provided below.

Table 4 : List of load (Equipment) in the plant

S. No.	Location	Rating (H.P.)
1	BFP-1, Inner Extruder	50
2	BFP-1, Middle Extruder	50
3	BFP-1, Outer Extruder	50
4	BFP-2, Inner Extruder	40
5	BFP-2, Middle Extruder	40
6	BFP-2, Outer Extruder	40
7	BFP-3, Inner Extruder	100
8	BFP-3, Middle Extruder	100
9	BFP-3, Outer Extruder	100
10	BFP-3, OBC Motor	20
11	BFP-4, Inner Extruder	120
12	BFP-4, Middle Extruder	120
13	BFP-4, Outer Extruder	120
14	BFP-4, OBC Motor	20
15	BFP-5, Inner Extruder	120
16	BFP-5, Middle Extruder	200
17	BFP-5, Outer Extruder	120
18	BFP-5, Air Ring 1 Motor	50
19	BFP-5, Air Ring 2 Motor	15
20	BFP-5, Supply Air Motor	15
21	BFP-5, IBC Outlet Motor	15
22	BFP-6, Inner Extruder	120
23	BFP-6, Middle Extruder	200
24	BFP-6, Outer Extruder	120
25	BFP-6, Air Ring 1 Motor	50
26	BFP-6, Air Ring 2 Motor	15
27	BFP-6, Supply Air Motor	15
28	BFP-6, IBC Outlet Motor	15
29	CI-1, Main Drum Motor	20
30	CI-1, Drum Exhaust Blower Motor	15

S. No.	Location	Rating (H.P.)
31	CI-1, Drum Blower Motor	15
32	CI-1, Tunnel Exhaust Blower Motor	15
33	CI-1, Tunnel Blower Motor	15
34	CI-2, Main Drum Motor	20
35	CI-2, Drum Exhaust Blower Motor	15
36	CI-2, Drum Blower Motor	15
37	CI-2, Tunnel exhaust Blower Motor	15
38	CI-2, Tunnel Blower Motor	15
39	SR8-1, Main Drive	10
40	SR8-1, Re winder Motor	10
41	SR8-2, Main Drive	10
42	SR8-2, Re winder Motor	10
43	SR8-2, Unwinder Motor	10
44	SR8-3, Main Drive	10
45	SR8-3, Re winder Motor	10
46	SR8-3, Unwinder Motor	10
47	SR8-4, Main Drive	10
48	SR8-4, Re winder Motor	10
49	SR8-4, Unwinder Motor	10
50	Dahua Slitter – Re winder Motor	20
51	Dahua Slitter – Re winder Brake Motor	30
52	Silo - Main Motor	40
53	CT - 3 Pump 1	20
54	CT - 3 Pump 2	20
55	CT - 4 Pump 1	20
56	CT - 4 Pump 2	20
57	Fire Station Jokey Pump	15
58	Fire Station Main Pump	60
59	Air Compressor - 1 Motor	120
60	Air Compressor - 2 Motor	120
61	Air Compressor - 3 Motor	120
62	Old FAV Motor - 1	40
63	Old FAV Motor - 2	40
64	New FAV Motor - 1	30
65	New FAV Motor - 2	30
66	New FAV Motor - 3	30
67	New FAV Motor - 4	30
68	New FAV Motor - 5	30
69	New FAV Motor - 6	30

The next section discusses about the field observation and analysis of the same.

4. Observation and Analysis

Mother dairy has its packing film plant in the Gandhinagar for manufacturing the plastic films for packing its various products. PFP plant manufactures the all types/sizes of plastic films for milk, buttermilk and curd. Plant uses the LDP (Low density plastic) and LLDP (Linear low-density plastic) granules in the BFP machines to manufactures plastic films of 50, 60 and 120 microns thickness. Plant is having six BFP (Blow film plant) machines to manufacture different sizes of plastic films. All machines will be running to meet the demand during normal working day. Detailed energy audit was conducted in the PFP plant to identify energy conservation measures. The observations and analysis are provided next.

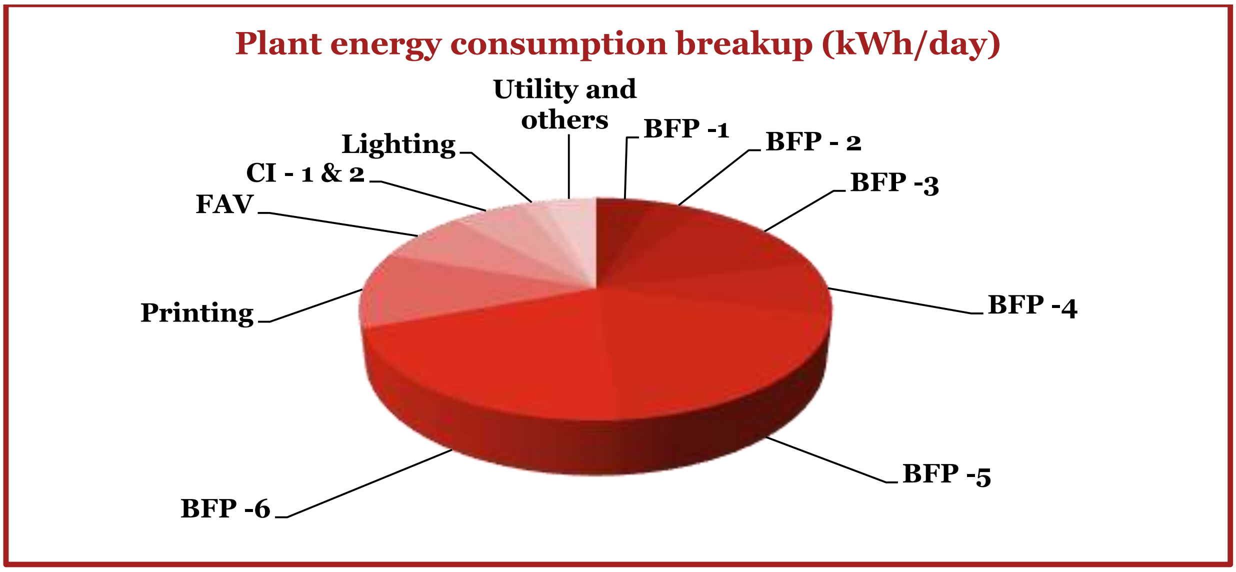
4.1. Energy Consumption breakup

Detailed electrical measurement was done on all energy-consuming equipment in the PFP plant during the energy audit and energy consumption breakup was derived. This has been tabulated below for reference.

Table 5 : Energy consumption breakup

Description	Energy consumption (kWh/day)	Percentage of consumption (%)
BFP -1	1,458	5%
BFP - 2	1,280	4%
BFP -3	3,644	12%
BFP -4	2,445	8%
BFP -5	6,024	20%
BFP -6	6,308	21%
Printing	3,380	11%
FAV	2,262	7%
CI - 1 & 2	1,849	6%
Lighting	553	2%
Utility and others	1,316	4%
Total	**30,519**	**100%**

Figure 2 : Energy consumption breakup



- The major energy consumer in the PFP plant are process equipment which consume about 69% of total energy consumption of the plant.
- PFP plant is working 24 hours a day and manufacturers about 46 MT plastic film per day.

4.2. Electricity bill analysis

The plant receives electricity supply from Torrent power at 11kV HT line and plant is installed with 3.5 MVA transformer to step down voltage from 11kV to 440 volts. The electricity bill is analyzed in detail and the details are as follows.

Tariff structure:

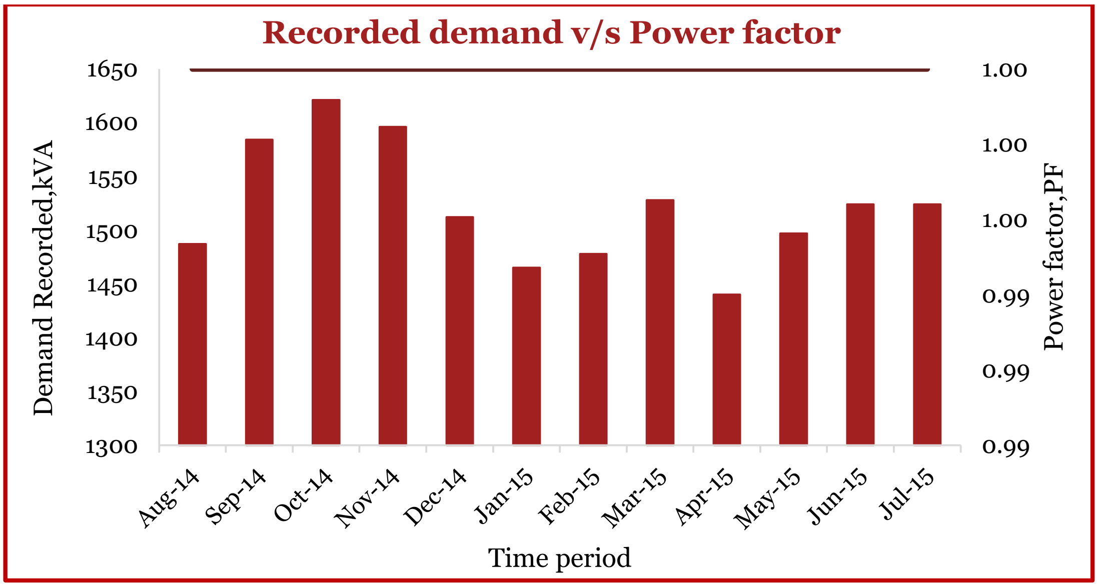
Tariff code	=	HTMD - 1
Service number	=	HT-8000545
Billing demand	=	Rs. 335 per kW
Excess billing (Demand recorded above contract demand)	=	Rs. 385 per kW
Energy consumption charges		
For first 400 kWh	=	4.45 per kWh
For remaining kWh	=	4.35 per kWh
TOU charges		
For every kWh	=	Rs. 1 per kWh

Each component of the electricity bill are provided below.

Table 6: Electricity bill analysis

Months	Billing demand (kW)	Energy consumption (kWh/month)	TOU Energy consumption (kWh/month)	Fixed charges (Rs.)	Energy charges (Rs.)	FPPPA Charges (Rs.)	TOU Charges (Rs.)	PF	PF Adjustment (Rs.)	Total energy charges (Rs.)	Govt. duty (Rs.)	Total bill (Rs.)
Aug-14	1,487	979,760	319,460	446,100	4,223,460	1,841,948	287,514	1	20,575	6,776,401	1,016,347	7,792,749
Sep-14	1,584	990,180	325,910	475,200	4,271,625	1,861,538	293,319	1	20,793	6,876,563	1,031,372	7,907,935
Oct-14	1,621	1,016,880	333,810	487,350	4,386,580	1,911,734	300,429	1	21,354	7,062,033	1,059,192	8,121,227
Nov-14	1,596	992,390	328,320	478,800	4,281,497	1,865,693	295,488	1	20,840	6,897,607	1,034,529	7,932,136
Dec-14	1,512	922,200	305,710	453,600	3,979,830	1,733,736	275,139	1	19,366	6,420,348	962,939	7,383,289
Jan-15	1,465	849,330	283,750	439,500	3,668,252	1,681,673	255,375	1	17,835	6,025,959	903,781	6,929,741
Feb-15	1,478	796,520	265,360	443,400	3,444,330	1,577,109	238,824	1	16,726	5,683,680	852,439	6,536,120
Mar-15	1,528	1,013,250	337,850	458,400	4,367,432	2,006,235	304,065	1	21,278	7,111,994	1,066,686	8,178,681
Apr-15	1,440	918,270	299,340	482,400	4,0502,074	1,818,174	299,340	1	19,283	6,630,251	994,425	7,624,676
May-15	1,497	384,288	127,608	501,495	4,339,923	1,948,158	324,418	1	20,662	7,093,554	1,063,967	8,087,661
Jun-15	1,524	969,168	317,376	510,540	4,276,840	1,918,952	317,376	1	20,352	6,999,140	1,049,871	8,049,012
Jul-15	1,524	1,025,316	335,856	510,540	4,521,084	2,030,125	335,856	1	21,531	7,372,805	1,105,920	8,478,727
Average	**1,521**	**904,796**	**298,363**	**473,944**	**7,188,577**	**1,849,590**	**293,929**	**1**	**20,050**	**6,745,861**	**1,011,789**	**7,751,829**
Total		**10,857,552**	**3,580,350**	**5,687,325**	**86,262,927**	**22,195,075**	**3,527,143**		**2,40,595**	**80,950,335**	**12,141,468**	**93,021,954**

Figure 3 : Demand and PF variation for last one year



- The average demand recorded per month from last one year is 1,521 kW, which is well within the contract demand of 1,600 kW.
- Average electricity bill amount per month from last one year is Rs. 77,51,829 and annual electricity bill cost is Rs. 9,30,21,954

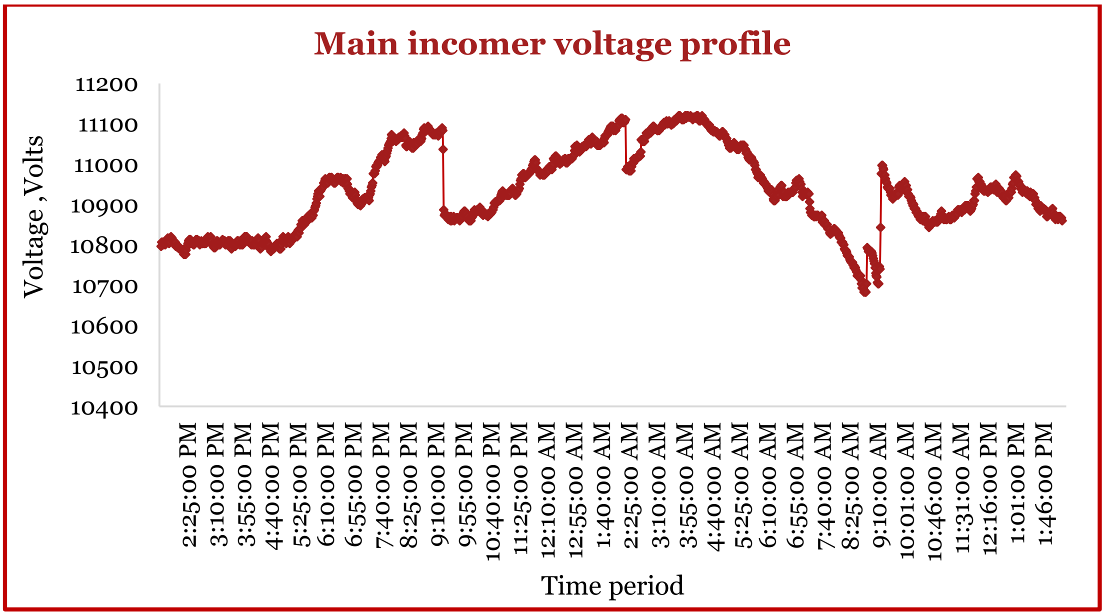
4.3. Main incomer power profile

Plant is getting electricity supply from Torrent power through 11 kV HT line and plant is installed with 3.5 MVA transformer to step down voltage from 11 kV to 440 volts. Power consumption profile recorded at the HT side of the transformer during the audit and it is discussed below.

Voltage profile:

The voltage profile was recorded for transformer at HT side, from 07-09-15 @02:30PM to 08-09-15 @ 1:30 PM and same is presented below.

Figure 4 : Main incomer voltage profile

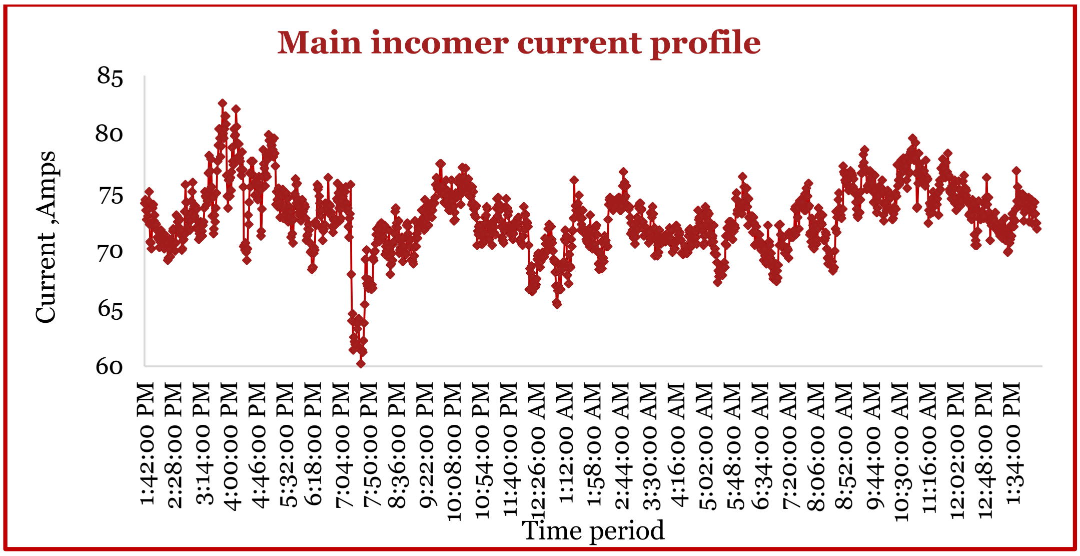


The maximum voltage recorded during this period	=	11,000 volts
The minimum voltage recorded during this period	=	10,700 volts

Current profile:

The current profile was recorded for transformer at HT side, from 07-09-15 @02:30PM to 08-09-15 @ 1:30 PM and same is presented below.

Figure 5 : Main incomer current profile

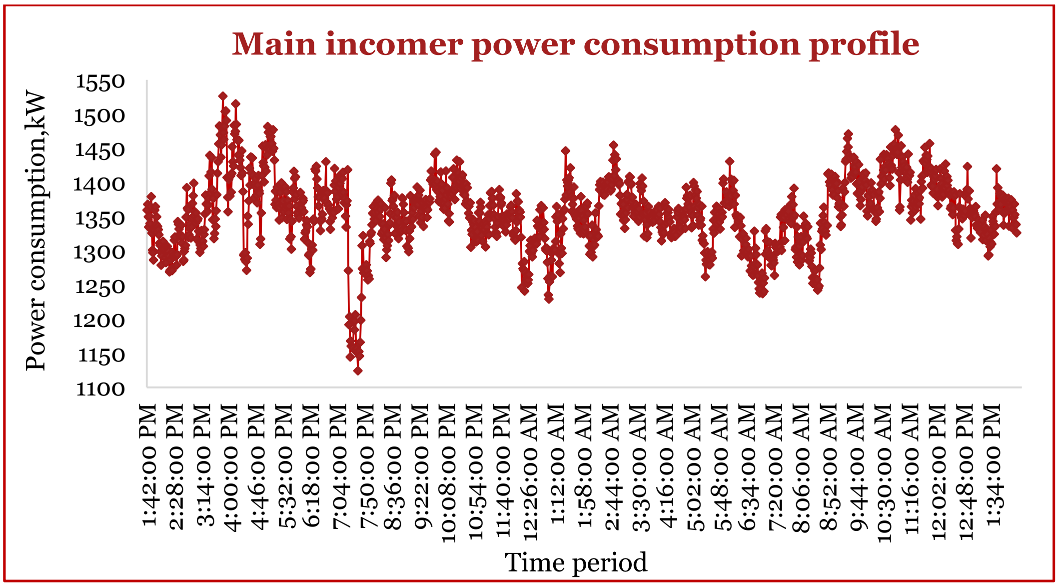


The maximum current recorded during this period	=	70 Amps
The minimum current recorded during this period	=	80 Amps

Power profile:

The actual power profile was recorded for transformer at HT side, from 07-09-15 @02:30 PM to 08-09-15 @ 1:30 PM and same is presented below.

Figure 6 : Main incomer power consumption profile

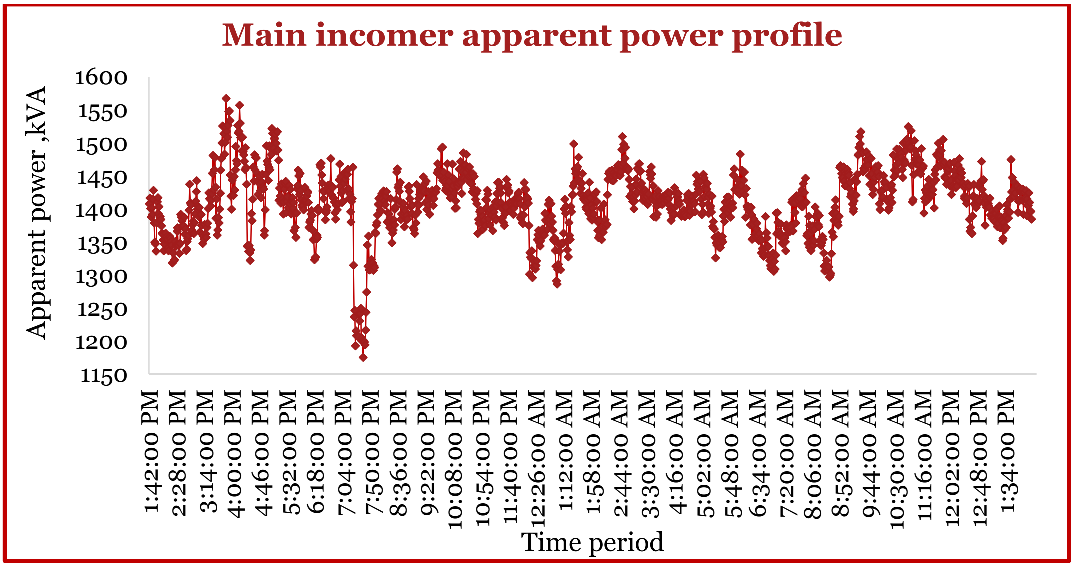


The maximum power consumption recorded during this period	=	1,500 kW
The minimum power consumption recorded during this period	=	1,250 kW

Apparent power profile:

The apparent power profile was recorded for transformer at HT side, from 07-09-15 @02:30PM to 08-09-15 @ 1:30 PM and same is presented below.

Figure 7 : Main incomer apparent power profile

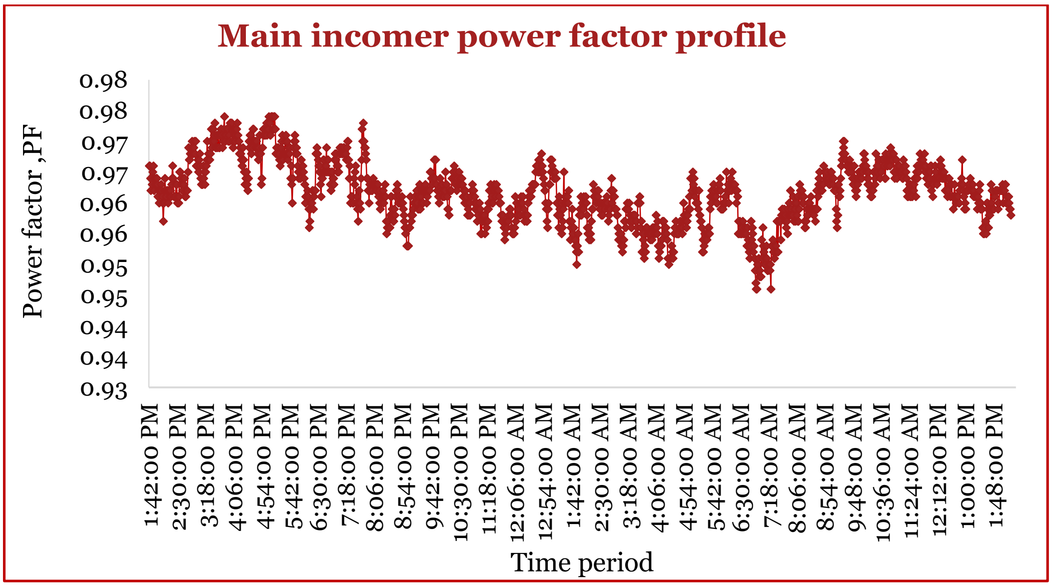


The maximum apparent power recorded during this period	=	1,550 kVA
The minimum apparent power recorded during this period	=	1,300 kVA

Power factor profile:

The power factor profile was recorded for transformer at HT side, from 07-09-15 @02:30PM to 08-09-15 @ 1:30 PM and same is presented below.

Figure 8 : Main incomer power factor profile



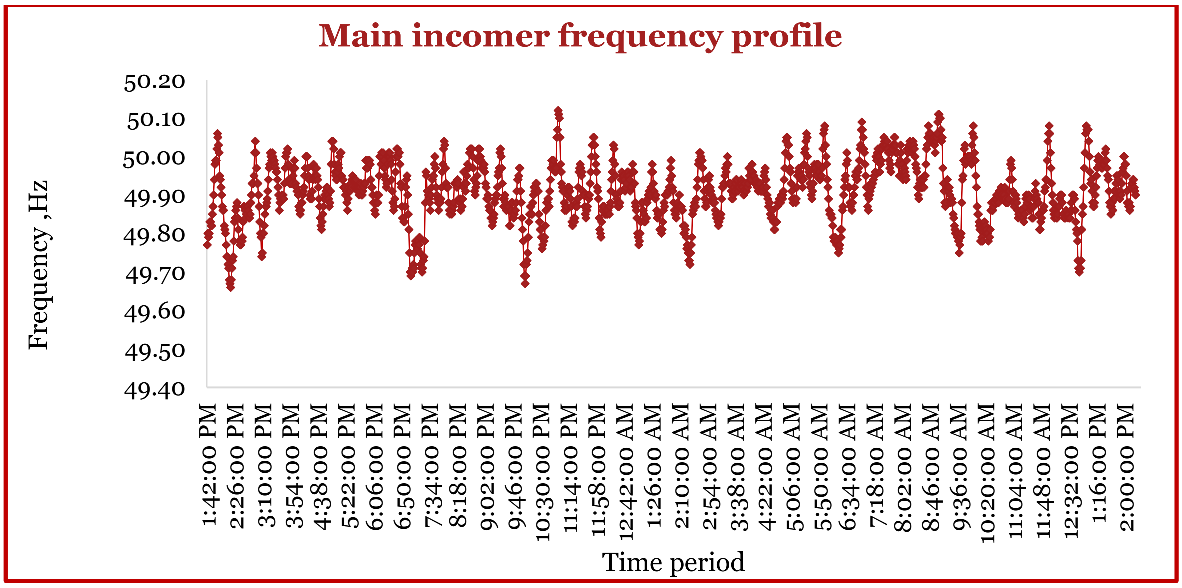
The maximum power factor recorded during this period = 0.98 lagging

The minimum power factor recorded during this period = 0.95 lagging

Frequency profile:

The frequency profile was recorded for transformer at HT side, from 07-09-15 @02:30PM to 08-09-15 @ 1:30 PM and same is presented below.

Figure 9 : Main incomer frequency profile



The maximum frequency recorded during this period = 50.1 Hz

The minimum frequency recorded during this period = 49.7 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.

4.4. Blow film plant (BFP) machines

There are six-blow film plant machines installed in the plant and all the machines are working to meet the requirement of plastic films. All the machines manufacture different types of plastic films, the capacity of machines and other details are as follows.

Machine -1 = 150 kg/h, manufactures 50 Micron plastic films

Machine -2 = 150 kg/h, manufactures 50 Micron plastic films

Machine -3 = 400 kg/h, manufactures 60 Micron plastic films

Machine -4 = 270 kg/h, manufactures 50 Micron plastic films

Machine -5 = 650 kg/h, manufactures 120 Micron plastic films

Machine -6 = 650 kg/h, manufactures 120 Micron plastic films

All the machines were studied in detail to identify energy saving opportunities during the audit, and same is given below.

4.4.1. Blow film plant -1

Blow film plant -1 machine is old compared to other machines in the plant and produces 50 microns plastic films and these films are used for 500 ml milk packing. The machine is having the capacity of 150 kg/h. The complete load details and actual parameters measured are as follows.

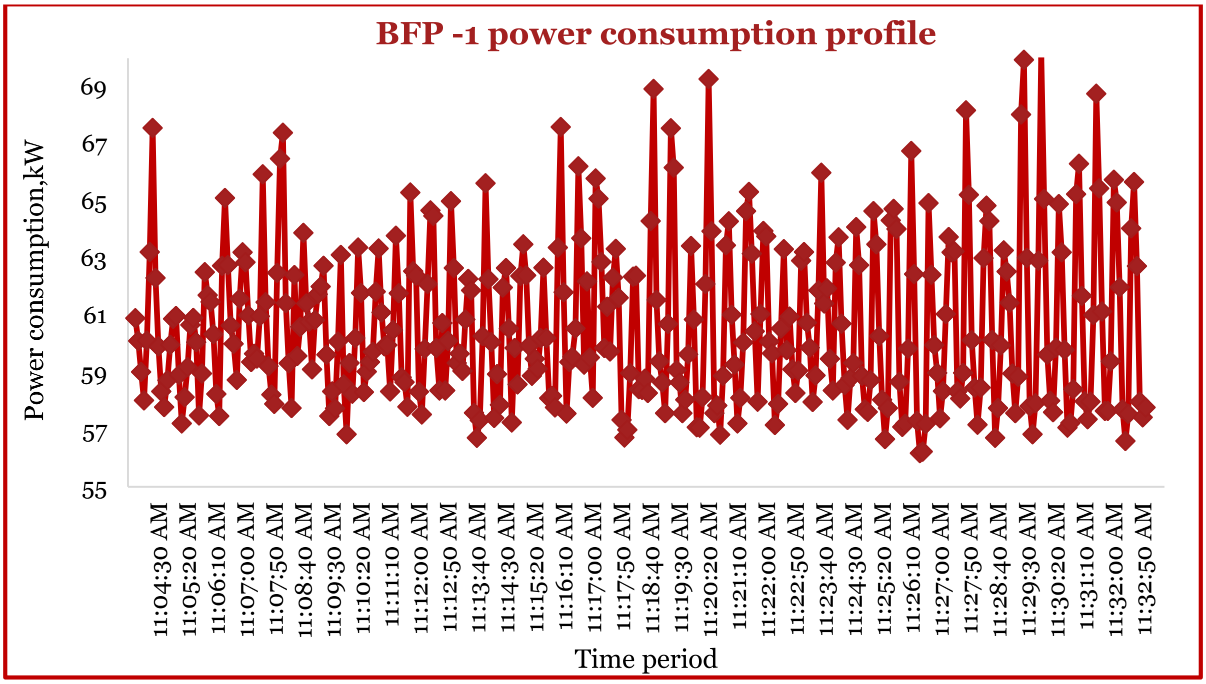
Table 7 : BFP machine – 1 complete load details

Description	Units	Numbers	Capacity (kW)
Barrel zone	kW	9	2.1
SC	kW	3	3.55
DZ -1	kW	1	5.2
DZ-2	kW	1	6.7
DZ – 3	kW	1	8.4
DZ-4	kW	1	3
Extruder	kW	3	37
Barrel blower 1 Phase	kW	6	0.075
Barrel blower 3 Phase	kW	3	0.188
Cooling ring blower	kW	1	5.6
Calibration cage	kW	1	0.75
Nip Movement	kW	1	0.375
Re generative blower	kW	1	0.375
Oscillation Nip	kW	1	0.735
Winder nip	kW	1	1.748
Main Nip	kW	1	2.2
Winder – 1	kW	1	1.748
Winder – 2	kW	1	1.748
Web Aligner	kW	1	0.25
Ozone blower	kW	1	1.5
Corona treater	kW	1	3
Actual parameters		**Set temperature**	**Actual temperature**
Barrel zone heater -1	^{o}C	165	207
Barrel zone heater -2	^{o}C	180	180
Barrel zone heater -3	^{o}C	189	180
Barrel zone heater -4	^{o}C	205	205
Barrel zone heater -5	^{o}C	175	180
Barrel zone heater -6	^{o}C	185	185
Barrel zone heater -7	^{o}C	190	190
Barrel zone heater -8	^{o}C	200	205
Barrel zone heater -9	^{o}C	160	160
SC heater -1	^{o}C	185	191
SC heater -1	^{o}C	190	208
SC heater -1	^{o}C	210	220
DZ -1	^{o}C	205	212
DZ-2	^{o}C	195	200

Description	Units	Numbers	Capacity (kW)
DZ – 3	ºC	190	190
DZ-4	ºC	185	185

The power consumption measurement done on the complete machine during the audit is as follows.

Figure 10 : BFP machine -1 power consumption profile



Machine running load during measurement	=	140 kg/h
Machine minimum power consumption	=	57 kW
Machine maximum power consumption	=	70 kW

4.4.2. Blow film plant -2

Blow film plant -2 machine is also as old as machine - 1 in the plant and produces 50 micron plastic films and these films are used for 500 ml milk packing. The machine is having the capacity of 150 kg/h. The complete load details and actual parameters measured are as follows.

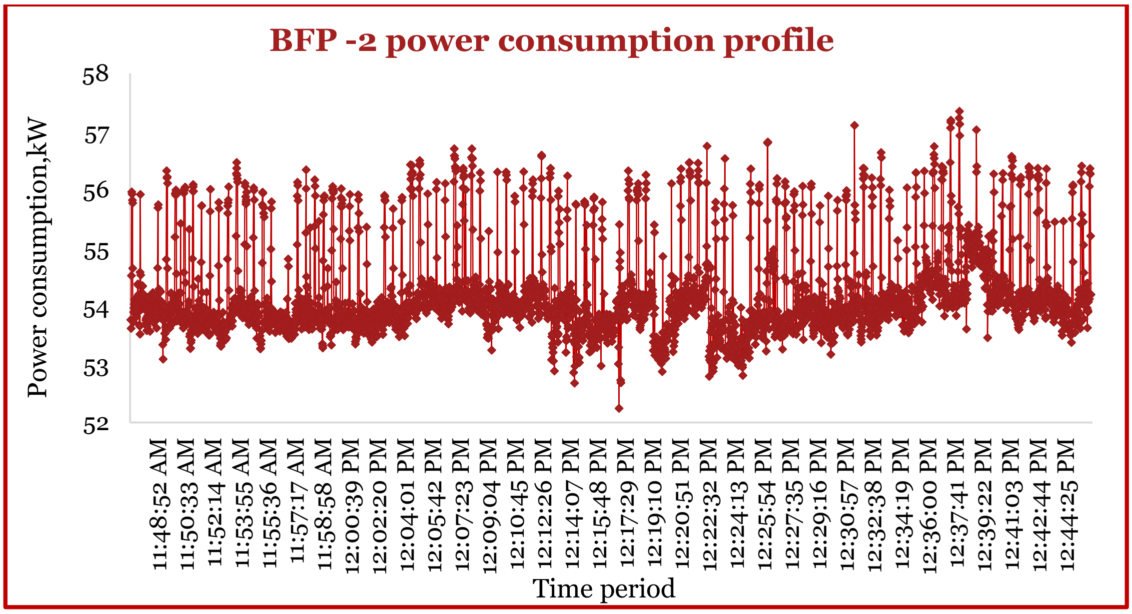
Table 8 : BFP machine -2 complete load details

Description	Units	Numbers	Capacity (kW)
Barrel zone	kW	9	2.1
SC	kW	3	3.55
DZ -1	kW	1	5.2
DZ-2	kW	1	6.7
DZ – 3	kW	1	8.4
DZ-4	kW	1	3
Extruder	kW	3	31.5
Barrel blower 1 Phase	kW	6	0.075
Barrel blower 3 Phase	kW	3	0.188

Description	Units	Numbers	Capacity (kW)
Cooling ring blower	kW	1	7.5
Calibration cage	kW	1	0.75
Nip Movement	kW	1	0.375
Re generative blower	kW	1	0.375
Oscillation Nip	kW	1	0.735
Winder nip	kW	1	1.748
Main Nip	kW	1	2.2
Winder - 1	kW	1	1.748
Winder - 2	kW	1	1.748
Web Aligner	kW	1	0.25
Ozone blower	kW	1	1.5
Corona treater	kW	1	3
Actual parameters		**Set temperature**	**Actual temperature**
Barrel zone heater -1	°C	190	192
Barrel zone heater -2	°C	190	190
Barrel zone heater -3	°C	170	190
Barrel zone heater -4	°C	175	175
Barrel zone heater -5	°C	190	212
Barrel zone heater -6	°C	185	216
Barrel zone heater -7	°C	175	189
Barrel zone heater -8	°C	175	175
Barrel zone heater -9	°C	195	197
SC	°C	190	195
SC	°C	180	180
SC	°C	185	177
DZ -1	°C	180	203
DZ-2	°C	185	204
DZ – 3	°C	180	206
DZ-4	°C	190	202

The power consumption measurement done on the complete machine during the audit is as follows.

Figure 11 : BFP machine -2 power consumption profile



Machine running load during measurement	=	135 kg/h
Machine minimum power consumption	=	53 kW
Machine maximum power consumption	=	57 kW

4.4.3. Blow film plant -3

Blow film plant -3 machine produces 60-micron plastic films and these films are used for 1000 ml milk packaging. The machine is having the capacity of 400 kg/h. The complete load details and actual parameters measured are as follows.

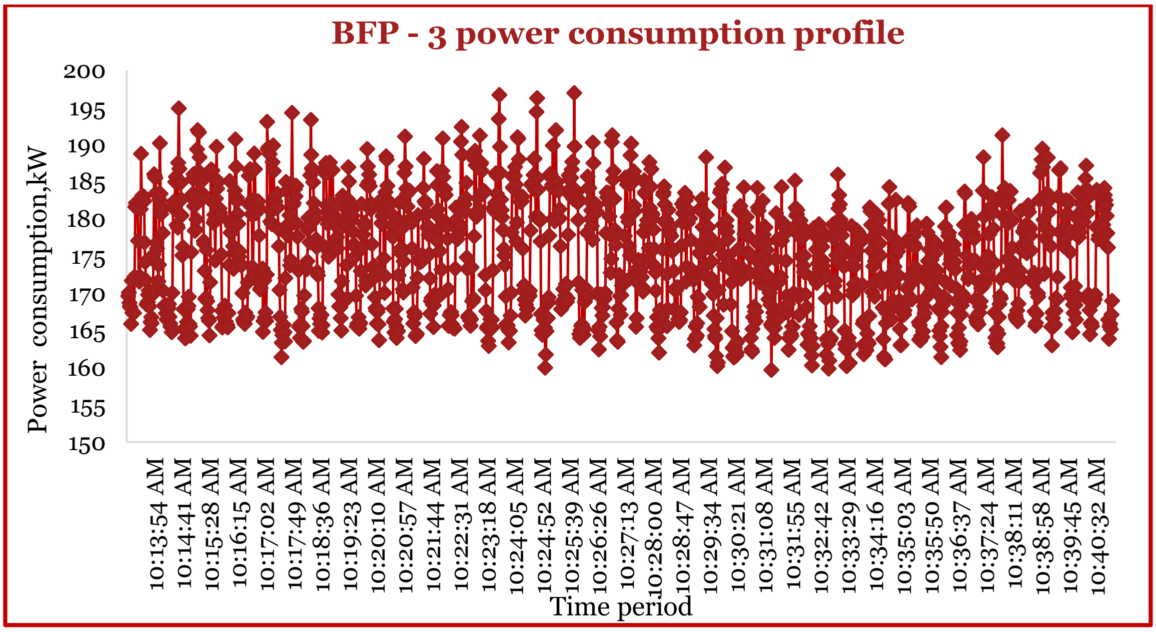
Table 9 : BFP machine -3 complete load details

Description	Units	Numbers	Capacity (KW)
Rated Parameters			
BFP-3, Inner Extruder	kW	1	100
BFP-3, Middle Extruder	kW	1	100
BFP-3, Outer Extruder	kW	1	100
BFP-3, OBC Motor	kW	1	20
Actual parameters		**Set temperature**	**Actual temperature**
Inner extruder heater Zone -1	°C	180	180
Inner extruder heater Zone -2	°C	195	190
Inner extruder heater Zone -3	°C	205	207
Inner extruder heater Zone -4	°C	215	216
Inner extruder heater Zone -5	°C	220	220
Inner extruder heater Zone -AD	°C	225	222
Inner extruder heater Zone -SC	°C	225	225
Middle extruder heater Zone -1	°C	190	190
Middle extruder heater Zone -2	°C	200	200

Description	Units	Numbers	Capacity (KW)
Rated Parameters			
Middle extruder heater Zone -3	ºC	205	205
Middle extruder heater Zone -4	ºC	220	220
Middle extruder heater Zone -5	ºC	220	220
Middle extruder heater Zone -AD	ºC	230	232
Middle extruder heater Zone -SC	ºC	235	235
Outer extruder heater Zone -1	ºC	180	185
Outer extruder heater Zone -2	ºC	195	193
Outer extruder heater Zone -3	ºC	205	205
Outer extruder heater Zone -4	ºC	215	215
Outer extruder heater Zone -5	ºC	220	220
Outer extruder heater Zone -AD	ºC	230	230
Outer extruder heater Zone -SC	ºC	225	222
Die extruder heater Zone -1	ºC	235	235
Die extruder heater Zone -2	ºC	230	230
Die extruder heater Zone -3	ºC	225	225
Die extruder heater Zone -4	ºC	220	220
Die extruder heater Zone -5	ºC	215	216

The power consumption measurement done on the complete machine during the audit is as follows

Figure 12: BFP machine -3 power consumption profile



Machine running load during measurement	=	380 kg/h
Machine minimum power consumption	=	195 kW
Machine maximum power consumption	=	160 kW

BFP – 3 machine chillers:

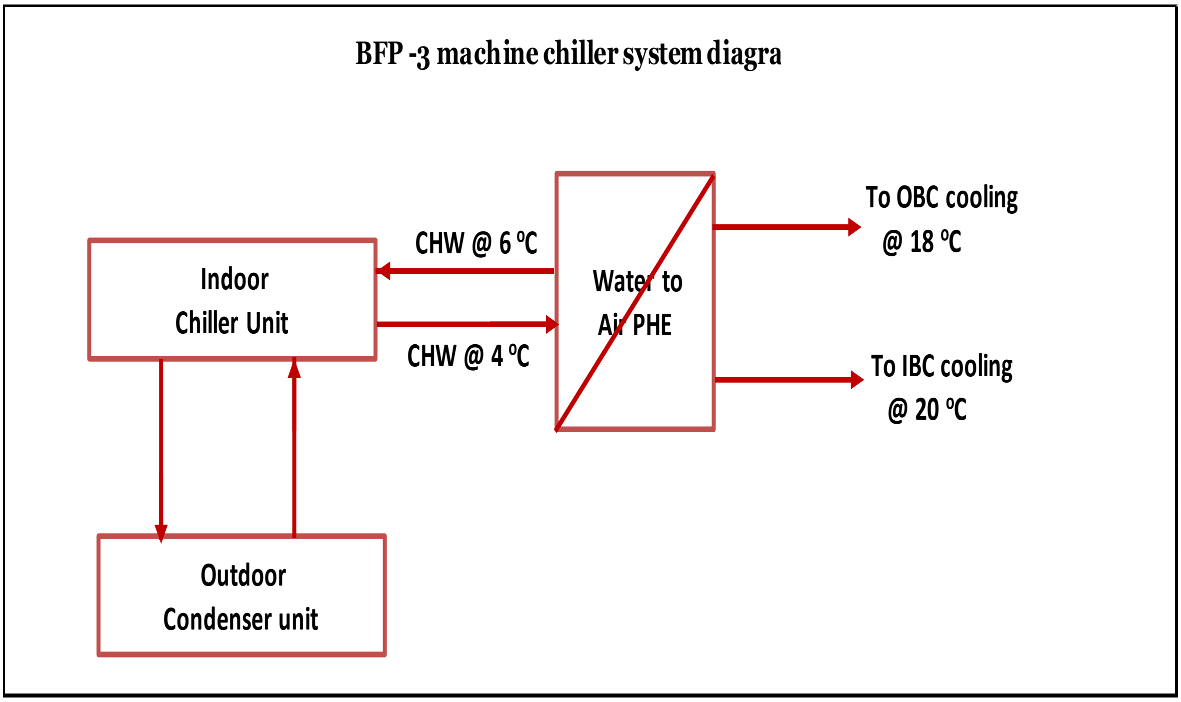
There is a chiller installed for BFP -3 machine for cooling the hot bubbles from machine. This type of cooling arrangement for hot bubble is present only in BFP-3 whereas for BFP – 1, 2 and 4; bubble is cooled by ambient air only.

The design details were not available for the chiller to assess the capacity and temperature details. The temperature of water, air measured and power consumption of the chiller compressor and blowers are as follows.

Return chilled water temperature	=	7.5 °C
Supply chilled water temperature	=	4 °C
Blower -1 air supply temperature	=	18 °C
Blower -2 air supply temperature	=	20 °C
Blower -1 power consumption	=	9.5 kW
Blower -2 power consumption	=	1.8 kW

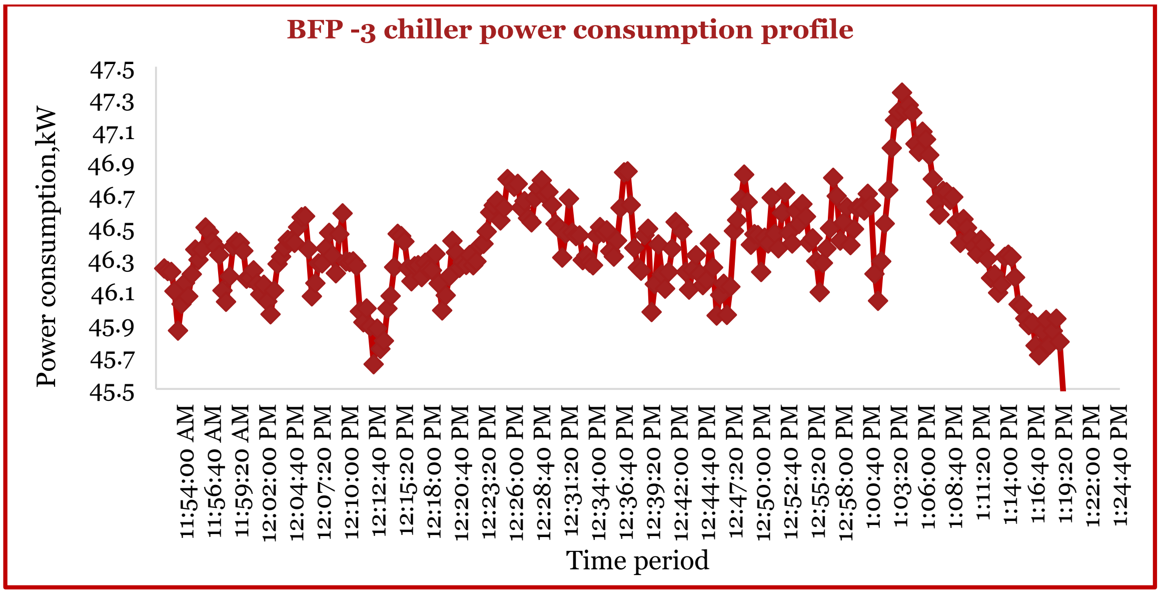
BFP -3-machine system arrangement diagram is as follows.

Figure 13: BFP -3-machine chiller system diagram



Power consumption profile recorded for the chiller units during the audit is as follows.

Figure 14 : BFP machine -3 chiller power consumption profile



Average chiller power consumption = 46 kW

The parameters collected in the chiller system is tabulated to evaluate the SEC of the chiller and the same is tabulated below.

Table 10 : BFP-3 machine chiller SEC estimation

Description	Units	Parameters
Supply chilled water temperature	°C	4
Return chilled water temperature	°C	7.5
Water flow rate	m^3/h	28
Power consumption of chiller	kW	46
Actual TR delivered by the chiller	TR	32
BFP machine power consumption	kW	195
	TR	55
Specific energy consumption	**kW/TR**	**1.4**

The SEC of the chiller is 1.4 kW/TR, which is very high compared to new screw chillers. As this chiller is old and SEC is also high. Hence this chiller is suitable for new replacement.

4.4.4. BFP -5 & 6

Blow film plant – 5 & 6 machines are same make and type, their production capacity is similar to each other. These machines manufacture 120-micron plastic films, which is used for packaging of 5-liter milk. These machines are installed two-year back, so these are very new in the plant and are fully automated. The production capacities of these machines are 600 kg/h each. The complete load details and actual parameters measured are as follows.

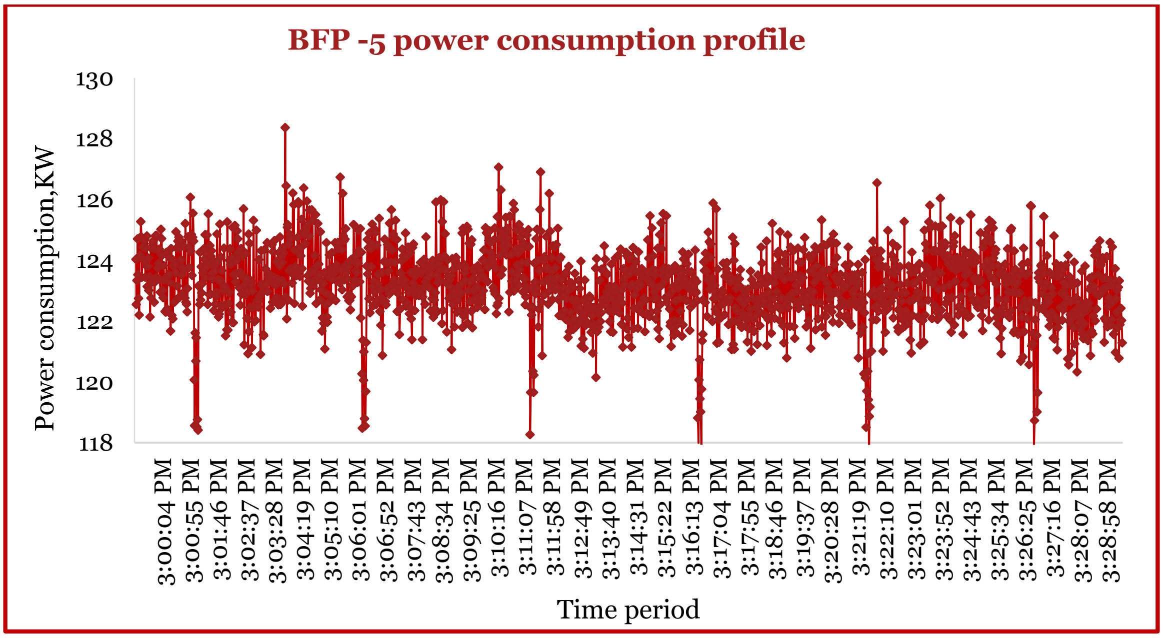
Table 11 : BFP machine -5 & 6 complete load details

Description	Units	BFP -5	BFP -6
Design details			
Inner Extruder	kW	90	90
Middle Extruder	kW	150	150
Outer Extruder	kW	90	90

Description	Units	BFP -5				BFP -6		
Design details								
Air Ring 1 Motor	kW				37			37
Air Ring 2 Motor	kW				11.5			11.5
Supply Air Motor	kW				11.5			11.5
IBC Outlet Motor	kW				11.5			11.5
Actual parameters								
Set temperature range	°C							185 - 212
Inner Extruder heater (A)	°C	60	185	195	205	210	212	212
Inner Extruder heater (B)	°C	85	180	195	208	212	215	215
Inner Extruder heater (C)	°C	72	185	195	205	208	210	212
Die heaters	°C	218	218	222	218	224	220	

The power consumption measurement done on the machine – 5 during the audit is as follows

Figure 15 : BFP machine -5 power consumption profile



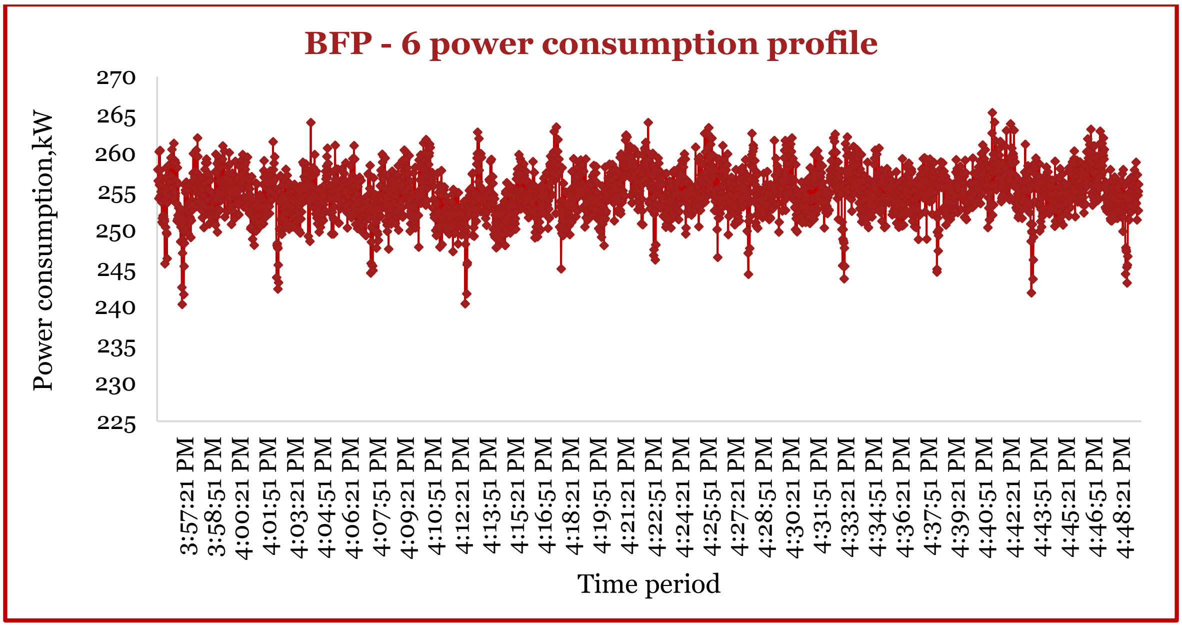
Machine running load during measurement = 400 kg/h

Machine minimum power consumption = 122 kW

Machine maximum power consumption = 126 kW

The power consumption measurement done on the machine – 6 during the audit is as follows

Figure 16 : BFP machine -6 power consumption profile



Machine running load during measurement	=	620 kg/h
Machine minimum power consumption	=	250 kW
Machine maximum power consumption	=	260 kW

BFP – 5 &6 chillers:

There are three set of chillers installed for each of machines for cooling the hot bubbles. Chilled air is required to cool the bubble in these machines due to high production capacity of machines and higher thickness of films manufactured. The design and operating details of these machine chillers are tabulated below.

Table 12 : BFP – 5 & 6-chiller analysis

Description	Units	BFP Machines	
Design details		**Machine - 5**	**Machine -6**
Make		EURO chillers	
Chiller -1			
Power consumption	kW	8	8
Current rating	Amps	13.5	13.5
Water temperature in condenser	°C	30	30
Air temperature to process	°C	15	15
Cooling capacity	kW	24	24
	TR	6.8	6.8
Chiller -2			
Power consumption	kW	54.5	54.5
Current rating	Amps	90	90
Water temperature in condenser	°C	30	30
Air temperature to process	°C	15	15
Cooling capacity	kW	168	168

Description	Units	BFP Machines	
Design details		Machine - 5	Machine -6
	TR	47.8	47.8
Chiller -3			
Power consumption	kW	14.5	14.5
Current rating	Amps	26	26
Water temperature in condenser	^oC	30	30
Air temperature to process	^oC	15	15
Cooling capacity	kW	45	45
	TR	12.8	12.8
Measured Parameters			
Chiller -1			
Power consumption	kW	7.5	7
Air temperature to process	^oC	17	16
Chiller -2			
Power consumption	kW	52	50
Air temperature to process	^oC	15	17
Chiller -3			
Power consumption	kW	13	14
Air temperature to process	^oC	15	15.5

4.5. Air compressor

There are three air compressors installed in the plant of which two compressors are water-cooled type and other one compressor is air-cooled type. All compressors are fitted with VFD. Of the three compressors installed in the plant, usually, one compressor works to meet the air demand of the plant.

Design details:

Make = Atlas Copco

Type = ZT 90 VSD

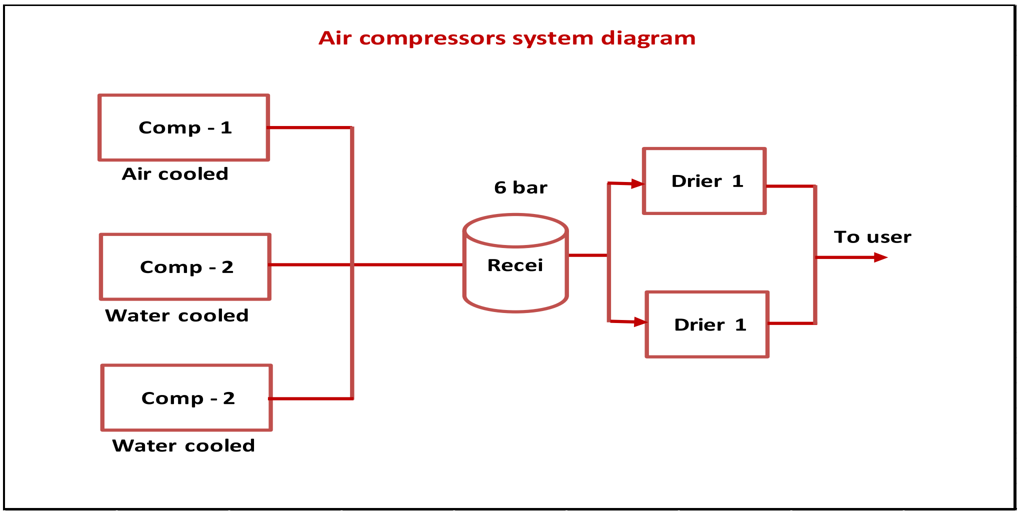
Maximum working pressure = 9 kg/cm^2

Input power = 90 kW

Speed = 2,810 rpm

The compressor system diagram is as follows.

Figure 17 : Air compressor system diagram

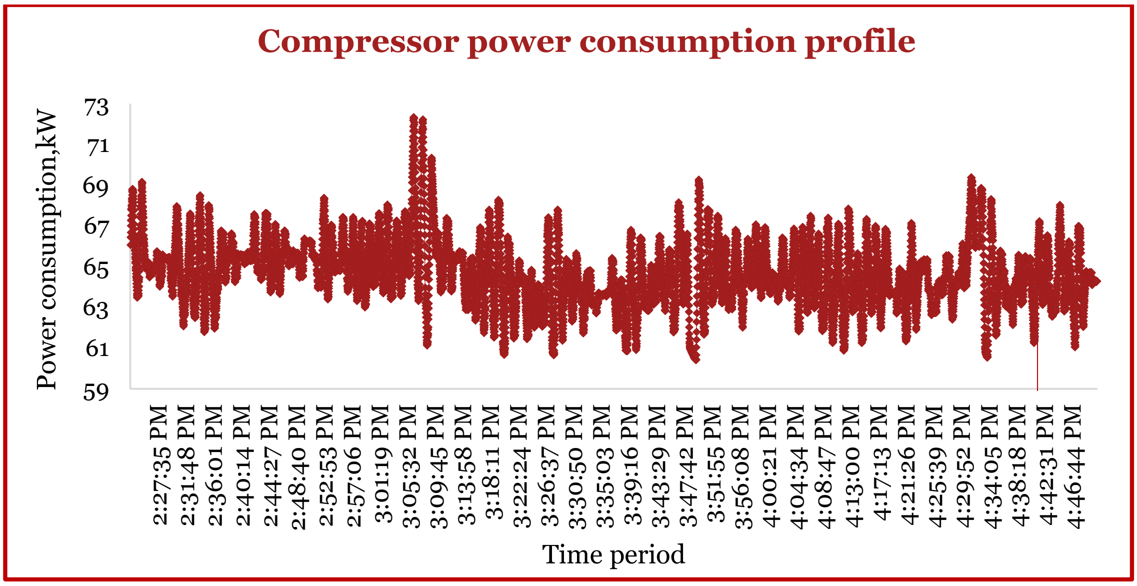


Operating details of the compressor is as follows

Outlet pressure	=	7.1 kg/cm²
Actual speed	=	2,535 rpm
Set point -1 for pressure	=	7.1 kg/cm²
Running hours	=	30,608 hours
Module hours	=	18,924 hours
Oil pressure	=	2.3 kg/cm²
Compressed air outlet temperature	=	43 °C

Power consumption profile recorded for the working compressor during the audit is presented below.

Figure 18 : Compressor power consumption profile



Power consumption of the compressor	=	61 – 72 kW
VFD frequency	=	40 Hz

4.6. Cooling water system

There are two cooling water system installed in the plant, one is near to utility room called as utility & machines cooling tower and other cooling tower is installed at terrace of new plant for BFP machines 5 &6. In machines, cooling water is used for die cooling in BFP machines and for oil cooling purpose in compressors.

4.6.1. Utility and machine cooling water system:

CT -1: Cooling tower -1 water is used for die cooling of machine – 1, 2 and 3. The capacity of this cooling tower is 35 TR. No design details were available for this cooling tower and associated pumps. Both cooling tower and pumps are working in ON/OFF mode.

Actual power consumption of the CW pump = 3.2 kW

CT -2: This cooling water is used only for compressor cooling as there are two water-cooled compressors installed out of which one will be working and other will be in standby mode.

CT design details:

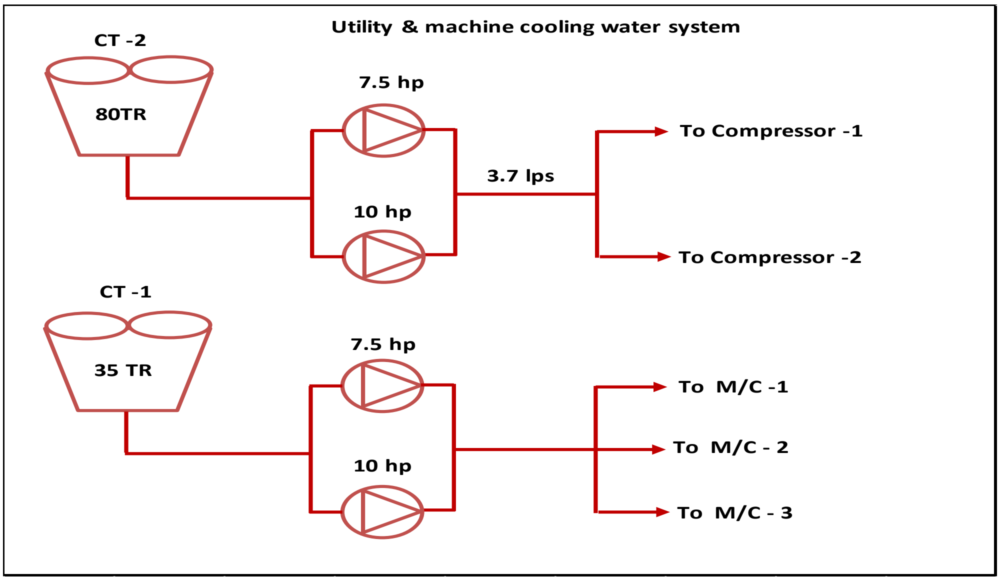
	Make	:	Advanced CT Pvt. Ltd
	Fan motor	:	2 hp
	Amps	:	3.7 Amps
	Operating temperature	:	35 °C

CW Pump design:

Make	:	KBL
Type	:	KDS 85- 2++
Head developed	:	16 m
Flow rate	:	3 lps
Power consumption	:	5.5 kW

The cooling water system -1 and 2 system diagram is as follows.

Figure 19 : Utility and machine cooling water system



Actual parameters measured at cooling water system are as follows.

Table 13 : Utility and machine cooling water pump efficiency estimation

Description	Units	Parameters
CT -2 Pump flow rate	m^3/h	13.32
Head developed	m	25
Power consumption	kW	4.8
Pump efficiency	%	19%

Efficiency of the pump is found to be very low due to ageing and it is observed that water was flowing to non-operating compressor as well.

4.6.2. BFP – 5 &6 machine cooling water system:

There are two cooling towers operating for BFP machines – 5 &6. CT -3 is dedicated only for machine -6 and CT – 4 is dedicated for machine 5. The cooling water system arrangement diagram is as follows.

Figure 20 : BFP machine – 5 & 6 cooling water system diagrams

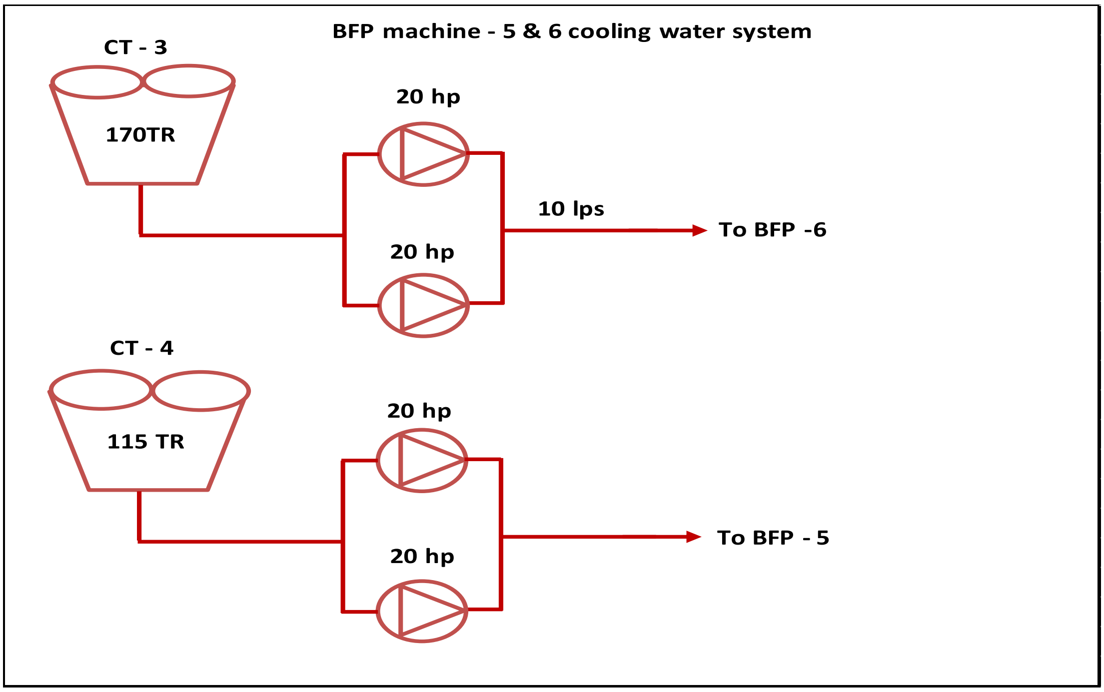


Table 14 : BFP – 5 & 6 machine cooling water pump efficiency estimation

Description	Units	Parameters
Design details		
Make		KBL
Type		KDS - 2050+
Water flow	m^3/h	79.2
Head developed	m	42
Power consumption	kW	16
Motor rating	kW	18.5
Pump rated efficiency	%	61

Operating parameters		CT -3	CT-4
Number of pumps operating	Numbers	2	2
Flow delivered by both pumps	m^3/h	36	72
Head developed	m	45	45
Power consumption of both pumps	kW	26	29
Overall efficiency	**%**	**17%**	**30%**
Efficiency of pump @95% of motor efficiency	**%**	**18%**	**32%**

The efficiency of the both cooling water pumps are found to be very low and these pumps are eligible for replacement.

4.7. Fresh air fans

There are fresh air fans installed in the plant at various locations, to supply fresh air to shop floor for human comfort. These fans are working at all times of the day for human comfort at shop floor. The location and number of fans installed at each location is as follows.

New printing project area = 4 fans each 40,000 cfm

Old printing area = 2 fans

BFP – 5 & 6 machine area = 2 fans each 40,000 cfm

The parameters measured and analysis done on the each unit is as follows.

New printing Area:

Table 15 : New printing area fresh air fans analysis

Description	Units	New printing project			
Design details		**Unit -1**	**Unit -2**	**Unit -3**	**Unit -4**
Make		Flakt India Pvt. Ltd			
Model		CCTU - 420			
Power consumption	kW	22.5			
Pressure	mmWg	650			
Air flow rate	cfm	40,000			
	m^3/h	68,000			
Actual parameters					
Ambient temperature measured	^oC	33.2			
Airflow delivered	m^3/h	62,000	60,000	59,000	63,000
Total airflow delivered by these units	m^3/h	2,44,000			
Area covered by these units	m^2	9,200			
Air changes per hour	**Numbers**	**27**			
Room temperature measured	^oC	34			
Power consumption	kW	18	17	18.5	16.5

Description	Units	New printing project			
Design details		Unit -1	Unit -2	Unit -3	Unit -4
Total power consumed by these units	kW	70			

Old printing Area:

Table 16 : Old printing area fresh air fans analysis

Description	Units	Old printing	
Design details		**Unit -1**	**Unit -2**
Make		Flakt India Pvt. Ltd	
Power consumption	kW	30	
Actual parameters			
Ambient temperature	°C	33.2	
Airflow delivered	m³/h	58,000	54,000
Total airflow delivered by these units	m³/h	1,12,000	
Area covered by these units	m²	12,000	
Air changes per hour	**Numbers**	**9**	
Room temperature measured	°C	35	
Power consumption	kW	26	23.5

BFP -5 & 6 machine area:

Table 17 : BFP – 5 & 6-area fresh air fans analysis

Description	Units	BFP - 5 & 6 Machines	
Design details		**Unit -1**	**Unit -2**
Make		Flakt India Pvt. Ltd	
Model		CCTU - 420	
Pressure	mmWg	650	
Air flow rate	cfm	40,000	
	m³/h	68,000	
Actual parameters			
Ambient temperature	°C	33.2	
Airflow delivered	m³/h	65,000	64,000
Total airflow delivered by these units	m³/h	1,29,000	
Area covered by these units	m²	6,900	
Air changes per hour	**Numbers**	**19**	
Power consumption	kW	16.5	15.5
Total power consumed by these units	kW	32	
Room temperature	°C	34	

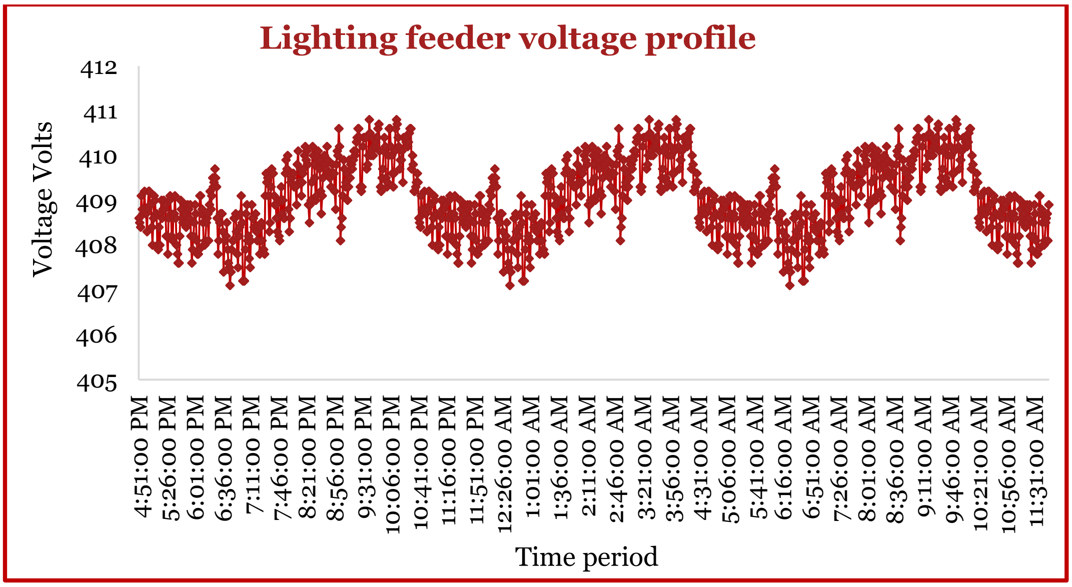
- The number of air changes maintained at the new printing area is 27 , which is found to be very high compared to the standard (As per ASHRAE standard, number of air changes for human comfort in shop floor is 8 – 12)
- The number of air changes maintained at the old printing area is 9 , which is found to be optimum compared to the standard (As per ASHRAE standard, number of air changes for human comfort in shop floor is 8 – 12)
- The number of air changes maintained at the BFP machine – 5 & 6 area is 19 , which is found to be very high compared to the standard (As per ASHRAE standard, number of air changes for human comfort in shop floor is 8 – 12)

4.8. Lighting

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

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

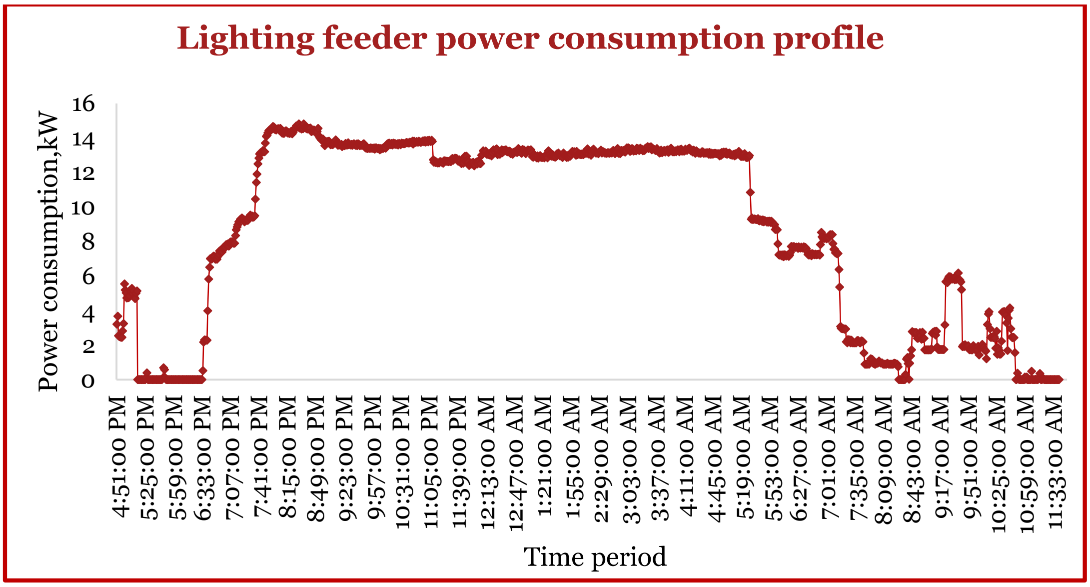
Figure 21 : Lighting operating voltage profile



Maximum lighting voltage during the recording period	=	411 Volts
Minimum lighting voltage during the recording period	=	407 Volts
Average lighting voltage during the recording period	=	410 Volts

Lighting power consumption profile:

Figure 22 : Lighting feeder power consumption profile



Maximum lighting consumption during the recording period	=	15 kW
Minimum lighting consumption during the recording period	=	4 kW

Lux level:

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

Table 18 : Plant lux level measurement

Area	Lux Measured
Office area	
Engineering office	230,213,290,276,256,190
AGM office	290,300,210,267,256,267
BFP -1 area	189,167,190,200,210,150
BFP -2 area	190,100,200,220,230,270,290,300
BFP -3 area	200,220,290,300,320,180,140,190
BFP – 4 area	190,160,170,190,200,220,270
BFP – 5 area	180,190,200,220,280,210,220
BFP -6 area	190,190,200,220,256,230,240,300
New printing area	200,230,250,270,260,230
Old printing area	190,160,150,190,200,220,217
Substation area	120,190,180,200,220,210

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

5. Energy Conservation Measures

5.1 Blow film plant

5.1.1 Replace old inefficient reciprocating chillers in BFP -3 with new screw chiller

Background

In BFP-3 machines, a chiller is installed for cooling hot bubble coming out from machine whereas for other machines like BFP – 1, 2 and 4; plastic bubble is cooled by ambient air only. The chiller operating for cooling the bubble is very old and reciprocating type. The operating details of chiller are measured to assess present operating SEC and the same is provided below.

Table 19 : BFP -3 reciprocating chiller present SEC

Description	Units	Parameters
Supply CHW temperature	ºC	4
Return CHW temperature	ºC	7.5
Water flow rate	m3/h	28
Power consumption of chiller	kW	46
Actual TR delivered by the chiller	TR	32
BFP machine power consumption	kW	195
	TR	55
Specific energy consumption	**kW/TR**	**1.4**

Findings

The specific energy consumption of this chiller is very high compared to new energy efficient screw chillers. A new screw chiller will have specific energy consumption of 0.6 kW/TR.

Recommendation

Replace present inefficient reciprocating chiller with new energy efficient screw chiller which will consume less energy compared to existing chiller.

Energy & financial savings

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

Table 20 : BFP - 3 chillers replacement saving and investment estimation

Description	Units	Parameters
Present system		
Supply CHW temperature	ºC	4
Return CHW temperature	ºC	7.5
Water flow rate	m3/h	28
Power consumption of chiller	kW	46

Description	Units	Parameters
Actual TR delivered by the chiller	TR	32
BFP machine power consumption	kW	195
	TR	55
Specific energy consumption	**kW/TR**	**1.4**
Proposed system parameters		
SEC of proposed chiller compressor	kW/TR	0.6
SEC of the chiller compressor considered for saving	kW/TR	0.7
Proposed chiller capacity	TR	55
Proposed power consumption of chiller	kW	38.5
Proposed load on chiller	TR	32
Proposed power consumption as per load	kW	23
Power consumption saved	kW	23
Annual operating hours	Hours	8,400
Annual energy saved	**kWh**	**195,844**
Power cost	Rs/kWh	5.75
Annual cost saved	**Rs. Lakhs**	**11.26**
Investment required for chiller	**Rs. Lakhs**	**8.0**
Payback period	**Months**	**8.5**

5.2 Cooling water system

5.2.1 Replace BFP – 5 & 6 cooling water pumps with energy efficient pump

Background

BFP – 5 & 6 machines are installed with cooling water system to supply cooling water to the different application during machines operation. Each machine is having separate cooling towers and pumps. The details of the cooling water system are as follows.

Table 21: BFP – 5 &6 CW pump efficiency evaluation

Description	Units	Parameters	
Design details			
Make		KBL	
Type		KDS - 2050+	
Water flow	m^3/h	79.2	
Head developed	m	42	
Power consumption	kW	16	
Motor rating	kW	18.5	
Pump rated efficiency	%	61	
Operating parameters		**BFP - 5**	**BFP - 6**
Number of pumps operating	Number	2	2

Description	Units	Parameters	
Design details			
Flow delivered by both pumps	m^3/h	36	72
Head developed	m	45	45
Power consumption of both pumps	kW	26	29
Overall efficiency	**%**	**17%**	**30%**
Efficiency of pump @95% of motor efficiency	**%**	**18%**	**32%**

The actual flow required for the each machines operation is

Machine extruder = 78 lpm

Evaluation takeoff = 70 lpm

Chillers -1,2 and 3 = 845 lpm

The total cooling water flow requirement for one machine when working in full load is 63 m^3 /h.

Findings

The efficiency of cooling water pumps are found to be very low due to mismatch in design and operating parameters. Actual water flow in to the BFP -5 machine is less than rated and due to less water flow; the power consumption of machine will increase due to excess heat.

Recommendation

Replace the existing cooling water pumps with new energy efficient water pumps with following design parameters

Flow required = 63 m^3/h

Head = 40 m

Energy & financial savings

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

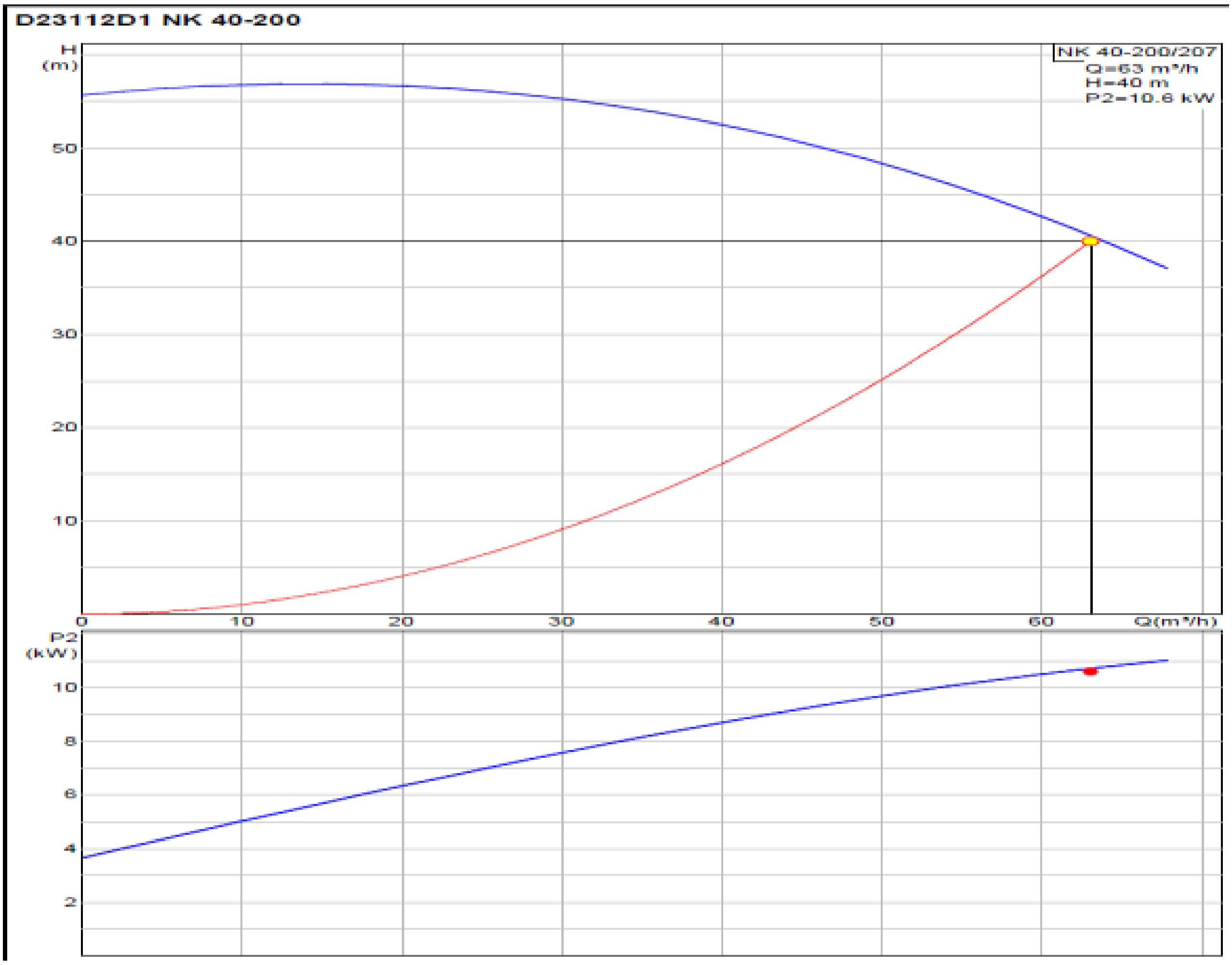
Table 22: BFP – 5 & 6 CW pump replacement saving and investment estimation

Description	Units	Parameters	
Design details			
Make		KBL	
Type		KDS - 2050+	
Water flow	m^3/h	79.2	
Head developed	m	42	
Power consumption	kW	16	
Motor rating	kW	18.5	
Pump rated efficiency	%	61	
Operating parameters		**CT -3**	**CT-4**
Number of pumps operating	Number	2	2

Description	Units	Parameters	
Flow delivered by both pumps	m3/h	36	72
Head developed	m	45	45
Power consumption of both pumps	kW	26	29
Efficiency of pump	%	17%	30%
Overall efficiency @95% of motor efficiency	%	0.18	0.32
Proposed parameters			
Water flow required in each machines			
Extruder	Lpm	78	
Evaluation takeoff	Lpm	70	
Chillers	Lpm	845	
Total water flow required	Lpm	1,049	
Total water flow required	m3/h	62.94	
Head requirement	m	40	
New pump parameters			
Make		Grundfos	
Model		NK 40-200/207	
Pump power consumption	kW	10.6	
Motor rating	kW	11.5	
Number of pumps required	Numbers	2	
Total power consumption of proposed pumps	kW	21.2	
Power consumption saved by pump replacement	**kW**	**33.8**	
Annual operating hours	Hours	8,400	
Annual energy saved	**kWh/annum**	**283,920**	
Power cost	Rs/kWh	5.75	
Annual cost saved	**Rs. Lakhs**	**16.32**	
Investment for new pump with VFD	**Rs. Lakhs**	**16.0**	
Payback period	**Months**	**12**	

New proposed pump curve is as follows.

Figure 23 : BFP – 5 & 6 new proposed pump performance curve



5.2.2 Arrest CW water flow into non-operating air compressors and install common CW system for machines, air compressor and other utilities

Background

There are two separate cooling towers installed near substation to cater cooling water for utilities and machines. The utility cooling tower serves water only for air compressors. In addition, machine-cooling tower serves water for machines – 1, 2 and 3. Air compressor cooling tower and pumps are working continuously when compressors runs and machine cooling tower and pump works in OFF and ON mode depending on user end temperature requirement.

Utility cooling tower pump operating details:

Table 23 : Utility CW pump efficiency estimation

Description	Units	Parameters
CT -2 Pump flow rate	m^3/h	13.32
Head developed	m	25
Power consumption	kW	4.8
Pump efficiency	%	19%

Machine cooling tower pump operating details:

Pumps design details were not available, and pump operating in ON /OFF mode. Also, water flow measurement was not possible during audit due to lack of provision.

Findings

There are two compressors installed out of which one works during normal working hours, but cooling water was found flowing to non-operating air compressor as well which is not required.

The machine cooling tower is small (35TR) in size and operating in ON/OFF mode. There was no CT fan in this cooling tower. Instead, external fan was provided to supply air from one side of CT, which was not effective.

Recommendation

Switch off machine-cooling tower and operate only air compressor cooling tower for both compressors and machines. Arrest the CW flow to non-operating compressors by installing control valve at both air compressors, which should open when compressor switches ON and closes when compressor switches OFF.

Note: Check the water flow of machine CW pumps before implementing this recommendation.

Energy & financial savings

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

Table 24 : Utility and machine CW pump operation and automation saving estimation

Description	Units	Parameters
Present operating details		
CT -2 Pump flow rate	m^3/h	13.32
Head developed	m	25
Power consumption	kW	4.8
Pump efficiency	%	19%
CT -1 capacity	TR	35
CT fan rating	kW	1.5
CT pump rating	kW	3.2
Proposed operating details		
CT proposed to operate		CT -2
Capacity of CT	TR	85
Proposed flow rate of pump	m^3/h	13.32
Head developed	m	25
Power consumption saved by CT -1 switch off	kW	4.7
Power consumption saved by arresting water flow to non-operating compressor	kW	1.8
Annual operating hours	Hours	8,400
Annual energy saved	**kWh**	**15,120**
Power cost	Rs/kWh	5.75
Annual cost saved	**Rs. Lakhs**	**0.86**
Installation cost for ON/OFF controller and VFD on compressor	**Rs. Lakhs**	**1.00**
Payback period	**Months**	**14**

5.3 Fresh air fans

5.3.1 Install VFD to all fresh air fans

Background

There are fresh air fans installed at the different area of the plant, to maintain the airflow and temperature in the shop floor for the human comfort. These units are working throughout the day (all three shifts) to supply air for human comfort in shop floor.

The details of the units with number of air changes maintained, ambient temperature, room temperature and other details are tabulated as below.

Table 25 : Fresh air fans air changes estimation

Description	Unit's	Parameters
Design details		
New printing area		
Number of units installed	Numbers	4
Number of units operating	Numbers	4
Ambient temperature in day time	°C	33
Ambient temperature in night time	°C	28
Room temperature during day time	**°C**	**34**
Room temperature during night time	**°C**	**28**
Number of air changes	**Numbers**	**27**
Old printing area		
Number of units installed	Numbers	2
Number of units operating	Numbers	2
Ambient temperature in day time	°C	33
Ambient temperature in night time	°C	28
Number of air changes	**Numbers**	**9**
Room temperature during day time	**°C**	**35**
Room temperature during night time	**°C**	**29**
BFP - 5 & 6 area		
Number of units installed	Number	2
Number of units operating	Number	2
Ambient temperature in day time	°C	33
Ambient temperature in night time	°C	28
Number of air changes	**Numbers**	**19**
Room temperature during day time	**°C**	**34**
Room temperature during night time	**°C**	**28**

Findings

The number of air changes maintained at the new printing machine and BFP – 5 & 6 machines area is very high compared to the ASHRAE standard. (ASHRAE standard for fresh air supply to shop floor). As per ASHRAE standard, number of air changes need to maintain at shop floor is 8 to 12.

There is a lot of temperature variation in the Gandhinagar city, from one season to other season and from day to night. These units are supposed to work as per the seasonal ambient temperature variation and number of air changes required to maintain in shop floor.

Presently there is no control on the fan motor to vary airflow rate as per ambient temperature, due to this reason these units are working at constant speed throughout the year, with same speed which is not required.

Recommendation

Install VFD control on these fresh air fan units to maintain the airflow rate as per ASHRAE standards and to vary airflow rate &temperature as per ambient temperature.

In the daytime, since ambient temperature will be more, the VFD frequency may be increased to increase the airflow rate to maintain human comfort requirement. During nighttime ambient temperature will be less, during this time VFD frequency can be reduced. Adopting this mechanism will maintain the required temperature in shop floor and saves the energy consumed by these fan units.

Energy & financial savings

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

Table 26 : VFD installation on fresh air fan saving and investment estimation

Description	Units	Parameters
Design details		
New printing area		
Number of units installed	Number	4
Number of units operating	Number	4
Number of air changes	Numbers	27
Old printing area		
Number of units installed	Numbers	2
Number of units operating	Numbers	2
Number of air changes	Numbers	9
BFP - 5 & 6 area		
Number of units installed	Numbers	2
Number of units operating	Numbers	2
Number of air changes	Numbers	19
Proposed parameters		
Proposed number of air changes	Numbers	8 to 12
Air changes considered for calculation	Numbers	12
Proposed airflow rate in new printing area	m^3/h	110,400
Proposed airflow rate in BFP - 5 & 6 area	m^3/h	82,800
Reduction in airflow due to VFD for new printing area units	m^3/h	133,600
Reduction in airflow due to VFD for BFP - 5 & 6 area units	m^3/h	46,200

Description	Units	Parameters
Power consumption saved in new printing area units	kW	38.3
Power consumption saved in BFP - 5 & 6 area units	kW	11.5
Annual operating hours	Hours	8,400
Annual energy consumption saved	**kWh**	**418,320**
Power cost	Rs./kWh	5.75
Annual cost saved	**Rs. Lakhs**	**24.05**
Investment for VFD's	**Rs. Lakhs**	**15.60**
Payback period	**Months**	**7.7**

5.4 Lighting

5.4.1 Install lighting energy saver to lighting feeder

Background

Lighting is one of the major load in plant and consumes roughly 2% of total energy consumption of the plant. There is three separate feeder installed for the lighting, through which power is supplied to all lighting DB's.

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

Lighting energy consumption per day = 553 kWh /day

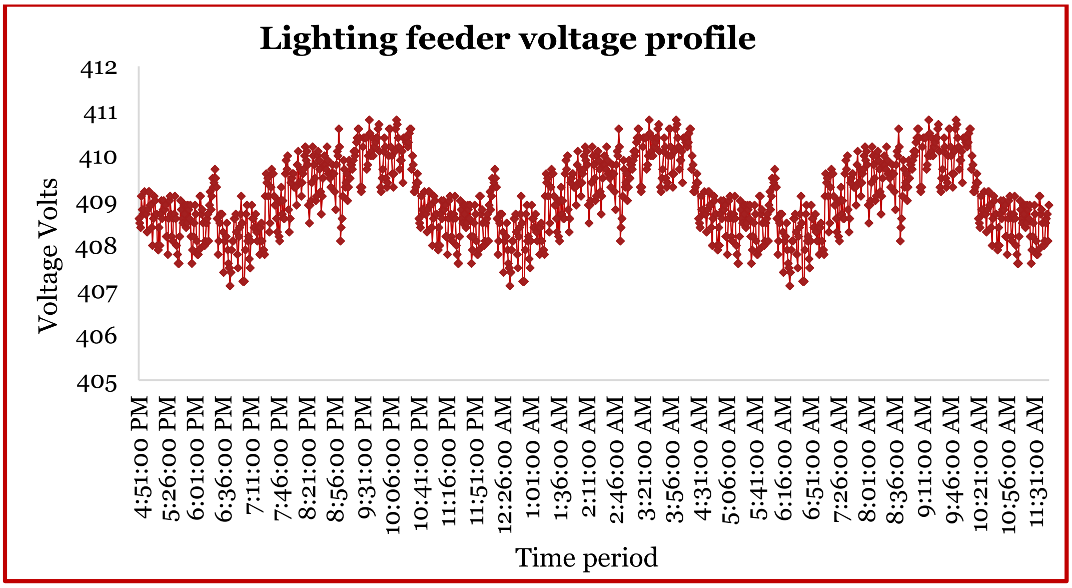
Note: Lighting consumption data is collected from plant officials

Findings

The voltage profile recorded for lighting feeder during audit shows that lighting is operated with a voltage of 407 volts to 411 volts, which is very high.

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

Figure 24 : Lighting feeder voltage profile



The lighting can be operated at 370- 380 volts and reduction in lighting voltage at lighting feeder will have slight impact on the lux level.

Recommendation

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

Energy & financial savings

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

Table 27 : Lighting energy saver saving and investment estimation

Description	Units	Parameters
Actual parameters		
Actual voltage recorded in lighting feeder	Volts	407-411
Lighting energy consumption per day	kWh	553
Proposed parameters		
Proposed lighting voltage	Volts	370 – 380
Expected power saving by saver	%	20%
Actual energy consumption saving per day	kW	110
Operating days per year	Days	350
Annual energy consumption saved	**kWh**	**38,710**
Energy cost	Rs/kWh	5.75
Annual cost saved	**Rs. Lakhs**	**2.22**
Investment for Lighting energy saver	**Rs. Lakhs**	**3.00**
Payback period	**Months**	**16.2**

5.5 Use of Renewable Energy Sources

The plant depends only on the conventional energy sources for meeting its energy demands. Electricity and diesel are the dominant sources of energy and contributor to the total energy costs. During the 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.

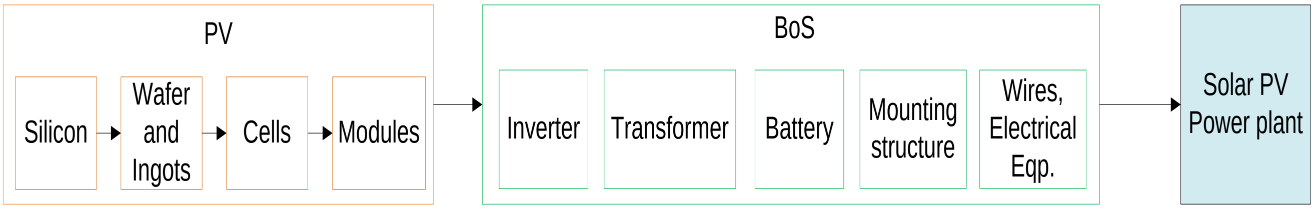
5.5.1 Solar PV system

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 3,500 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 25: 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.

5.5.2 Solar assessment in PFP plant - Gandhinagar

For the solar resource assessment, we will rely on the publicly available solar irradiation data provided by the National Aeronautics and Space Administration (NASA). The data has been measured over a 22-year period and is based on highly reliable modelling techniques using information on cloud cover, atmospheric water vapour and gases, and the amount of colloids in the upper atmosphere. For PFP plant in Gandhinagar area, the details of the site and the data is as follows:

Table 28: Physical features of the PFP plant - Gandhinagar

Parameters	Unit	Climate data location
Latitude	°N	23.22
Longitude	°E	72.68
Elevation	m	129
Heating design temperature	°C	15.39
Cooling design temperature	°C	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 PFP 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 29: Average monthly insolation data

Month	Daily solar radiation horizontal (kWh/m²/d)	Air Temperature (°C)	Winds Speed (m/s)	Relative Humidity (%)
January -15	4.5	21.1	3.5	34.30%
February -15	5.12	23.3	3.6	29.60%
March -15	5.96	28.3	3.6	25.50%
April-15	6.41	31.4	4	29.60%
May -15	6.59	32.3	4.6	40.80%
June-15	5.93	30.4	4.2	61.40%
July-15	4.73	28.1	3.7	75.20%
Aug-15	4.49	27.7	3.3	73.70%

Month	Daily solar radiation horizontal (kWh/m²/d)	Air Temperature (°C)	Winds Speed (m/s)	Relative Humidity (%)
September-15	5.14	28.6	3	60.80%
October -15	5.12	28.8	2.8	39.70%
November -15	4.55	25.9	3	29.70%
December -15	4.15	22.4	3.3	33.00%
Annual average	**5.22**	**27.4**	**3.6**	**27.4%**

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

On the basis of availability of 3,500 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 30: 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	291.6	233.3
Capacity Utilization Factor	%	18%	18%
Useful Life	Years	20	20
Net Electricity Generation	MWh/year	459.89	367.8
Tentative capital cost of project (after 15% MNRE capital cost subsidy)	Rs. Lakhs	198.3	158.6
Net monetary electricity savings	Rs. Lakhs/year	20.0	16
Simple payback period	Months	119	119

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.

6. Annexure

6.1 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 31: 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

6.2 List of suppliers

The objective of the mapping of suppliers is to provide guidance to the plant 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 32 : Vendor details for recommended saving solution

Equipment/ Technology	Product	Manufacture/ Brand	Location with 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, Nr Girish Cold drinks cross roads, Off. C. G. Road, Ahmedabad - 380009 Tel.: +91 (079) 30927600/40207600
Screw chiller	Chiller comp	Voltas	**Voltas Limited** 301, Shivalik Corporate Park, 132 Ft Ring Road Behind IOC Petrol Pump, Satellite city Ahmedabad – 380015
CW pump	Pump	Kirloskar	**Kirloskar Brothers Limited** Shop No. 107, 1st Floor, Swapneel - 5, Near Commerce Six Roads, Drive in Rd, Sarvottam Nagar Society Navrangpura , Ahmedabad - 380009
	Pump	Grundfos	**Grundfos India Private Limited** 11, Mill Officer Colony, Behind La Gajjar Chamber, Ashram Road, Ashram Road, Ahmedabad. Phone : 079 2657 4802
Lighting		Schneider	**Schneider electric India Private Limited**

Equipment/ Technology	Product	Manufacture/ Brand	Location with address
	Lighting energy saver		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 Phone: +91-4344-276358 / 278658 Mobile: +91-9443376558

** 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.*

DISCLAIMER: