February 2019

DETAILED ENERGY AUDIT REPORT

M/s Trivandrum Dairy Plant – Kerala Dairy Cluster

Submitted to
(Prepared under GEF-UNIDO-BEE Project)

Bureau of Energy Efficiency

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Prepared by

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Bureau of Energy Efficiency, 2019

This Detailed Energy Audit Report has been originally prepared by Confederation of Indian Industry as a part of Cluster level activities in Dairy Sector (Kerala & Sikkim Cluster) under the GEF-UNIDO-BEE project 'Promoting Energy Efficiency and Renewable Energy in selected MSME clusters in India'.

GEF-UNIDO-BEE Project, Bureau of Energy Efficiency, 2019

"Cluster level activities in Dairy Sector (Kerala & Sikkim Cluster) "

For more information

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

BEE	Bureau of Energy Efficiency
BOP	Best Operating Practice Document
CS	Capital Structure
°C	°Celsius
CO_2	Carbon dioxide
CIP	Cleaning in Process
CMP	Common Monitorable Parameters
DEA	Detailed Energy Audit
EE	Energy Efficiency
FCU	Fan Coil Unit
FI	Financial Institution
GEF	Global Environmental Facility
HSD	High Speed Diesel
kW	Kilo Watt
LSP	Local Service Provider
MSME	Micro and Medium Scale Industries
OEM	Original Equipment Manufacturer
RE	Renewable Energy
TOE	Tonnes of Oil Equivalent
UNIDO	United Nations Industrial Development Organisation
VFD	Variable Frequency Drive

ACKNOWLEDGEMENT

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CII also thanks Mr. Jamshed P Umar, Cluster leader for Kerala Dairy cluster for the continuous support extended all throughout this activity.

We also take this opportunity to express our appreciation to the Original Equipment Suppliers and Local Service Providers for their support in giving valuable inputs and ideas for the completion of the Detailed Energy Audit Report.

We would also like to mention that the valuable efforts being taken and the enthusiasm displayed towards energy conservation by the Kerala Dairy Cluster is appreciable and admirable.

1. EXECUTIVE SUMMARY

Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India, in collaboration with United Nations Industrial Development Organization (UNIDO) is executing a Global Environment Facility (GEF) funded national project "Promoting energy efficiency and renewable energy in selected MSME clusters in India".

The overall aim of the project is to develop and promote a market environment for introducing energy efficiency and enhanced use of renewable energy technologies in process applications in 12 selected energy-intensive MSME clusters across 5 sectors in India (with expansion to more clusters later). This will enable improvement in the productivity and competitiveness of units, as well as reduce overall carbon emissions and improve the local environment.

The major activities associated with project are

- Interact closely with cluster associations to identify their technology and service needs and mapping of the cluster units, based on which a pre-activity workshop would be organized
- Assess the present capacity, strengths, weaknesses and training needs of MSME units from the perspective of their needs for EE/RE technologies
- A form will be prepared for inviting expression of interest from cluster units for carrying out energy audits
- Conduct detailed energy audits in MSME units decided in mutual agreement with the cluster association.
    - Make a final presentation to the respective units on energy audit findings seeking their consent on EE & RE findings
    - Prepare final report including the accepted findings
- Prepare cluster specific energy benchmarking report covering complete product range with comparison to available international standards.
- Identify and enumerate common regularly monitorable parameters (CMP) at the process level which have impact on energy performance. This will include:
    - List of appropriate instrumentation with 3 options including make, supplier, indicative costs, specifications and accuracy of measurements.
- Develop a high quality poster based on the CMP document to disseminate the information at unit level.
- Develop a cluster specific high quality ready to publish Best Operating Practices (BOP) document for the energy consuming equipment/ process in the industry cluster on the basis of:
    - Process / technology used in the cluster
    - Energy audit findings
    - Discussions with at least 3 subject matter experts in/around the cluster

    - Discussions with at least 2 equipment suppliers for each equipment
- Identify set of energy auditing instruments that should be used for carrying out periodic energy audits in the units. This will include:
    - Minimum 3 sets of options including make, supplier, indicative costs, specifications, accuracy of measurements including quotations.
- Conduct post energy audit training workshops in the cluster. For this:
    - The training programs would be customized based on the needs of the MSMEs, covering EE and RE topics
- Prepare and design ready to print case-studies prepared under the project based on the content provided by the PMU

Project deliverables, linked to the above activities, will be as follows:

- Proceedings of pre-activity workshop.
- Unit specific comprehensive energy audit reports, with copies submitted to unit and BEE.
- Cluster specific benchmarking report with complete product range with comparison to international standards.
- Cluster specific list of common regularly monitorable parameters with ranges and suggested instrumentation to monitor, and also compile the information in the form of high quality poster.
- Cluster specific custom designed ready to publish best operating practices document
- Cluster specific list of energy audit equipment along with minimum three quotations
- Proceedings of post energy audit training workshops
- Custom designed, ready to publish case-studies.

The main outcomes expected at the end of the project are,

1. Creating a scope for energy savings, by increasing the level of end-use demand and implementation of energy efficiency and renewable energy technologies
2. Improving the productivity and competitiveness of units
3. Reducing overall carbon emissions and improving the local environment
4. Increasing the capacity of energy efficiency and renewable energy product suppliers,
5. Strengthening policy, institutional and decision-making frameworks
6. Scaling up of the project to a national level

1.1 Brief Unit Profile

Table 1: Unit Details

Particulars	Details
Name of Plant	Thiruvananthapuram Dairy Plant
Name(s) of the Plant Head	Mr. T. Sreenivas, Senior Manager
Contact person	Balasubramony. G
Constitution	Cooperative Society
MSME Classification	Medium Scale
Address:	Milma, Thiruvananthapuram Dairy, Ambalathara, Poonthura.P.O, Thiruvananthapuram-26
Industry-sector	Dairy

The plant has incorporated several energy conservation aspects in the design stage itself resulting in energy efficient operation. Subsequently more measures have also been identified and implemented.
Some of the important energy conservation measures implemented are as below.

- Use of LED Lighting and star rated ACs
- Installation of Evaporative Condenser
- Use of Solar thermal for Boiler Feed Water Heating
- Optimized voltage at Main Incomer
- Maintaining PF close to Unity
- Use of Briquette Fired Boiler
- Use of Screw Compressors

CII – Godrej GBC Energy Audit Team conducted Detailed Energy Audit at Thiruvananthapuram Dairy Main Plant from 25th July 2018 to 28th July 2018 and final presentation to plant team was given on 28th July 2018.

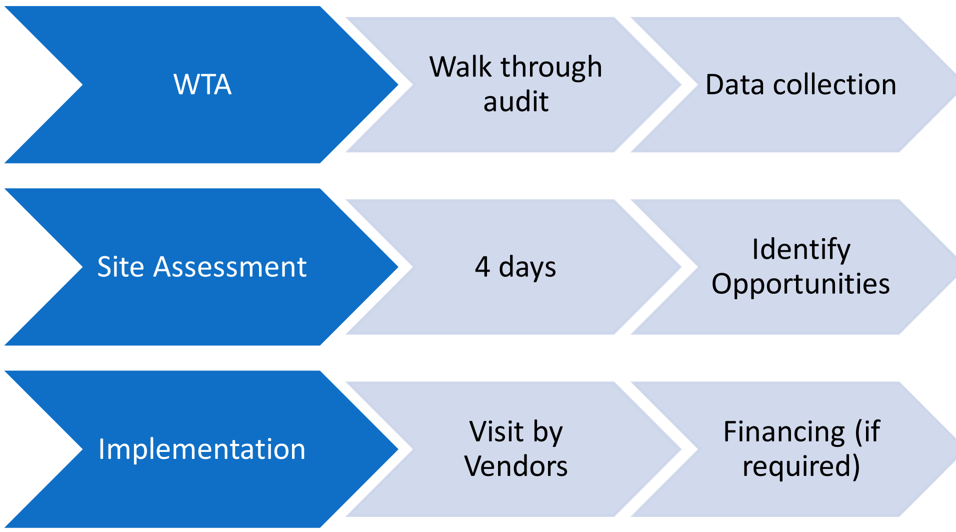
The energy audit included detailed data collection, power measurements of major electrical energy consumers, process measurements, analysis of data, and performance analysis of the equipment and identification of specific energy saving proposals.

Electricity energy for the plant is purchased from Kerala State Electricity Board. For thermal energy, plant is using Briquette, HSD, Furnace Oil as the fuels.

1.2 Methodology and Approach

The methodology adopted for energy audit starts from historical energy data analysis, power quality analysis, monitoring of operational practices, system evaluation and cost benefit analysis of the energy conservation opportunities and prepare plan for implementation. The proposals given in the report includes economical energy efficiency measures to reduce facilities unnecessary energy consumption and cost. The energy conservation options, recommendations and cost benefit ratio, indicating payback period are included in this report.

Approach for the energy audit adopted is shown below:



1.3 Summary of Savings

Trivandrum Dairy plant team and CII energy team have together identified an annual energy saving potential of Rs. 37.47 Lakhs with an investment of Rs.64.12 Lakhs based on energy cost.

Table 2: Summary of savings

Details	No. of Proposals	Annual savings
Total Annual savings	14	37.47
Investment Required (Rs. Lakhs)	13	64.12
Pay Back	Months	21

Table 3: Summary of fuel savings

Details	UOM	Annual savings
Total Electricity Savings	kWh	2,85,572
Total Fuel Savings (Briquette)	Kgs	3,22,641
Annual TOE Savings	TOE	153.6
Annual $MTCO_2$	$MTCO_2$	234.2

Table 4: Summary of Energy Saving Proposals

Sl. No.	ECM	Annual savings (lakhs)	Investment (lakhs)	Payback	Electricity Savings (kWh)	Fuel Savings (kg Briquette)	TOE savings	MTCO2 savings
1	Installation of condensate recovery system	7.41	11.82	19		1,12,348	44.9	
2	Installation of Automatic Pumping Trap for CIP Section	0.98	1.50	18		11,772	4.71	
3	Installation of VFD for ID Fan in 3TPH Boiler	0.31	0.55	21	5640		0.49	4.60
4	Waste heat recovery from chiller compressor	13.10	21.00	19		1,98,521	79.4	0.00
5	Replacement of existing chilled water pumps with energy efficient pumps	1.84	1.65	11	32744		2.82	26.90
6	Replacement of Ceiling fans with BLDC fans	0.78	2.10	32	13961		1.20	11.40
7	Replacement of existing compressor with Screw Compressor	0.67	1.48	27	12000		1.03	9.80
8	Reduce the Generating Pressure of Main Plant Compressor and Product Dairy Compressor	1.02	0.00	0	18270		1.57	15.0
9	Install VFD for Main Plant Compressor to avoid unloading	2.00	2.00	12	36096		3.10	29.6
10	Installation of temperature interlock control for EVAPCO fans	0.65	0.60	11	11556		0.99	9.50
11	Replace Identified Motors with Energy Efficient Motors	3.94	3.89	12	70065		6.03	57.5
12	Replacement of T8 and T12 light with LED	1.37	1.56	14	24430		2.10	20.0
13	Installation of AC Energy Savers	0.95	0.97	12	17010		1.46	13.9
14	Installation of 30 kWp Solar Roof Top PV	2.45	15.00	73	43800		3.77	35.9
	Total	**37.47**	**64.12**	**21**	**2,85,572**	**3,22,641**	**153**	**234**

2. INTRODUCTION ABOUT TRIVANDRUM DAIRY PLANT

2.1 Unit Profile

Kerala Co-operative Milk Marketing Federation (KCMMF) was formed in 1980 as a state adjunct of the National Dairy Programme 'Operation Flood'. It is a three-tiered organization. At the grassroots level MILMA has 3206 Anand model primary milk co-operative societies as on 31.03.2015 with 9.24 lakh local milk producing farmers as members.

Thiruvananthapuram Dairy is located on the way to Kovalam, 4 Km from the city. The Dairy with a capacity to handle 1 lakh LPD was commissioned in 1992. The Dairy is selling milk in Thiruvananthapuram District except Chirayinkeezh Thaluk. Thiruvananthapuram Dairy started to collect the entire milk through Bulk Milk Coolers since November 2009. The capacity of the Dairy has been expanded to 2 Lakh litres per day by 2001 Now it is proposed to expand the capacity to 3 Lakh litres per day. In addition, a separate block for manufacture of Products is proposed to be constructed. Thiruvananthapuram is the first "ISO 2001" certified Dairy in the State and all steps have been initiated to get HACCP for Thiruvananthapuram Dairy.

Table 5: Unit Profile

Particulars	Details
Name of Plant	Thiruvananthapuram Dairy Plant
Name(s) of the Plant Head	Mr. T. Sreenivas, Senior Manager
Contact person	Mr. Balasubramany.G
Contact Mail Id	milmatdengg@gmail.com
Contact No	+91 9633802195
Constitution	Cooperative Society
MSME Classification	Medium Scale
No. of years in operation	26
No of operating hrs/day	15
No of operating days/year	365
Address:	Milma, Thiruvananthapuram Dairy, Ambalathara, Poonthura P.O., Thiruvananthapuram-695026
Industry-sector	Dairy
Type of Products manufactured	Milk & Milk Products

2.2 Production Details

The various products manufactured in Thiruvananthapuram Dairy Plant are liquid milk, Ghee, Curd, Butter, Paneer and Ice cream. The graph below shows the milk processed during last one year:

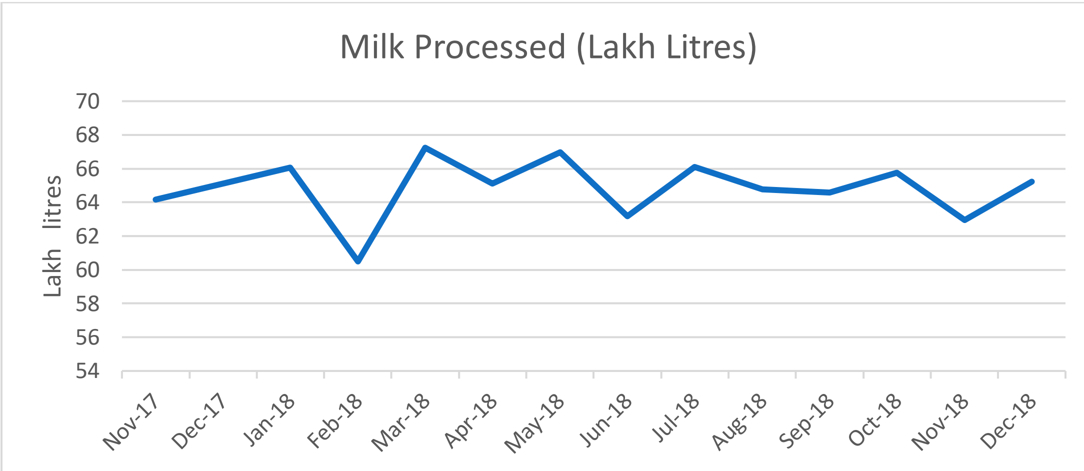


Figure 1: Milk Processed

2.3 Dairy Process Flow Diagram

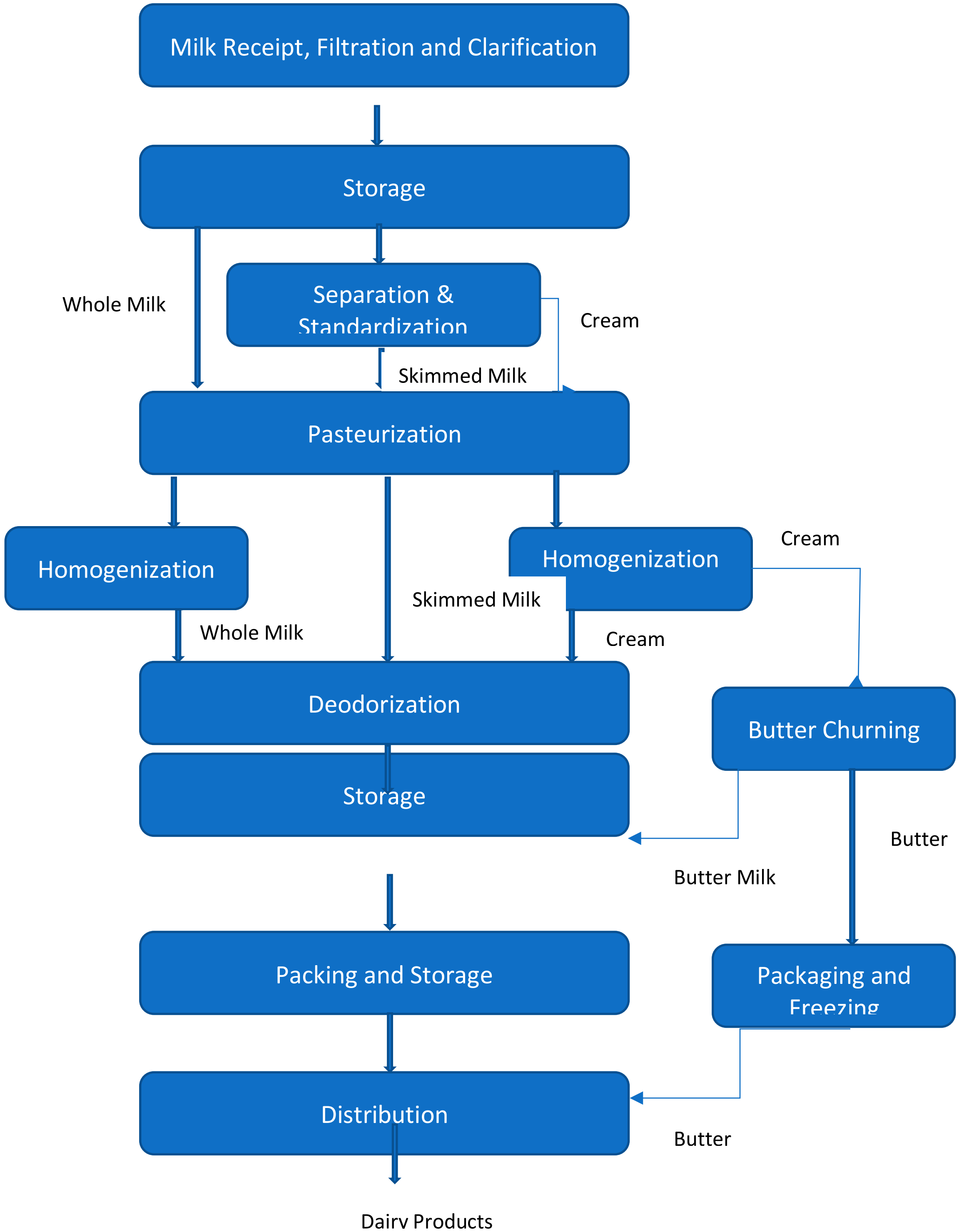


Figure 2: Typical process flow of Milk manufacturing

The processes taking place at a typical milk plant after receiving and filtration of milk from the chilling units includes:

Separation: After being held in storage tanks at the processing site, raw milk is heated to separation temperature in the regeneration zone of the pasteurizer. The milk (now hot) is standardized and homogenized by sending it to a centrifugal separator where the cream fraction is removed. The skim is then usually blended back together with the cream at predefined ratios so that the end product has the desired fat content. Surplus hot cream is cooled and usually processed in a separate pasteurizer ready for bulk storage and transportation to a cream packing plant.

Pasteurization is a process of heating milk to 77°C for 15seconds then quickly cooling it to 4°. This process slows spoilage caused by microbial growth in the food. Unlike sterilization, pasteurization is not intended to kill all micro-organisms in the food. Instead, it aims to reduce the number of viable pathogens so they are unlikely to cause disease.

Homogenization (if required): Milk must then be homogenized. Without homogenization, the milk fat would separate from the milk and rise to the top. Milk fat is what gives milk its rich and creamy taste. Homogenization makes sure that the fat is spread out evenly in the milk so that every sip of milk has the same delicious flavor and creamy texture. Milk is transferred to a piece of equipment called a homogenizer. In this machine the milk fat is forced, under high pressure, through tiny holes that break the fat cells up in to tiny particles, 1/8 their original size. Protein, contained in the milk, quickly forms around each particle and this prevents the fat from rejoining. The milk fat cells then stay suspended evenly throughout the milk.

Packaging and storage: Milk is pumped through automatic filling machines direct into bags, cartons and jugs. The machines are carefully sanitized and packages are filled and sealed without human hands. This keeps outside bacteria out of the milk which helps keep the milk stay fresh. During the entire time that milk is at the dairy, it is kept at 1°-2°C. This prevents the development of extra bacteria and keeps the milk fresh.

The table below shows the production capacity of various section in plant daily

Table 6: Production Capacity

Sl No	Product	UOM	Quantity
1	Milk Processing	Lakh Litres per Day	2.00
2	Milk Packaging in Poly Pouches	Lakh Litres per Day	4.00
3	Curd Manufacturing	Ton/Month	28
4	Butter Manufacturing	Ton/Month	41
5	Ice Cream Manufacturing	Litres/Month	10000
6	Ghee Manufacturing	Ton/Month	37
7	Others	Litres/Month	15000

2.4 Energy Profile

Both electricity and thermal energy are used for carrying out various dairy processing activities. The following fuels are used in the plant:

Table 7: Type of fuel used

Sl. No.	Type of fuel/Energy used	Unit	Tariff	GCV (kCal/kg)
1	Electricity	Rs./kWh	5.6	-
2	High Speed Diesel	Rs/L	65	10000
3	Briquette	Rs/Kg	6.6	4000
4	Furnace Oil	Rs/L	42	10500

The table below shows the monthly consumption of various fuel used in the plant during the last one year and the contract demand of the plant is 800 kVA. FO and Briquette is used as fuel for boiler and HSD is used as fuel for DG.

Table 8: Fuel Consumption Details

Month	Electricity Consumption (kWH)	Fuel Consumption - Briquette (Tonnes)	Fuel Consumption - Furnace Oil (litre)	Fuel Consumption Fuel- HSD (litre)
Jul-17	3,15,072	126.51	6	-
Aug-17	3,22,336	123	7.5	-
Sep-17	3,82,984	100.8	9	-
Oct-17	3,30,560	114.75	6	-
Nov-17	3,35,256	117	5.5	-
Dec-17	3,63,336	104.5	6.4	-
Jan-18	3,61,592	105.5	1022	2430
Feb-18	3,53,820	58.5	10395	1440
Mar-18	3,93,072	112.5	10395	1260
Apr-18	3,95,400	98.8	2475	810
May-18	3,96,912	98.8	6210	1170
Jun-18	3,35,652	102.5	6107	1440
Jul-18	3,54,576	95	6107	1440
Aug-18	3,61,680	84.7	4590	1170
Sep-18	3,50,880	99.6	7539	1440
Oct-18	3,63,732	85.8	5667	990
Nov-18	3,63,804	82.5	6944	270
Dec-18	3,64,992	103.75	3690	810
Total	**64,45,656**	**1,815**	**71,181**	**14,670**

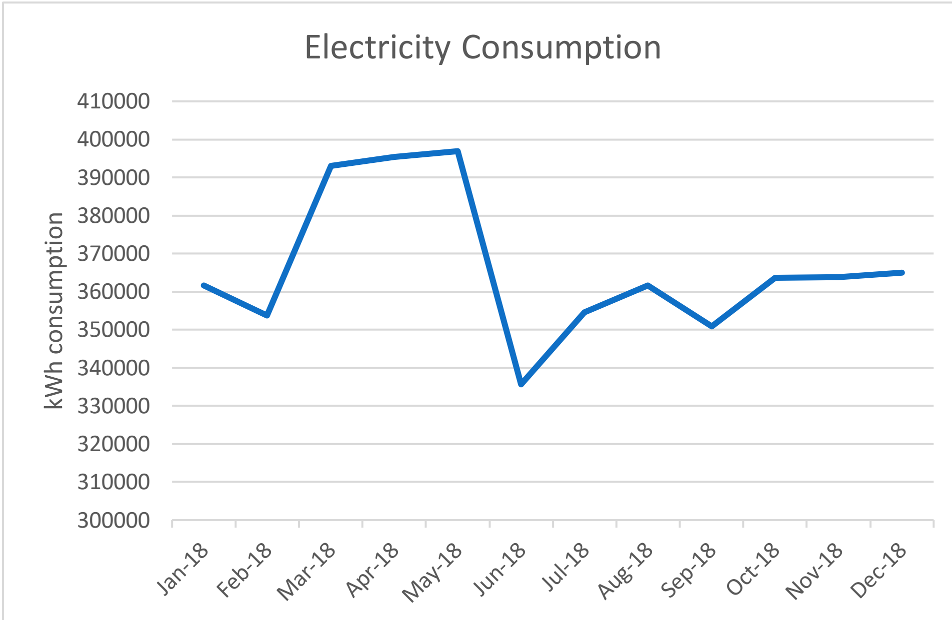


Figure 3: Electricity consumption profile

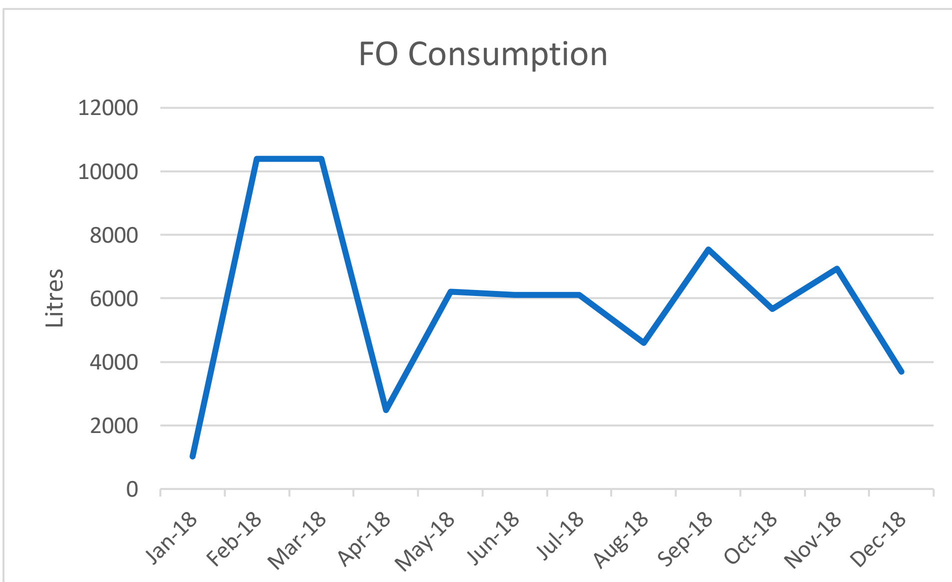


Figure 4: Furnace Oil consumption profile

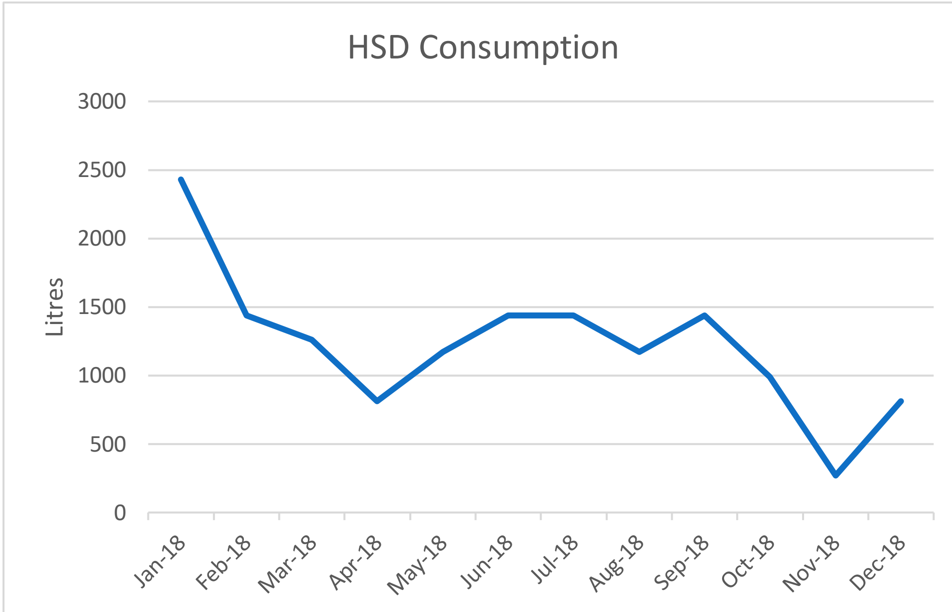


Figure 6: HSD consumption profile

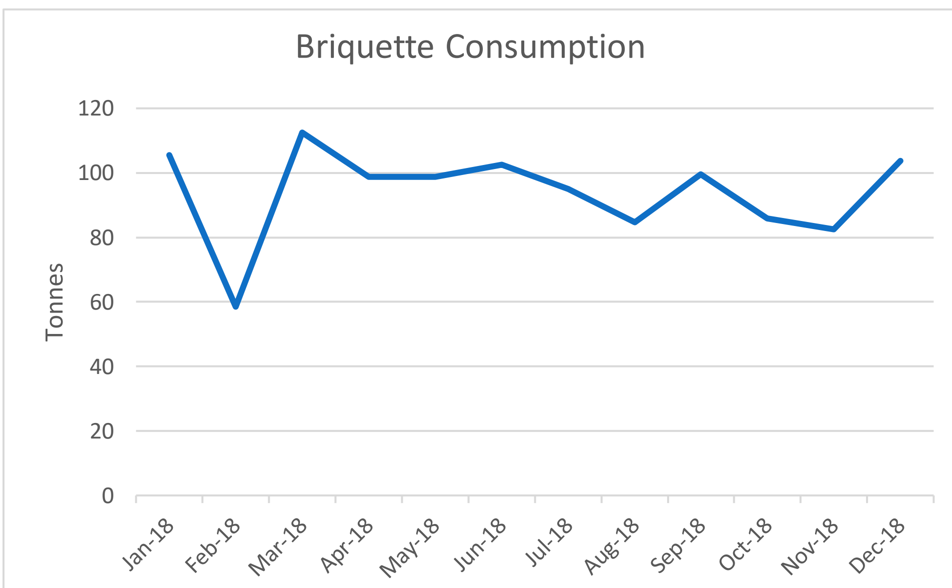


Figure 5: Briquette consumption profile

The energy consumption breakup of the plant both thermal and electrical is shown in the below table. Total energy consumption of the plant is 914 MTOE out of which 63% of the total energy is contributed by thermal and rest only 37% is contributed by electricity.

Table 9: Energy consumption breakup of plant

Sl No	Particulars	UOM	Value
1	Annual Electricity Consumption	kWh	4396112
2	Annual Electricity Consumption	kCal	3780656320
3	Annual Electricity Consumption	MTOE	378.07
4	Annual Diesel Consumption	kg	12470
5	Annual Diesel Energy Consumption	kCal	124695000
6	Annual Diesel Energy Consumption	MTOE	12.47
7	Annual FO Consumption	Kg	69007
8	Annual FO Energy Consumption	kCal	724571085
9	Annual FO Energy Consumption	MTOE	72.46
10	Annual Briquette Consumption	Kg	1127950
11	Annual Briquette Energy Consumption	kCal	4511800000
12	Annual Briquette Energy Consumption	MTOE	451.18
13	Total Energy Consumption	kCal	9141722405
14	Total Energy Consumption	MTOE	914

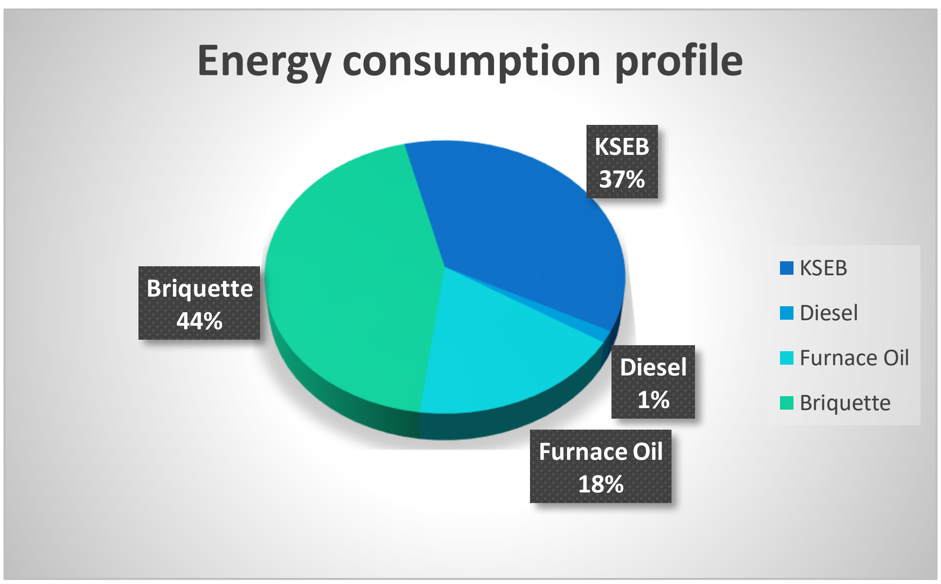


Figure 7: Energy profile

Based on the data collected from the plant, the graph above shows the variation of fuel cost over the last one year. Average electricity cost is Rs 20.5 Lakhs/month whereas the average thermal energy cost is Rs 9.5 lakhs/month.

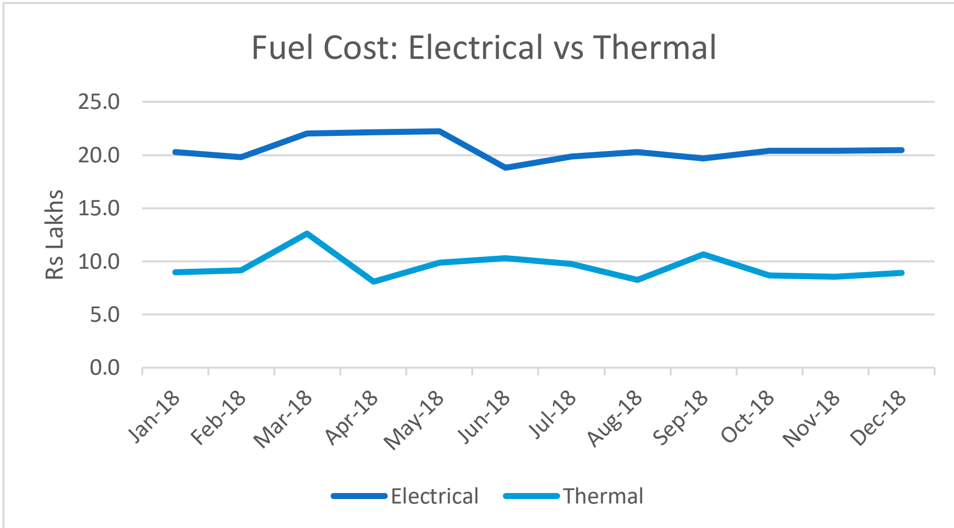


Figure 8: Variation of fuel cost

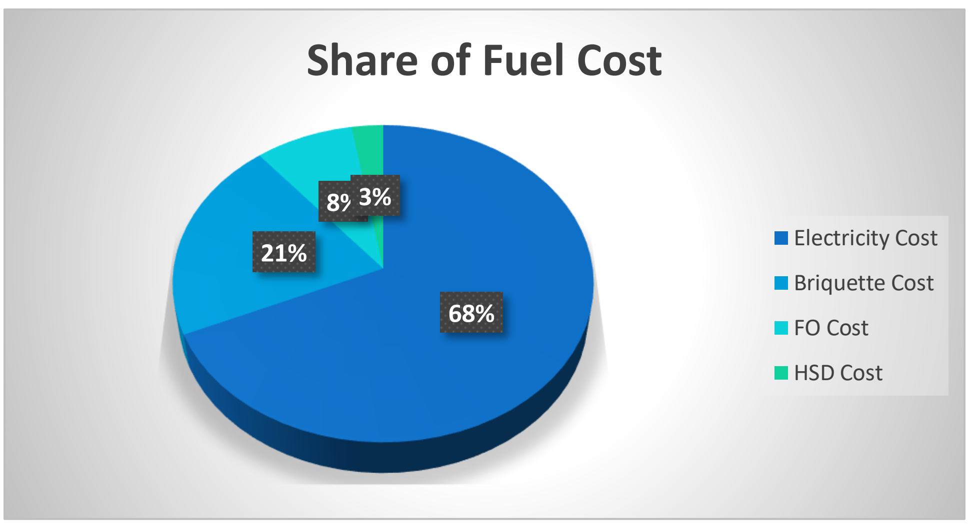


Figure 9: Percentage share of fuel cost

3. PERFORMANCE EVALUATION OF EQUIPMENT/PROCESS

3.1 List of equipment and process where performance testing done

CII during the detailed energy audit at Trivandrum dairy plant carried out measurements and performance testing in the following equipment and process.

Refrigeration System

- Performance of refrigeration compressor
- Chilled water system
- Condenser circuit

Boiler and Steam System

- Boiler efficiency by direct method
- Steam mapping
- Flue gas measurements

Compressor

- Free Air Delivery test by pump up method (wherever possible to isolate the receiver and compressor from circuit).
- Leakage test during shut down (if any during the audit period).
- Identification of leakage points.
- Loading / unloading study

Pumps

- Efficiency estimation

Electrical

- Power Measurements
- AC Load analysis
- Transformer Measurements
- Lighting load

3.2 Result of Performance Testing

The table below shows electrical measurements done in the plant.

Table 10: Electrical Measurements

Sl No	Feeder	Voltage	Current	Power (kW)	PF
1	Homogenizer	413	142	83.6	0.82
2	ETP and Air Compressor	387.3	200.4	116.4	0.853
3	Light and Power	405	55	38.2	0.98
4	Product Block Main 1	406	80	45	0.77
5	Milk Filling	406	39.2	15	0.6
6	Ammonia Compressor CP Main	403	201	121.9	0.86
7	Process Hall Main	403	146.5	77.2	0.78
8	Refrigeration SB	404	69	41	0.83
9	Product Block Main 2	402	220	123	0.74
10	Refrigeration DB	46	166	98	0.79
11	ID fan	412	9.4	4.86	0.683
12	Plant Air compressor	410	43.8	27.77	0.89
13			19.5	9.36	0.649
14	FCU Curd Cold Storage * 2	400	37	19.7	0.75
15	Butter Cold Storage	406	10.5	4.48	0.6
16	Ice Cream Cold Storage *2	403	26.5	11.7	0.63
17	Chocobar Glycol Cooling	402	13	6.3	0.71
18	Product CT Pump	395	6.5	3.3	0.78
19	Ice Cream Cold Storage *2	401	38	21.3	0.81
20	Ice cream Marketing	402	15	7.7	0.74
21	Ice cream Marketing * 2	403	9.5	5	0.75
22	Product Block Screw Comp	395	37	23.5	0.91
23	Product Block Reciprocating Compressor	400	10	5	0.68
24	Milk Cold Storage	400	17	9.3	0.79
25	Agitator IBT *5	400	8.1	2.5	0.44
26	Condenser Fan *4	401	2.77	1.4	0.7
27	Chiller Compressor	407	119	73.1	0.87
28	CHW 1	410	9.1	5.54	86
29	CHW 2	409	8.9	5.3	84
30	CHW 3	411	9.4	5.7	0.87
31	CHW 4	412	6.3	3.22	0.71
32	CHW 7	412	10.5	7	0.92
33	CHW 8	412	10.6	6.9	0.905
34	Primary Agitator 1	407	0	11.9	0.8
35	Primary Agitator 2	407	23.8	13.4	0.82
36	Primary Agitator 3	407	23.5	12.67	0.77
37	Primary Agitator 4	408	5.5	3.02	0.773
38	Effluent Pump	407	5.9	3.3	0.801

Table 11: Transformer Measurements

Rated(kVA)	Transformer	Voltage (3 Phase)	Current	kW	kVA	PF	%Loading	VTHD	ITHD
500	TR 3	408.8	304.6	211	220.41	0.96	**44**	1.5	4.2
500	TR2	405.2	352.66	278	283.67	0.98	**57**	4	16

500	TR 3	412.2	244.33	174	175.75	0.99	**35**	1.5	4.5

- Harmonics are within the limits as per standard IEEE 519 -2014 (VTHD < 8% and ITHD < 15%)
- Plant is operating at good power factor and monthly plant is getting incentive from electricity board

Table 12: Boiler Efficiency

Boiler Efficiency Direct Method		
Feed Water Temperature	55	°C
Calorific value of fuel	4000	kCal/kg
Feed Water Flow	1024	kg/hr
Fuel Firing Rate	209.00	kg/hr
Enthalpy of steam at 8kg/cm2	662	kCal/kg
Feed Water Enthalpy at 55 °C	55	kCal/kg
Boiler Efficiency	74.32	%

Table 13: Pump Measurements

Pump efficiency calculation					
Parameter	CHW Pump 1	CHW Pump 2	CHW Pump 3	CHW Pump7	CHW Pump 8
Power (kW)	5.54	5.3	5.7	7	6.9
Flow (m3/h)	24	25	27	80	75
Head assumed (m)	30	30	30	15	15
Efficiency	41.66	45.37	45.56	54.96	52.27
Design Efficiency	50	50	50	58	58

Table 14: Performance of Reciprocating Air Compressor

Parameters	UOM	
Rated capacity of compressor	CFM	32
Rated power of compressor	kW	5.5
Free air delivery of compressor (FAD)	CFM	20.83
Operating power consumption of compressor	kW	5
Specific power consumption of compressor	kW/CFM	0.24
Volumetric Efficiency of compressor	%	63

Table 15: Performance of Chiller Compressor

Parameters	UOM	
Total Chiller Load	kW	270
	TR	180
Power Consumption of Compressors	kW	195
Discharge Temperature	°C	95
Evaporator Temperature	°C	IBT (0.5 – 1.5°C) and Cold Store (5.5 -7.5°C)

Condensing Temperature	°C	38
Operating Power	kW	95
Operating TR	TR	115
SEC	kW/TR	1.60

3.3 Energy Balance of Thiruvananthapuram Dairy

During the detailed energy audit at Thiruvananthapuram dairy the total load on the plant measured at transformer level was 663 kW. For major process/equipment measurements were carried out at individual feeders. The pie chart below shows the breakup of electricity consumption inside the plant.

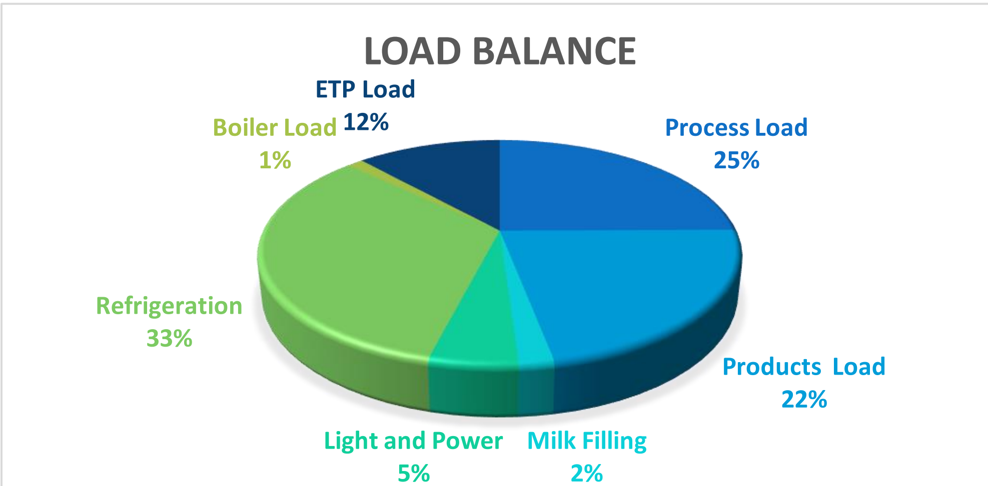


Figure 10: Equipment/Process wise energy breakup

The figure below shows energy balance diagram of Trivandrum dairy

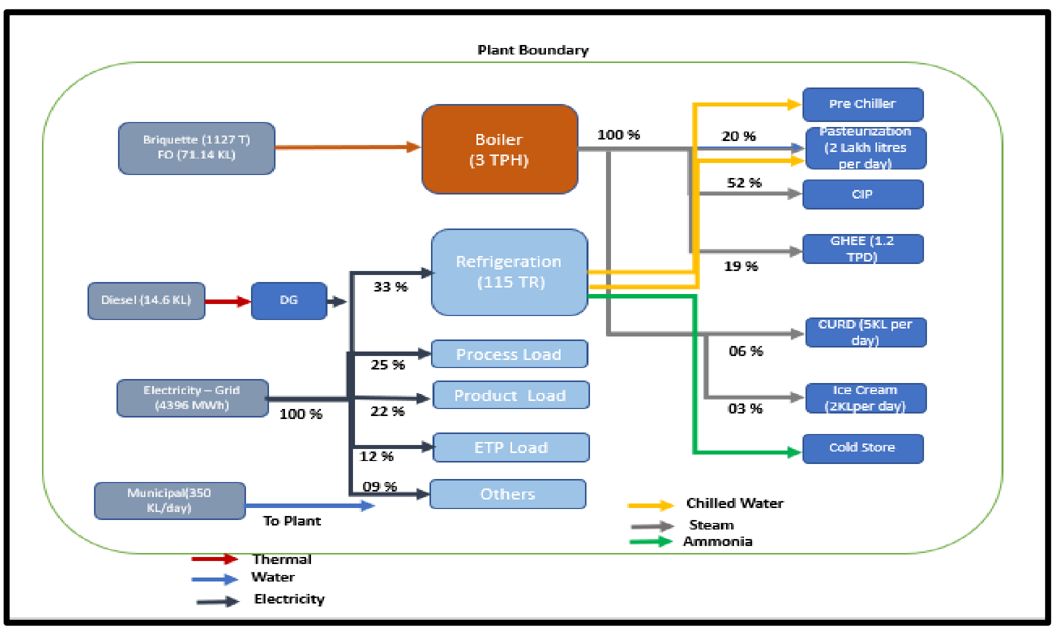


Figure 11: Energy Balance of Trivandrum Dairy

3.4 Water Profile of Trivandrum Dairy

Trivandrum dairy is purchasing water from corporation for the water requirement in the plant. The table below shows the monthly consumption of water in the plant.

Table 16: Monthly water consumption

Monthly Consumption	
	Lakh Litre
Jul-17	106.98
Aug-17	129.42
Sep-17	113.75
Oct-17	133
Nov-17	118.32
Dec-17	128.67
Jan-18	127.69
Feb-18	126.56
Mar-18	133.2
Apr-18	125.98
May-18	125.27
Jun-18	130.97
Jul-18	149.22
Aug-18	144.32
Sep-18	98.76
Oct-18	105.46
Nov-18	114.71
Dec-18	108.29
Total	**2,220**

Water is mainly used for process, cooling water make up and domestic applications. The daily report of water usage in the plant is given below:

Table 17: Daily consumption data

Water Data		
Water Source		Muncipal
Daily Average Consumption	KL	350
Daily average ETP Load	KL	280
Cost of Water	Rs/L	0.04
% Reused /Recycled	%	100%

The section wise water consumption is shown in the below graph

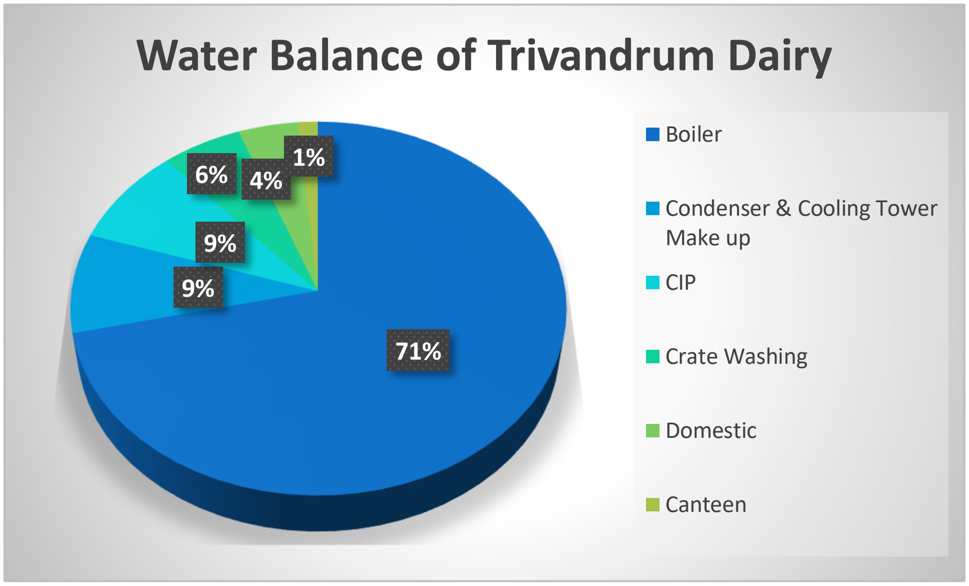


Figure 12: Water balance of Trivandrum Dairy

3.5 Specific Energy Consumption

Specific electricity and specific fuel consumption have been estimated based on the fuel data and production data given by the plant team.

Table 18: Specific energy consumption

Sl No	Particulars	UOM	Value
1	Annual Electricity Consumption	kWh	4396112
2	Annual Electricity Consumption	kCal	3780656320
3	Annual Electricity Consumption	MTOE	378.07
4	Annual Diesel Consumption	kg	12470
5	Annual Diesel Energy Consumption	kCal	124695000
6	Annual Diesel Energy Consumption	MTOE	12.47
7	Annual FO Consumption	Kg	69007
8	Annual FO Energy Consumption	kCal	724571085
9	Annual FO Energy Consumption	MTOE	72.46
10	Annual Briquette Consumption	Kg	1127950
11	Annual Briquette Energy Consumption	kCal	4511800000
12	Annual Briquette Energy Consumption	MTOE	451.18
13	Total Energy Consumption	kCal	9141722405
14	Total Energy Consumption	kCal	914
15	Total Production	KL	77851
16	Overall Electrical SEC	kWh/KL of Milk	56
17	Overall Thermal SEC	MkCal/KL of Milk	0.069
18	Overall SEC	MkCal/KL of Milk	0.117

3.6 Performance Analysis of Major Processes

3.6.1 Pasteurizing Section

Table 19: Analysis of pasteurizing section

Pasteurisation		
Description	**Unit**	**Pasteuriser I**
Pasteurizer Capacity	KL/hr	20
No of Shifts	Nos	2
Average Shift Time	Hours	7
Average Milk Processed per shift	Litres/shift	110000
Average Milk Processed per day	Litres/day	220000
Incoming milk temperature from Silo	ºC	7
Heating Temperature	ºC	77
Steam Pressure	Kg/cm^2 g	3
Holding time	Seconds	15
Regeneration Efficiency	%	88
Cooling Temperature	ºC	5
Chilled water temperature	ºC	2
Raw Milk Silo Temperature	ºC	7
Process Milk Silo Temperature	ºC	5
Specific Steam Consumption	kg/KL	29.41

3.6.2 Ghee Section

Table 20: Analysis of Ghee Vat

GHEE Section				
Description	**Unit**	**VAT 1**	**VAT 2**	**VAT 3**
Ghee VAT Capacity	L/hr	2000	2000	1000
Incoming Cream Temperature	ºC	45	45	45
Initial Heating Temperature until boiling starts	ºC	60	60	60
Initial Heating Time until boiling starts	secs	1	1	1
Final heating temperature	ºC	115	115	115
Holding time	mns	60	60	60
Steam Pressure	Kg/cm2 g	2.5	2.5	2.5
Holding time in settling tank	hrs	24	24	24
No. of hours of operation per day	hrs	5	5	5
No of Shifts	Nos	1	1	1
Average Shift Time	Hrs	7	7	7
Average Ghee Produced per shift	Litres	1200	1200	600
Average Ghee Produced per day	Litres	1200	1200	600
Specific Ghee Consumption	kg/KL	137.40	137.40	137.40

3.6.3 CIP Section

Table 21: CIP Section Analysis

Parameters	UOM	
Hot Water tank capacity	KL	3
Delta T of heating	ºC	30
Heating Time	mins	15
Steam Pressure	kg/cm2g	3
Steam Flow Rate for Hot Water tank per batch	kg/hr	705.9
Steam Qty required per batch	kg/hr	176.5
Number of batches per day	No.	4
Acid Water tank capacity	KL	3
Delta T of heating	ºC	10
Heating Time	mins	5
Steam Pressure	kg/cm2g	3
Steam Flow Rate for Acid Water tank per batch	kg/hr	705.9
Steam Qty required per batch	kg/hr	58.8
Number of batches per day	No. s	3
Alkali Water tank capacity	KL	3
Delta T of heating	ºC	15
Heating Time	mins	15
Steam Pressure	kg/cm2g	3
Steam Flow Rate for Alkali Water tank per batch	kg/hr	352.9
Steam Qty required per batch	kg/hr	88.2
Number of batches per day	No. s	3
Total Steam Required per day	Kg/day	1147.1
CIP steam requirement per KL pasteurisation	Kg/KL	38.24

3.6.4 Curd Section

Table 22: Curd Section Analysis

Parameters	UOM	
Capacity	Litres	5000
Incoming Milk Temperature	ºC	4
Milk Temp after regenerative heating	ºC	73
Heating Temperature	ºC	90
Holding Time	Sec	-
Steam Pressure	Kg/cm2g	3
Regeneration Efficiency	%	-

Incubation Temperature	ºC	45
Specific Steam Consumption	Kg/KL	33.33

3.6.5 Raw Milk Pre-Chilling

Table 23: Raw Milk Prechilling Analysis

Parameters	UoM	
Capacity	KL	20
Incoming Raw Milk Temperature	ºC	9
Pre-Chilled Milk Temperature	ºC	6
Refrigeration requirement	TR/KL	0.59

3.6.6 Crate Washing

Crate Washing			
Description	**Unit**	**Value**	**Remarks**
Crates washed per hour	No. / hour	1200 X 2	Twin track
Hours of operation per day	hours	12	
Hot Water requirement	Litre/hr	70	
Hot Water temperature	Deg C	70 to 75	
Steam pressure	Kg/cm2 g	3	
Specific Steam Consumption	kg/100 crate	2.88	

3.6.7 Ice Cream

Ice Cream		
Description	**Unit**	**Value**
Ice Cream Production	Kg / day	2000
Incoming Cream/Standardised Milk Temperature	ºC	8
Pre-Heating Temperature	ºC	65
Holding Time	mn	50
Pasteurisation Temperature	ºC	85
Holding Time	Mns	2
Hot Water requirement for heating	Kg/hr	
Incoming hot water temperature	ºC	
Ageing Temperature	ºC	8
Holding Time	hours	5.12
Batch time	hours	7
No. of batches per day	No. s	1
Specific Steam Consumption	kg/KL	39.29

4. ENERGY SAVING PROPOSALS

Energy Saving Proposal 1 – Installation of condensate recovery system

Present System

Trivandrum Dairy Plant has installed one briquette fired boiler and two FO fired for the process application like pasteurization, curd making, CIP, crate washing etc. Briquette fired boiler is running and others are standby. All the heating process in dairy is through indirect heating.

The table below shows the details of boiler installed in the plant.

Table 24: Boiler Details

Boiler	Fuel Type	Design Capacity (TPH)	Make of the company	Operating Pressure (bar)	Operating Condition	Operating hrs
Boiler 1	Briquette Fired	3TPH	Thermax	9	Running	17

One of the major applications of steam is pasteurization process where the milk is heated to 77°C for 16 seconds then quickly cooling it to 4°C. This process slows spoilage caused by microbial growth in the food. Hot water at around 70°C to 80°C is used for indirect heating in the pasteurization process.

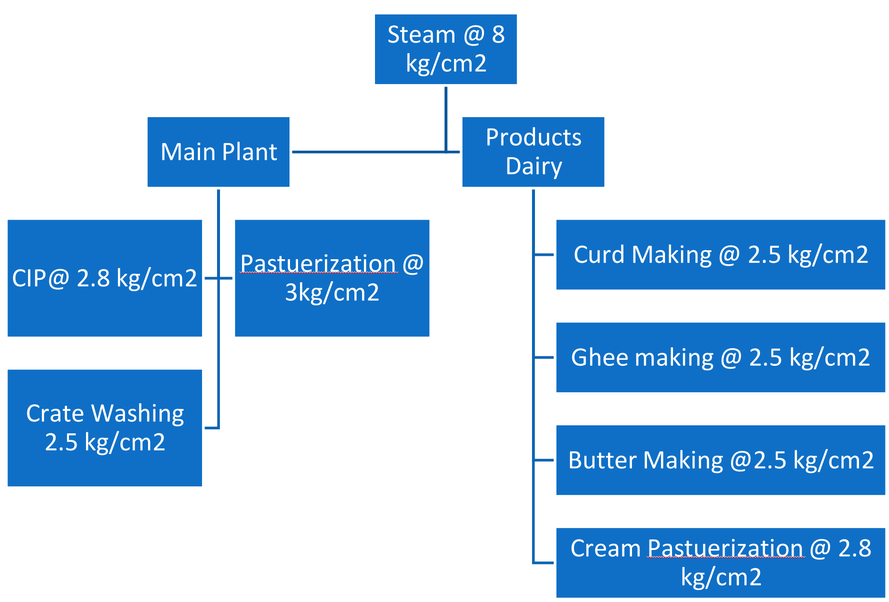


Figure 13: Steam Distribution System

The condensate after the process heating is currently drained or used in cleaning crates. As the condensate has some heat available which can be utilized in the boiler or any other indirect heating for the processes like CIP, crate washing etc.

During the course of detailed energy audit steam mapping and estimation of condensate that can be recovered was undertaken. Following figure shows some of the locations in plant where condensate is drained out.

Figure 14: Condensate drained out

Total condensate drained out from the process is around 900kg/hr at 70 - 80^{o}C after traps. Also it was observed that since most of the condensate drain are left open to atmosphere flashing is also happening at each locations which is a wastage of energy.

Recommendation

It is recommended to install a flash vessel and automatic condensate transfer system (TACTS) to recover all the condensate from various processes. Condensate recovery is a process to reuse the water and sensible heat contained in the discharged condensate. Recovering condensate instead of draining it can lead to significant savings of energy, chemical treatment and make-up water. TACTS is capable of pumping huge quantity of condensate effectively utilizing steam known as motive steam. Condensate is one of the purest forms of water having low electrical conductivity of only 5 µS/cm or TDS value of 3.5 ppm. The conductivity based level controller used in TACTS can sense this low conductivity even as low as 0.5 µS/cm or TDS value of 0.35 ppm.

Figure 15: Automatic condensate transfer system

Condensate flow from receiver of the pump to the pump body and the level of water starts increasing and reaches the high level. This is sensed by the conductivity based level sensor and activates the motive steam inlet valve. Steam Enters the pump at high pressure and the pressure in the pump body keeps on building till it overcomes the back pressure of delivery side. Now the outlet check valve opens and condensate starts flowing out of the pump body using high pressure of the steam. As soon as the level in the pump reaches the low level position the inlet valve for the motive steam is de activated and the pump is de pressurized. The pump again starts filling and the cycle repeats. The system requires no electric motor for operation.

As the quantity of condensate discharge d at each stroke is known, the total volume passed during a given period can be calculated by counting the number of strokes during the period. Such a counter is provided enabling display of the total condensate pumped. The totalized volume of condensate pumped is displayed on a electronic unit.

Also a flash steam generator is also proposed for the recovery of flash steam just before the condensate recovery system. When high pressure condensate is discharged from steam traps to low pressure condensate return lines, excess energy is released in the form of flash steam. This flash steam can be used to heat boiler feed water or for low pressure steam application.

Advantages of Automatic Condensate Recovery System

- High availability due to zero moving parts
    - High reliability and equipment availability
    - Low wear & tear
    - Low maintenance
    - Low downtime
- High motive inlet pressure up to 10 bar for TACTS ultra-series. No need of pressure reducing valve/ station till 10 bar where low pressure steam is not available, hence saving of installation cost
- High discharge of condensate of 50 liters per stroke
- High condensate temperature return- No cavitational issues over electrical pumps
- CE approved conductivity based level controller (a stringent quality & design process followed in European market, to ensure safe operation)
- A large LED display with 8 digits flow totaliser to display the total volume displaced up to 0.9 million m3. This does not require resetting the totaliser for 2 – 3 years.
- Flow totaliser designed with SMPS power supply can work with wide voltage variation from 90 to 270V
- Weather proof IP 65 design – suitable for outdoor installations.
- Energy efficient pump – Steam trap drain and pump vent taken back to the receiver tank to minimize vent losses.
- No electrical Motor Required.

The recovered condensate can be used for

- Boiler feed water
- Used in CIP process

- Used for crate washing

Savings

The expected fuel savings by installation of condensate recovery system is 1.1 Lakhs of Briquette annually. The annual monetary saving for this project is ***Rs 7.41 Lakhs with an investment of Rs 11.82 lakhs and payback for the project is 19 months.***

Detailed savings calculations are given in below table

Table 25: Savings calculation for condensate recovery

Parameters	UOM	
Boiler Capacity	TPH	3
Operating Pressure	Bar	9
GCV	kCal/kg	4000
Fuel Cost	Rs/kg	6.6
Fuel Consumption	kg/hr	209
Boiler Efficiency	%	75
Enthalpy of steam at 9 Bar	kCal/kg	663
Steam Flow	kg/hr	1024.00
Condensate Available considering losses	kg/hr	900
Condensate Working Pressure	bar	1.5
Flash Steam	%	5.19
Mass of Flash Steam	kg/hr	46
Mass of Condensate Available	kg/hr	853.33
Latent Heat of flash steam	kCal/kg	503.70
Fuel saved from condensate recovery	kg/hr	11
Fuel saved from flash steam recovery	kg/hr	7
Total Fuel Saved	kg/hr	18
Operating Hours	hrs	17
Operating Days	days/year	360.00
Annual Fuel Savings	kgs	112348.24
Monetary Savings	Rs Lakhs	7.41
Investment	Rs Lakhs	11.82
Pay Back	Months	19
NPV at 70% Debt	**Rs Lakhs**	**32**
IRR (%)	**%**	**85.09**
TOE Savings	**TOE**	**44.94**

Energy Saving Proposal 2 – Installation of Automatic Pumping Trap for CIP Section

Present System

Trivandrum Dairy Plant has installed one briquette fired boiler and two FO fired for the process application like pasteurization, curd making, CIP, crate washing etc. Briquette fired boiler is running and others are standby. All the heating process in dairy is through indirect heating. For all the processes hot water is generated using steam and condensate is drained out. Currently all the locations ball float traps are installed. Most of the traps are having by pass arrangement for the condensate to flow during stalling condition.

In CIP section it was observed that condensate is bypassed as the trap is not operating properly. This happens when there is no sufficient delta P will be there across the inlet and outlet of trap for the trap to operate. As a result stalling happens and by pass valve opens and condensate starts flowing through this valve and also steam leakage is there. The figure below shows the traps at CIP section:

Figure 16: CIP trap bypassed

The steam flow to the Heat Exchanger is regulated by a PID based Temperature Control Valve (TCV) which is taking feedback from the temperature sensor (RTD) at the outlet hot water line. Now, as the set temperature of hot water is attained, the TCV tends to close position. This in turn causes the steam flow rate, and thus steam pressure be reduced, which in turn causes water logging at the steam trap due to the lack of required differential pressure across the trap. A steam trap will be operational only above the rated minimum differential pressure. Normally, operation of a steam trap requires a minimum differential pressure of 0.1 kg/cm2, however, this may vary with manufacturers. If the condensate flow pressure is lesser than the minimum required differential pressure, water logging happens

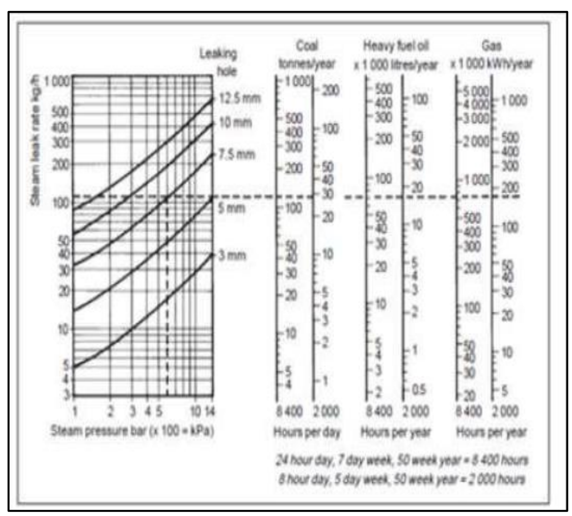


Figure 17: Steam Loss Chart

which is also called stalling. This leads to problems of hammering, reduction of thermal performance of heat exchanger, corrosion of heating surfaces, inevitably reducing the service life of exchanger. Now, to avoid this stall condition of steam traps, equipment operator normally operate the by-pass valve, either keeping bypass line partially open full time or intermittently opening and closing of bypass line. In both the cases, live steam loss occurs, thereby increasing the energy consumption. The orifice size of 15NB bypass valve open is 5 mm at 2.8 barg operating pressure. Through this orifice size steam loss is 30kg/hr from the steam loss chart.

Recommendations

First arrest all the steam leakages in the pipeline and proper insulation should be done for steam line in CIP section. After this it is recommended to replace the ball float steam trap with Steam Operated Pumping Trap (SOPT). With this system in place, whenever the condensate pressure is low, motive steam / air shall provide the additional thrust to make the condensate flow, and avoid any stalling. Under normal working conditions, the steam operated pump trap works as a normal float trap. During the stall situations, the condensate accumulation lifts the float to the maximum height and actuates the motive steam connection. The condensate accumulated inside is pumped out by the pressure of the motive steam.

Figure 18: SOPT Trap

Savings

The expected fuel savings by installation of steam operated pumping traps is 0.14 Lakhs of Briquette annually. The annual monetary saving for this project is ***Rs 0.98 Lakhs with an investment of Rs 1.50 lakhs and payback for the project is 18 months.***

Detailed savings calculations are given in below table

Table 26: Savings Calculation SOPT

Parameters	UOM	
Orifize Size	mm	6
Operating Pressure	bar	2.8
Steam loss through orifice	kg/hr	30
Considering 50% live steam leakage	kg/hr	18
Enthalpy of steam at 2.8 bar	kCAl/kg	654
Total heat loss	kCAl/hr	11772
Fuel Loss	kg/hr	3.73
Operating hrs	hrs	4000
Savings	kg	14901.27
Monetary Savings	Rs Lakhs	0.98
Investment	Rs Lakhs	1.50
Pay Back	Months	18

NPV at 70% Debt	**Rs Lakhs**	**4.28**
IRR (%)	**%**	**88.54**
TOE Savings	**TOE**	**4.71**

Energy Saving Proposal 3 – Installation of VFD for ID Fan in 3TPH Boiler

Present System

Trivandrum Dairy Plant has installed one briquette fired boiler and two FO fired for the process application like pasteurization, curd making, CIP, crate washing etc. Briquette fired boiler is running and others are standby. All the heating process in dairy is through indirect heating.

The table below shows the details of boiler installed in the plant.

Table 27: Boiler Details

Boiler	Fuel Type	Design Capacity (TPH)	Make of the company	Operating Pressure (bar)	Operating Condition	Operating hrs
Boiler 1	Briquette Fired	3TPH	Thermax	9	Running	17

Boiler is installed with a 9.3 kW ID Fan for pushing the flue gases through chimney. During the audit it was observed that the fan is installed with a damper which is 40 % open for controlling the flow of flue gases. Damper control is a conventional method of controlling the flow, by this an additional head is developed across the fan which results in excess power consumption of fan. Also the fan is operated in frequent ON/OFF mode and motor is operated at 70% load which is pulley driven.

Figure 19: ID fan

Recommendations

- Open the damper fully
- It is recommended to install VFD for the ID fan to minimize the losses across the damper thereby eliminating the additional head developed. The feedback of the VFD should be pressure developed by the fan. Based on the change in flow of flue gas the head developed by fan changes and thereby speed of the fan can be controlled using VFD.

Savings

The expected electricity savings by installing VFD in ID fan is 5640 units annually fuel The annual monetary saving for this project is ***Rs 0.31 Lakhs with an investment of Rs 0.55 lakhs and payback for the project is 1.74 years.***

Detailed savings calculations are given in below table

Table 28: Savings calculation for VFD in ID fan

Parameters	UOM	
ID Fan	Rated kW	9.3
ID Fan	kW	4.7
Power Savings	%	15
New Power	kW	3.995
Power Savings	kW	0.705
Power Cost	Rs/kWh	5.6
Energy Savings	kWH	5640
Cost Savings	Rs Lakhs	0.31
Investment	Rs Lakhs	0.55
PB	Months	20.9
NPV at 70% Debt	**Rs Lakhs**	**5.55**
IRR (%)	**%**	**24.62**
TOE Savings	**TOE**	**0.49**
TCO_2 Savings	**TCO_2**	**4.62**

Energy Saving Proposal 4 – Waste heat recovery from chiller compressor

Present System

Trivandrum Dairy Plant has installed three reciprocating chiller compressors of 60 TR capacity and one 40 TR capacity for the chilled water requirement in the plant. During normal operation three 60 TR are running continuously and third compressor based on requirement.

In a refrigeration cycle, when the compressor is run, the refrigerant starts flowing through the system i.e., the system starts it's working. The compressor continuously sucks low pressure, low temperature refrigerant vapors from the evaporator and pump these to condenser at high pressure and high temperature condition. While flowing through the condenser, the high temperature vapors release their heat to atmosphere and condense to high pressure liquid state. After condenser this high-pressure liquid enters the expansion valve where it is throttled to low pressure. It is so constructed that a control quality of refrigerant flows (due to expansion valve) from one necessary steps to another at definite and predetermined pressure. On throttling the pressure and temperature of refrigerant (like ammonia, R-22 etc.) decreases and when this low pressure, low temperature throttled liquid flows through evaporator, it sucks heat and produce cooling. On absorbing heat in evaporator all the low-pressure liquid evaporates to low-pressure, low-temperature vapors, which are again sucked by compressor. In this way all these processes go on continuously and as long as the compressor runs, the system produces cooling around the evaporator. A block diagram of a vapour compression refrigeration system is shown below :

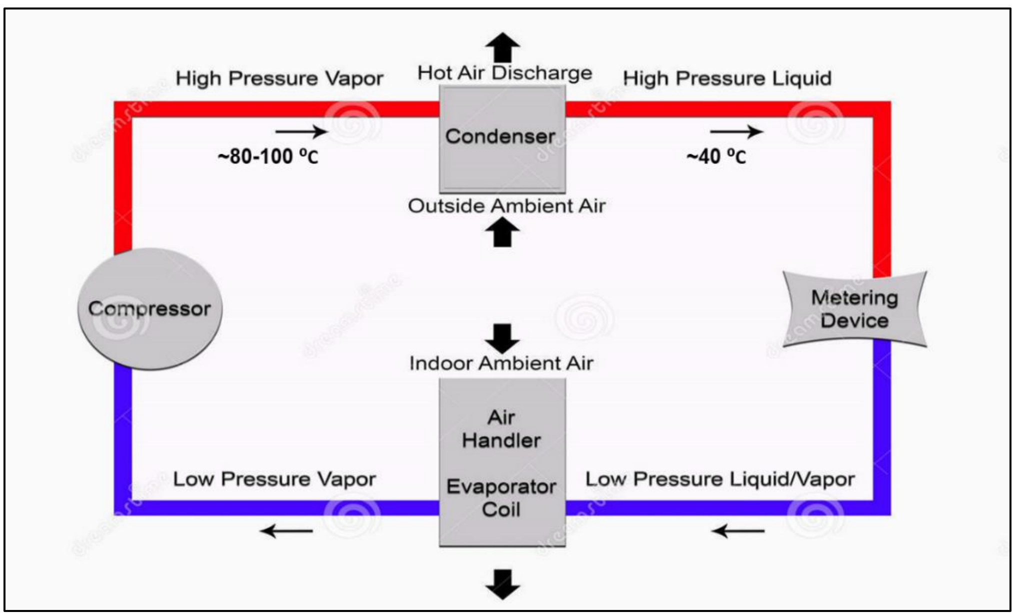


Figure 20: Vapor Compression Cycle

Refrigeration plants with air-cooled and water-cooled condensers produce a lot of waste energy by dumping the condensation energy to the ambient air. By installing a de superheater, a large proportion of this waste energy can be turned into hot water that may be used for many purposes such as:

- CIP
- Boiler feedwater heating
- Process heating for processes like Curd and Ghee preparation
- Crate washing and can washing in chilling center

Recommendation

De-super heater is proposed to be installed on chiller compressors to harness waste heat of ammonia gas. De superheater is installed on discharge side of NH_3 compressor. The temperature of NH_3 gas observed to be 95°C. This ammonia gas is expected to be cooled to 60°C and the recovered heat will be used to heat water from 22 °C to 70 °C. This hot water is proposed to be used in the boiler feedwater. The design of the de superheater has to ensure that you recover adequate heat with the required temperature lift. Apart from the direct energy saving after getting hot water, the heat load on condenser is expected to come down, and if the design is done appropriately, the condensing pressures can also marginally reduce, leading to reduction in power consumption of compressors.

De-superheater units are located between the compressor and condenser to utilize the high-temperature energy of the superheated refrigerant gas. By using a separate heat exchanger to utilize the high temperature of the discharge gas, it is possible to heat water to a higher temperature than would be possible in a condenser.

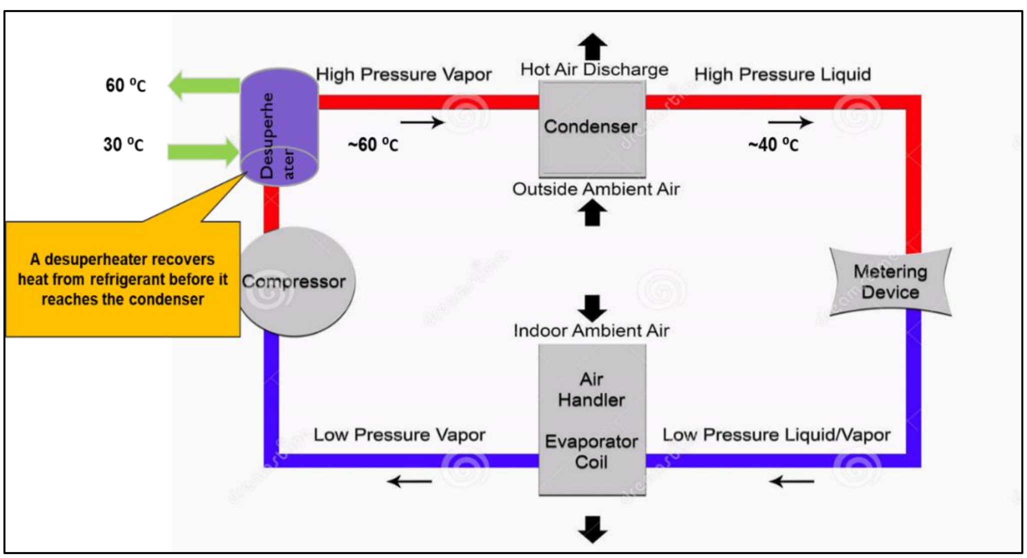


Figure 21: Refrigeration system with desuperheater

Some key technical parameters for the heat recovery system are given below:

Table 29: Technical parameters of desuperheater

Item	Value
Temperature of ammonia gas in/out	105 °C/60 °C
Temperature of water in/out	45 °C /70 °C
Amount of water that can be heated	2683 litre/hr
Heat load recovered	70 kW

Savings

The expected savings by installation of de super heater is 1.98 Lakhs kg of briquette annually. The annual monetary saving for this project is ***Rs 13.10 Lakhs with an investment of Rs 21.00 lakhs and payback for the project is 19 months.***

Detailed savings calculations are given in below table

Table 30: Savings Calculation for waste heat recovery

Parameters	UOM	
Total Load on Compressor	kW	195
Heat Recovery possible	kW	78
Heat Recovery possible	kCal/hr	67080
Amount of hot water available for process (from 45°C to 70°C)	litre per hour of water at 70C	2683
Hours of operation	Hours per day	24
Days of operation	Days per year	365
Total heat recovery possible	kCal/year	587620800
Cost of Briquette	Rs/kg	6.6
Calorific value	kCal/kg	4000
Boiler efficiency	%	74%
Fuel Savings	kg/year	198521
Annual Cost Savings	Rs Lakhs	13.10
Investment	Rs Lakhs	21.00
Pay Back	Months	19
NPV at 70% Debt	**Rs Lakhs**	**56.26**
IRR (%)	**%**	**84.63**
TOE Savings	**TOE**	**79.41**

Energy Saving Proposal 5 – Replacement of existing chilled water pumps with energy efficient pumps

Present System

Trivandrum dairy has installed two sets of chilled water pumps for pumping chilled water from IBT to process in which one is running and others are standby. The chilled water is mainly used in pasteurization process and pre chiller where the milk is cooled to 4°C. First 5 pumps are used for IBT 1,2 and 3 and CHW 6,7 and used for IBT 4 & %. Normally 3 pumps for first 3 IBT and 2 pumps for last two IBT will be in operation. Performance analysis of the pump is shown in the below table:

Table 31: Chilled water pump performance

Pump efficiency calculation					
Parameter	CHW Pump 1	CHW Pump 2	CHW Pump 3	CHW Pump7	CHW Pump 8
Power (kW)	5.54	5.3	5.7	7	6.9
Flow (m3/h)	24	25	27	80	75
Head assumed (m)	30	30	30	15	15
Efficiency	41.66	45.37	45.56	54.96	52.27
Design Efficiency	50	50	50	58	58

The design efficiency of the pumps 1,2 and 3 is 50% which is very low. During the study pump performance test was carried out to determine the efficiency of the pumps. The flow of the pump was measured using ultra sonic flow meter and head was determined to calculate the efficiency. The measured efficiency of the pump is 41% - 45% which is lesser than the design efficiency. The reasons for low efficiency of pump is

- Poor operational practices
- Pump is very old and undergone frequent maintenance
- Poor selection of pump

Recommendation

It is recommended to replace the old chilled water pumps 1,2 and 3 with energy efficient pump. The high efficient pump will consume less power than low efficiency pumps which will lead to energy saving. When a pump is installed in a system the effect can be illustrated graphically by superimposing pump and system curves. The operating point will always be where two curves intersect. Each centrifugal pump has a Best Efficiency Point (BEP) at which its operating efficiency is highest and its radial bearing loads are lowest. At or near its BEP, a pump operates most cost effectively in terms of both energy efficiency and maintenance. In practical applications, operating a pump continuously at its BEP is not likely, because pumping systems usually have changing flow rate and system head requirements and demands. Selecting a pump with a BEP that is close to the system's normal operating range can result in significant operating cost savings.

The parameters of proposed pump is given in the below table:

Table 32: Proposed pump parameters

Parameters	UOM	Proposed Pump Design
Power Consumption	kW	5.5
Flow	m^3/hr	30
Head	m	28
Efficiency	%	60

Savings

The expected electricity savings by installation of energy efficient chilled water pump is 32,745 units annually. The annual monetary saving for this project is ***Rs 1.82 Lakhs with an investment of Rs 1.65 lakhs and payback for the project is 10 months.***

Table 33: Replacement of chilled water pumps

Parameters	UOM	Present	Proposed Operating Condition
Power Consumption	kW	5.54	4.33
Flow	m3/hr	24	28
Head	m	30	30
Efficiency	%	41.66	60
Power Savings	kW	1.21	
Electricity Cost	Rs/kWh	5.6	
Operating hrs	hrs/day	24.00	
Operating days	days/year	360.00	
Energy Savings	kWH	10454.4	
Cost Savings	Rs Lakhs	0.59	
Investment	Rs Lakhs	0.55	
Pay Back	Months	11	

Parameters	UOM	Present	Proposed Operating Condition
Power Consumption	kW	5.7	4.33
Flow	m3/hr	27	28
Head	m	30	30
Efficiency	%	45.56	60
Power Savings	kW	1.37	
Electricity Cost	Rs/kWh	5.6	
Operating hrs	hrs/day	24.00	
Operating days	days/year	360.00	
Energy Savings	kWH	11836.8	
Cost Savings	Rs Lakhs	0.66	
Investment	Rs Lakhs	0.55	
Pay Back	Months	10	

Parameters	UOM	Present	Proposed Operating Condition
Power Consumption	kW	5.54	4.33
Flow	m3/hr	24	28
Head	m	30	30
Efficiency	%	41.66	60
Power Savings	kW	1.21	
Electricity Cost	Rs/kWh	5.6	
Operating hrs	hrs/day	24.00	
Operating days	days/year	360.00	
Energy Savings	kWH	10454.4	
Cost Savings	Rs Lakhs	0.59	
Investment	Rs Lakhs	0.55	
Pay Back	Months	11	

NPV at 70% Debt	Rs Lakhs	**8.57**
IRR (%)	**%**	**138.9**
TOE Savings	**TOE**	**2.82**
TCO_2 Savings	**TCO_2**	**26.85**

Energy Saving Proposal 6 – Replacement of Ceiling fans with BLDC fans

Present System

During the Detailed Energy Audit at **Trivandrum Dairy Plant** detailed study was carried out for energy savings for replacement of conventional ceiling fans with BLDC fans.

Table 34: Existing ceiling fans list

Sl No.	No of Fans	Power Consumption per fan (Watts)	Total Power (kW)
1	85	75	6.375

Recommendation

It is recommended to install BLDC fans instead of conventional ceiling fans , latest technology BLDC fans which consumes only 28W can be installed in the newly constructed building. A brushless DC (BLDC) motor is a synchronous electric Motor powered by direct-current (DC) electricity and having an electronic commutation system, rather than a mechanical commutator and brushes. A BLDC motor has an external armature called the stator, and an internal armature called the rotor. The rotor can usually be a permanent magnet. Typical BLDC motor based ceiling fan has much better efficiency and excellent constant RPM control as it operates out of fixed DC voltage. The proposed BLDC motor and the control electronics operates out of 24V DC through an SMPS having input AC which can vary from 90V to 270V. The operational block diagram of a BLDC motor is given below.

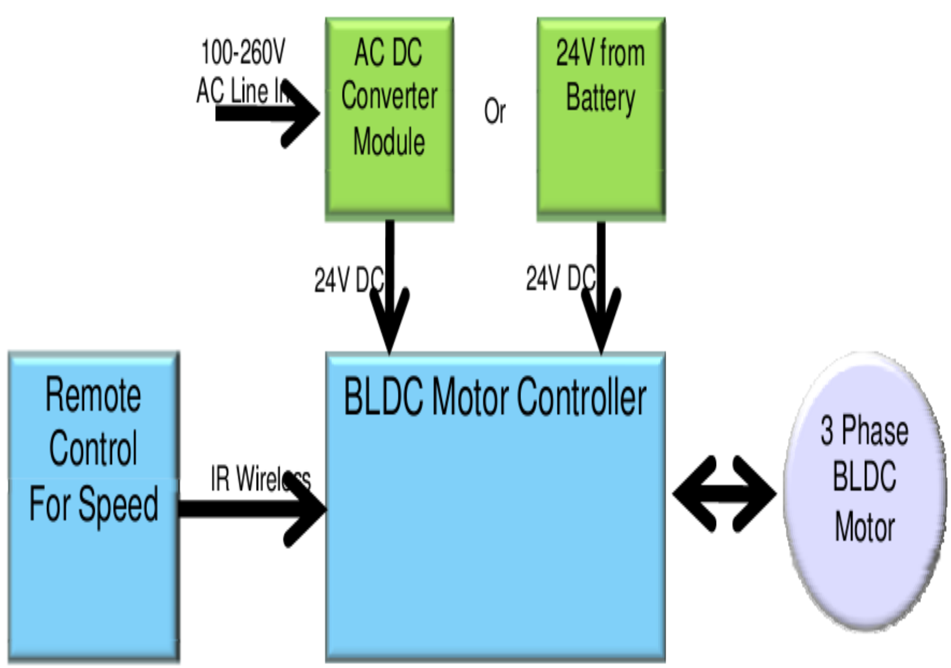


Figure 22: Schematic of BLDC fan

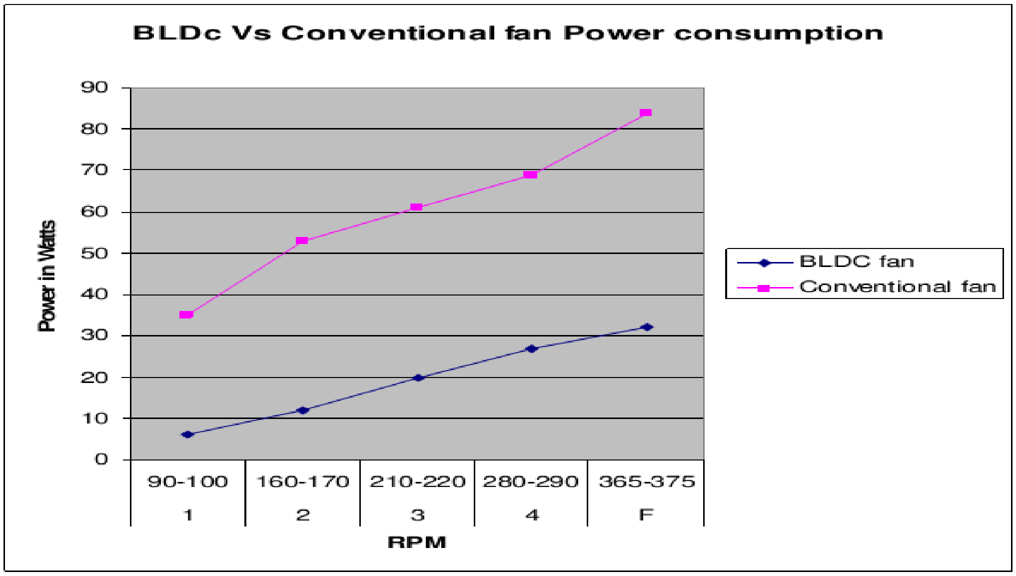


Figure 23: Comparison of normal fan vs BLDC fan

Savings

The expected savings by installation of BLDC fans is 13961 units annually. The annual monetary saving for this project is ***Rs 0.78 Lakhs with an investment of Rs 2.12 lakhs and payback for the project is 32 months.***

Detailed savings calculations are given in below table

Table 35: Calculations for BLDC Fan

Parameters	UOM	
No of Fans	Nos	85
Conventional Fan power	Watts	75
Total Power	kW	6.375
BLDC Fan Power	Watts	30
BLDC Fan Power	kW	2.55
Savings	kW	3.825
Electricity Cost	Rs/kWh	5.6
Annual Energy Savings	kWh	13961.25
Annual Cost Savings	Rs Lakhs	0.78
Investment	Rs Lakhs	2.1
Pay Back	Months	32
NPV at 70% Debt	**Rs Lakhs**	**2.99**
IRR (%)	**%**	**54.80**
TOE Savings	**TOE**	**1.20**
TCO_2 Savings	**TCO_2**	**11.48**

Energy Saving Proposal 7 – Replacement of existing compressor with Screw Compressor

Present System

Trivandrum Dairy Plant has installed two Screw compressor which caters the requirement of compressed air to all process and instrumentation inside the plant both in the main plant and product block. During the audit it was observed that there is a separate reciprocating compressor also installed for the product block.

Over a period of time the reciprocating compressor operating efficiency comes down and the quantity of free air delivered reduces due to reasons such as poor maintenance, wear and tear etc. If the operating efficiency of the compressor is low the specific power consumption (kW/cfm) increases and hence the cost of compressed air goes up. The quantity of free air delivered, operating efficiency and the specific power consumption of the compressor can be determined by carrying out a performance test. If the specific power consumption increases by 25 - 30 % as compared to a new efficient compressor, it makes economic sense to replace the compressor with new efficient. Compressor free air delivery test (FAD) was conducted for the reciprocating compressor to evaluate the volumetric efficiency and specific power consumption.

The parameters of the FAD test conducted is shown below:

Table 36: Performance of compressor

Parameters	UOM	
Rated capacity of compressor	CFM	32
Rated power of compressor	kW	5.5
Free air delivery of compressor (FAD)	CFM	20.83
Operating power consumption of compressor	kW	5
Specific power consumption of compressor	kW/CFM	0.24
Volumetric Efficiency of compressor	%	63

It can be seen clearly from the above parameters that the volumetric efficiency of the compressor is on lower side and have high operating specific energy consumption (SEC) figure 0.25kW/CFM. Typically for reciprocating compressor the specific power consumption should be 0.15 kW/CFM at an operating pressure of 6 kg/cm^2

Recommendation

It is recommended to replace the existing 32 CFM/5.5kW reciprocating compressor with a new screw compressor and the keep the old one as standby.

- Rated Power: 5.5 kW
- Rated Capacity: 25 CFM
- Overall specific power consumption: 0.15kW/CFM @6 Kg/cm^2

Savings

The expected electricity savings by replacement of the old compressor with new screw one is 1, 2000 units annually. The annual monetary saving for this project is ***Rs 0.67 Lakhs with an investment of Rs 1.48 lakh and payback for the project is 27 months.***

Detailed savings calculations is given in below table:

Table 37: Savings calculation for Screw Air Compressor

Parameters	UOM	
Power consumption of the existing compressor	kW	5
Rated capacity of the new compressor	CFM	25
Specific power consumption of the new compressor@ 6 kg/cm^2	kW/CFM	0.15
Compressed air requirement as per FAD test	CFM	20
Anticipated power consumption of new compressor	kW	3.0
Power Savings	kW	2.0
Annual operating Hours	Annually	6000
Annual Energy Savings	kWh	12000
Electricity Cost	Rs/kWh	5.6
Savings per year	Rs Lakhs	0.67
Investment	Rs Lakhs	1.48
Pay Back	Months	27
NPV at 70% Debt	**Rs Lakhs**	**2.72**
IRR (%)	**%**	**64.98**
TOE Savings	**TOE**	**1.03**
TCO_2 Savings	**TCO_2**	**9.84**

Energy Saving Proposal 8 - Reduce the Generating Pressure of Main Plant Compressor and Product Dairy Compressor

Present Status

2 screw compressors were installed in plant to cater the compressed air requirement in process and instrumentation. In main plant maximum pressure required is 6kg/cm ^{2} and for dairy products the maximum pressure required is 7kg/cm^2. Most of the machines are operating with pressure regulating valves (PRV) to match the exact requirement of the machine.

The operating set points of the compressors during the course of audit were as follows:

Table 38: Operating set points for main plant and product plant compressor

Tag No	Average Pressure (Bar)	Operating kW	Suggested Pressure
Main Plant compressor	7	27.7	6.5
Product plant compressor	8.5	23.5	7.5

It was observed that the generating pressures of the compressors are in higher side and there exists a potential to reduce the generating pressure to a lower value since pressure drop in the line was not more than 0.3ksc. This will lead to significant power saving as the operating power is directly proportional to the generating pressure.

Recommendation:

It is recommended to reduce the pressure settings of the compressors in steps of 0.2 and the average final generating pressure should be as follows:

Main Plant

- Loading: 6kg/cm^2
- Unloading: 7 kg/cm^2

Product plant compressor

- Loading: 7kg/cm^2
- Unloading: 8 kg/cm^2

Savings:

The expected savings by reducing the generation pressure is 18270 units annually. The annual monetary saving for this project is ***Rs 1.02 Lakhs without any investment.***

Table 39 Savings calculation for compressor pressure reduction

Parameters	UOM	
Percentage average pressure reduction in main plant compressor	%	6.25
Percentages average % pressure reduction in product compressor	%	10.53
Conservative power saving in main compressor	kW	0.83
Conservative power saving in product compressor	kW	1.78
Total Power Savings	kW	2.61

Annual operating Hours	Annually	7000
Annual Energy Savings	kWh	18270
Electricity Cost	Rs/kWh	5.6
Savings per year	Rs Lakhs	1.02
Investment	Rs Lakhs	Nil
Pay Back	Months	Immediate
TOE Savings	**TOE**	**1.57**
TCO_2 Savings	**TCO_2**	**14.98**

Energy Saving Proposal 9 -Install VFD for Main Plant Compressor to avoid unloading

Present Status

2 screw compressors were installed in to cater the compressed air requirement in process and instrumentation. In main plant maximum pressure required is 6kg/cm ^{2} and for dairy products the maximum pressure required is 7kg/cm^2.During the detailed energy it was found that the main plant compressor was unloading frequently.

The operating parameters of running compressors during the course of audit are as follows:

Table 40: Plant compressor loading pattern

Tag No	Loading %	Unloading %	Actual Load Power, kW	Actual Unload Power, kW
Plant Air Screw Compressor	48	52	27.77	9.9

The compressor has overall 52% unloading and during unload the compressor does not carry out any useful work. It consumes power to overcome its internal losses. Moreover, the unload power consumption of screw compressors is higher compared to reciprocating compressor. Generally, screw compressors are designed for 100% loading.

The unload time indicates excess capacity of the compressor. There is a good potential to optimize the capacity of the compressors. The capacity of the compressors can be optimized by installing VFD for one compressor in the interconnected loop of compressors. Capacity control of methods compressors are shown below:

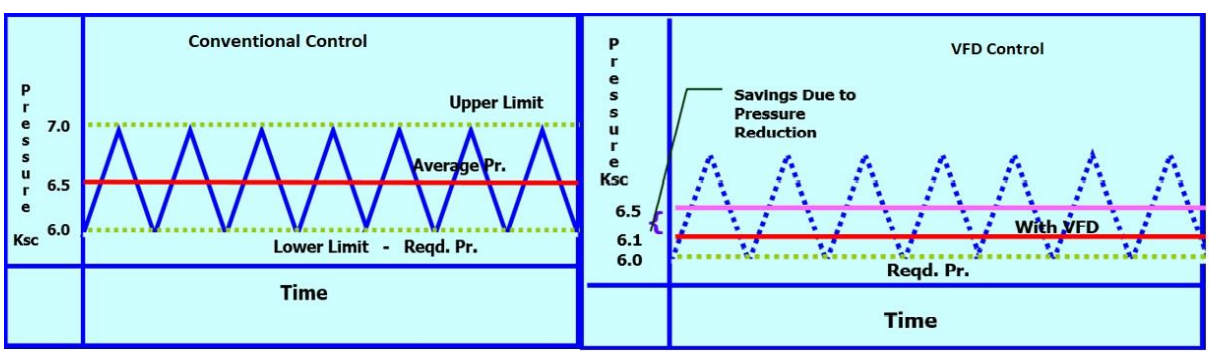


Figure 24: Capacity control of compressor

By installing VFD the average operating pressure can be set at ±0.1 bar of the required pressure.

Recommendation

It is recommended to install VFD and operate that with closed loop for all the above listed compressors to avoid the unloading of the compressors. The feedback for VFD can be given as required receiver pressure. By installing VFD the compressor can be operated in a pressure bandwidth of ±0.1 bar. Saving potential of 5.0 kW is available by means of installation of VFD in the above-mentioned compressors.

Savings

The expected savings by installation of VFD in the compressor is 36036 units annually. The annual monetary saving for this project is ***Rs 2.0 Lakhs with an investment of Rs 2.0 Lakhs and payback for the project is 12 months.***

Table 41: Savings calculation for VFD for air compressor

Parameters	UOM	
Unloading power of compressor	kW	9.9
Percentage unloading in the compressor	%	52
Power Saving	kW	5.148
Annual operating Hours	Annually	7000
Annual Energy Savings	kWh	36036
Electricity Cost	Rs/kWh	5.6
Savings per year	Rs Lakhs	2.0
Investment	Rs Lakhs	2.0
Pay Back	Months	12
NPV at 70% Debt	**Rs Lakhs**	**9.22**
IRR (%)	**%**	**124**
TOE Savings	**TOE**	**3.10**
TCO_2 Savings	**TCO_2**	**29.54**

Energy Saving Proposal 10 – Installation of temperature interlock control for EVAPCO fans

Present System

The plant has installed two evaporative condenser each having two of fans to condense the high temperature refrigerant coming from compressor. During the audit it was found that the condenser was having two pumps in which one is standby and other one is running, also all the 4 fans were running continuously without any temperature interlock.

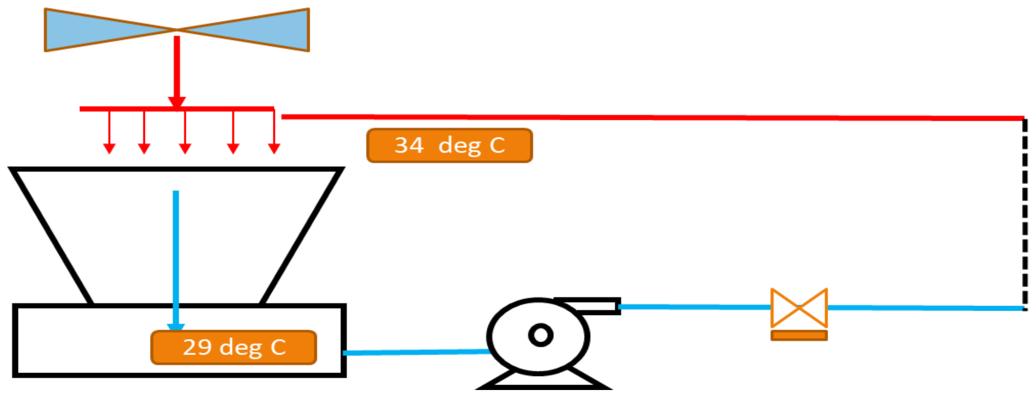


Figure 25: Evaporative Condenser

Cooling water fans are operated manually. Based on manual discussions and on seasonal variations, the fan to be run is set. Also it was observed that there was no control on the fan speed.

The temperature difference between the inlet and outlet of the condenser was measured to be 34^{0}C & 29^{0}C for evapco-1 and 34^{o}C & 28.8^{o}C for evapco-2 respectively. The outlet temperatures of the evapco. The WBT during measurement was 25^{o}C.

Recommendation

It is recommended to install a temperature interlock controller for the condenser fans. The TIC should be interlocked with cooling water sump temperature (WBT +3^{o}C). After interlocking the condenser fans operation will be based on cold well temperature. The fans will operate in such a way that if the cold well temperature falls below 27^{o}C, CT fan will automatically switch off. Savings can be achieved in favourable condition.

Savings

The expected savings by installation of TIC for condenser fans is 11556 units annually. The annual monetary saving for this project is ***Rs 0.65 Lakhs with an investment of Rs 0.60 Lakhs and payback for the project is 11 months.***

Table 42: Saving calculation for TIC

Parameters	UOM	
Total Fan Power	kW	10
Power Consumption after installing TIC	kW	7.11
Power Savings	kW	2.89
Annual operating hrs	hours	4000
Annual Energy Savings	kWh	11556
Electricity Cost	Rs/kWh	5.6
Savings per year	Rs Lakhs	0.65
Investment	Rs Lakhs	0.60
Pay Back	Months	11
NPV at 70% Debt	**Rs Lakhs**	**3.02**
IRR (%)	**%**	**135.54**
TOE Savings	**TOE**	**0.99**
TCO_2 Savings	**TCO_2**	**9.47**

Energy Saving Proposal 11 - Replace Identified Motors with Energy Efficient Motors

Present Status

During the audit at dairy electrical parameters of motor were measured and analysed. It was observed that some of the motors are very old and re wounded more than 7 times which mainly include the agitator motors. The list of motors that can go for higher efficiency class is given below:

Table 43: Measurements of motor to be replaced

Section	Name	Rated Power, kW	Running Power, kW	Loading, %
ETP	Primary Agitator 1	15	11.9	59
ETP	Primary Agitator 2	15	13.43	67
ETP	Primary Agitator 3	15	12.67	63
ETP	Primary Agitator 4	3.7	3.02	57
IBT	Agitator 1	3.7	2.5	47.3
IBT	Agitator 1	3.7	2.3	43.5
IBT	Agitator 1	3.7	2.1	37.2

It has been found that there is a potential of increasing the efficiency of the motor by replacing the existing ones with the new energy efficient motors.

The following are the disadvantages for old and re winded motors:-

- Motor burning and bearing failure
- Quality of insulation between stampings deteriorates
- Eddy current losses increases
- Magnetic property deteriorates
- Air gap becomes uneven
- Net torque developed is low

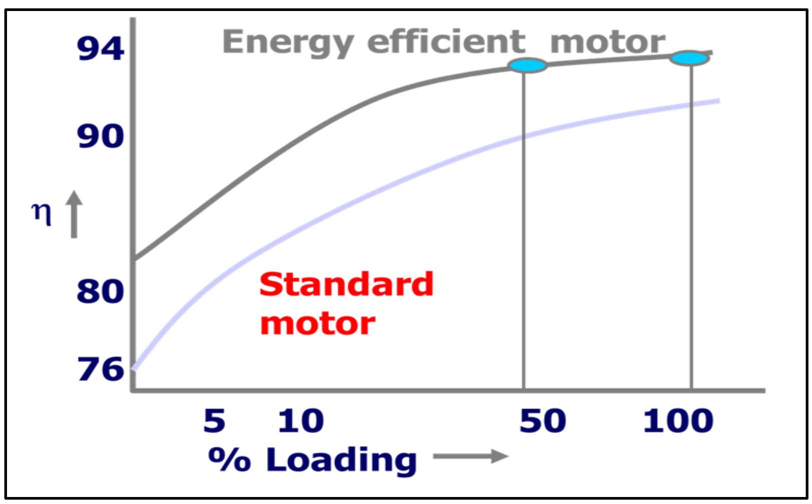


Figure 26: Loading Vs Efficiency curve

Recommendation

It is recommended to replace the identified motors with energy efficient motor. The following graph shows the how the efficiency varies for standard motor and energy efficient motor at different percentages of loading. The energy efficient motors are available at efficiencies as high as 94 to 95

% depending upon the capacities which are relatively prominent with respect to the standard counterparts.

The motors also retain more or less the same efficiencies in the range of 50-100% loading. The figure below shows the features of energy efficient motor.

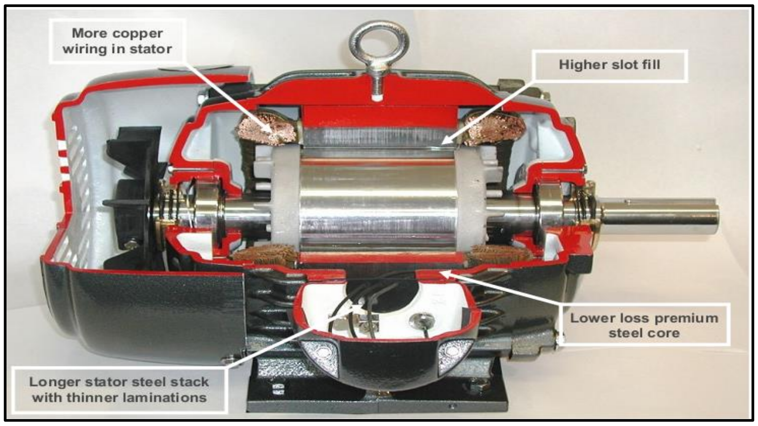


Figure 27: EE Motor features

The graph below shows the comparison of different class of motors based on efficiency

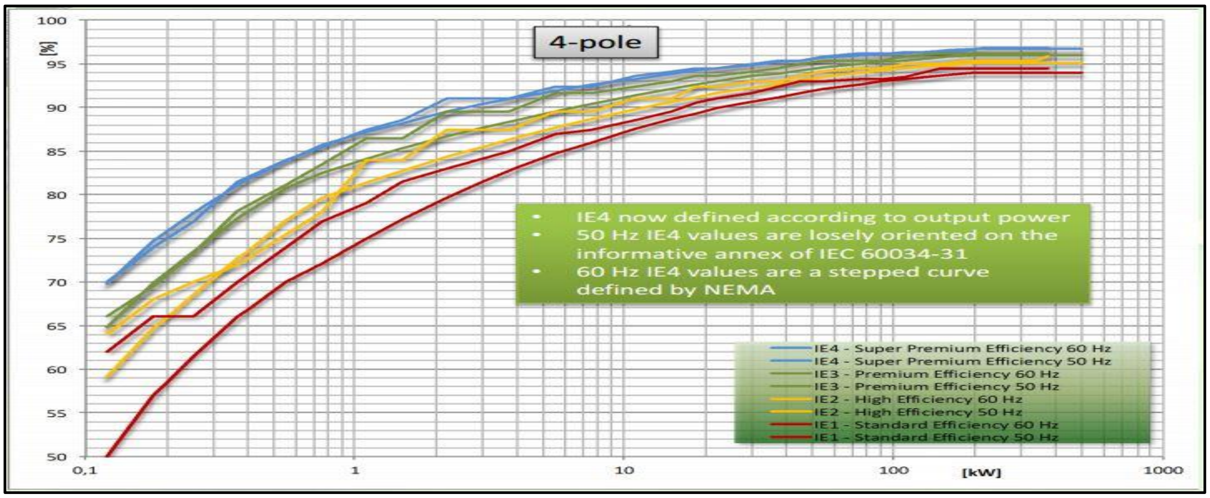


Figure 28: Losses in different classes of motors

Savings

The expected savings by replacement of old motors with energy efficient motors is 70065 units annually. The annual monetary saving for this project is ***Rs 3.94 Lakhs with an investment of Rs 3.89 Lakhs and payback for the project is 12 months.***

Table 44: Saving calculation for Motors

Parameters	UOM	
Total Power Consumption	kW	47.92
Total Power Saving based on improved efficiency	kW	11.68
Annual operating hrs	hours	6000
Annual Energy Savings	kWh	70065
Electricity Cost	Rs/kWh	5.6
Savings per year	Rs Lakhs	3.94
Investment	Rs Lakhs	3.89

Pay Back	Months	12
NPV at 70% Debt	**Rs Lakhs**	**18.18**
IRR (%)	**%**	**128.01**
TOE Savings	**TOE**	**6.03**
TCO_2 Savings	**TCO_2**	**57.45**

Energy Saving Proposal 12- REPLACEMENT OF EXISTING T 8 and T 12 LIGHTS WITH 20 W LED

Present Status

Plant is having two lighting DB's where the entire lighting load is supplied. Already the process of replacing the conventional light with LED's have already started which is an excellent initiative by the plant team. The lighting load of the load is shown in the below table:

During the day time the lighting load is 16 kW, in that the major contributor is 36W and 40W TFL lights.

Table 45: Plant lighting details

Type of Fixture	Total Nos	Wattage (W)	Total kW	LED (Wattage)
36 W T8	205	40	8.2	4.1
40 W T12	177	44	7.7	3.54

Recommendation

It is recommended to replace the identified T8 and T12 lamps in the plant with 20W LED.

Latest Design in Lighting

The latest trend in lighting is to utilize the right amount of pupil lumen. The pupil lumen also considers the variation in sensitivity of the eye in relation to the environment. The sensitivity of the eye varies between daytime lighting and night time lighting as shown in the figure below.

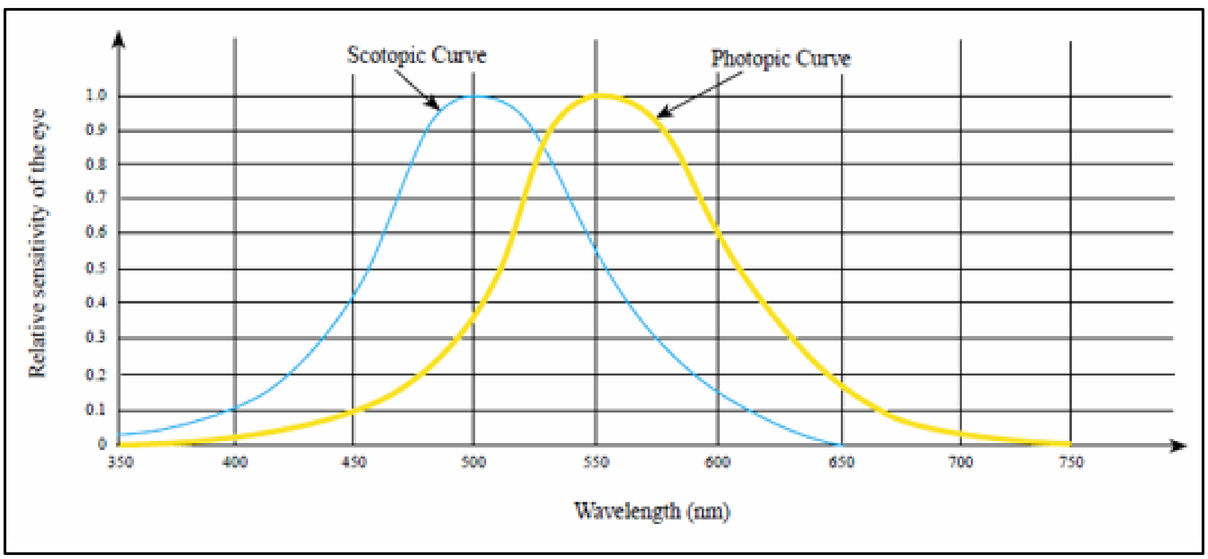


Figure 29: Eye sensitivity curve

The photopic curve and scotopic curve mention the day-time lighting and night-time lighting respectively. The eye colour is more sensitive towards the green colour for photopic curve and is correspondingly for blue colour in the case of scotopic vision. This data of relative sensitivity of eye helps us in designing the correct colour of the lamp required for different lighting conditions. The scotopic vision is well suited for night environment such as street lights, basements, closed rooms where sunlight is not available. The photopic on the other hand will be closer to day-time environment. The earlier system of lighting wherein the quantity of light delivered was mentioned in lumen and not in pupil lumen considered only the photopic curve.

Comparison of Lamps

The table below shows a brief comparison of all the lamps. LED is the latest energy efficient technology in lighting. Compared to the conventional lamps, it offers significant advantages in terms of energy consumption along with other benefits. The latest trend is to go for LED lamps. These LED lamps have very high scotopic to photopic ratio of 2.4. This is very well suited for lighting in dark surroundings. Eg: street lighting, Closed rooms with low sunlight.

Table 46: Comparison of different type of lighting fixtures

Sl. No	Parameter	LED	HPSV	CFL	Metal Halide	FTL T8
1	**Life**	50000 Hours +	15,000-20,000 Hours	6000-8000 Hours	10,000-12,000 Hours	8000 Hours
2	**Lamp Efficacy**	90-100	90-140	60-65	65 to 90	60-68
3	**Lumen Depreciation**	30% @ 50,000 Hours	Upto 40% @ 15000 Hours	15-20% till end of life	Upto 40% @ 12000 Hours	15-20% till end of life
4	**CRI**	70-90	22- 25	65-85	65-90	60-72
5	**Color**	Variety	Yellow	White	White	White
6	**Color temperature**	2100-10000K	2100K-3000K	3000-6000K	4000-5000K	3000-6500K
7	**S/P Ratio**	Upto 2.4	0.62	1.3-2.2	1.6	1.3
8	**Warm up time 90% Lumen**	Instant	4 minutes	1 minute	5 minutes	10-50 Seconds
9	**Flicker free**	yes	No	No	No	No

Advantages of LEDs

As identified from the above table, LED lamps offer the following advantages

- Lower energy consumption
- High S/P ratio
- Longer life time
- Faster switching
- Greater durability and reliability
- Good Color Rendering Index (CRI)
- More focused light and reduced glare

- Does not contain pollutants like mercury
- Highly compatible for solar lighting as low-voltage power supply is sufficient for LED illumination
- Higher Light Output Ratio (LOR): The Light Output Ratio indicates the actual amount of light that can be obtained after considering the losses in luminaire. As can be seen from the figure below, the light output also depends on the light fixture. In the first fixture, certain amount of light is lost. The second fixture has a mirror finish reflecting the light lost to the ceiling in the first case is directed downwards and the loss of light is low in comparison to the fixture on left. The light fixtures that house LED lamps are latest and hence the loss of light is low. LED fixtures have an LOR close to 100%.

Savings

The expected savings by replacement of FTL with LED lights is 24430 units annually. The annual monetary saving for this project is ***Rs 1.37 Lakhs with an investment of Rs. 1.56 Lakhs and payback for the project is 12 months.***

Table 47: Saving calculation for lighting replacement

Parameters	UOM	
Total conventional Lighting load	kW	16.02
Total LED lighting load	kW	7.658
Power Saving	kW	8.367
Annual operating hrs	hours	2920
Annual Energy Savings	kWh	24430
Electricity Cost	Rs/kWh	5.6
Savings per year	Rs Lakhs	1.37
Investment	Rs Lakhs	1.56
Pay Back	Months	12
NPV at 70% Debt	**Rs Lakhs**	**6.23**
IRR (%)	**%**	**113.4**
TOE Savings	**TOE**	**2.10**
TCO_2 Savings	**TCO_2**	**20.03**

Energy Saving Proposal 13 - INSTALLATION OF AC ENERGY SAVERS

Present Status

During the detailed energy audit at **Trivandrum**, Dairy, Air Conditioning system was studied in detail to optimize the energy usage. It was found during the study that the plant had split AC's of 1.5 TR to 3TR capacity at different locations such as admin office and site offices.

In Spit AC and packaged units compressor unit is normally controlled by relay or timer to achieve set temperature based on predefined algorithms for "hottest region". There is no close loop feedback so that compressor operation can be controlled based on ambient conditions.

Due to the standard loop in all the AC units there is a delay in compressor operation even after set temperature is achieved which results in an additional operation of AC compressor results in over cooling and thus higher SEC of AC units.

Some of the identified number of AC units with rated power consumption are as follows:

Table 48: List of AC units

S. No	Capacity of AC units	Power, kW	Nos.
1	1.2 TR	1.45	8
2	1.5 TR	1.63	3
3	1.8 TR	1.96	1
4	3 TR	3.3	3

Recommendation

It is recommended to install AC energy saver to all identified ACs in the plant. The latest generation intelligent AC controller in split ACs have dual sensors which are provided in the controller and gets reference from room and coil temperature. The multiple algorithms in a" closed -loop circuit" ensure the high savings and adapts AC to ambient temperatures and climatic changes. The dual sensor can sense both room temperature and return air temperature. Always the return temperature will be 1 or 2°C more than room temperature. Normally for conventional AC only one sensor is there for sensing return air temperature. As a result even if the room temperature is low based on the return air temperature compressor will operate and it will be in on condition for more time. But with the help of AC energy saver as it senses both room and return air temperatures, the operation of compressor can be precisely controlled and hence the running hours of compressor can be reduced.

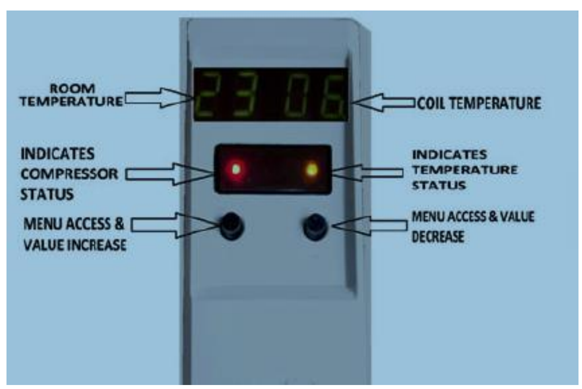


Figure 30: AC Remote controller

Savings

The expected saving after installation of AC energy saver is 17010 units annually. The annual monetary saving for this project is ***Rs 0.95 Lakhs with an investment of Rs 0.97 Lakhs and payback for the project is 13 months.***

Table 49: Saving calculation for AC Energy Saver

Parameters	UOM	
Total AC units power consumption	kW	28.35
Conservative Power Saving after AC energy saver (20% Saving)	kW	5.67
Annual operating hrs	hours	3000
Annual Energy Savings	kWh	17010
Electricity Cost	Rs/kWh	5.6
Savings per year	Rs Lakhs	0.95
Investment	Rs Lakhs	0.97
Pay Back	Months	13
NPV at 70% Debt	**Rs Lakhs**	**4.30**
IRR (%)	**%**	**124.42**
TOE Savings	**TOE**	**1.46**
TCO_2 Savings	**TCO_2**	**13.94**

Energy Saving Proposal 14 – Installation of 30 kWp Solar Roof Top

Present System

Trivandrum Dairy Plant is purchasing electricity from grid for the operation of various equipment's in the plant. The contract demand of the plant is 800 kVA with electricity price of Rs 5.6/kWh with an average load of 500 kW to 600 kW.

Observation

During the course of study it was observed that plant has enough roof top area which can be utilized to install solar PV panel to harness solar energy and generate electricity.

Table 50: Site Specifications

Parameters	
Effective Rooftop available, sq. ft	3000
Location	Latitude: - 08° 28' 28" N, Longitude: - 76° 56' 51" E
Altitude above sea level, m	4
Annual in plane irradiation	5.75 kWh/m2/day

Net Metering Business Model

The net metering based rooftop solar projects facilitate the self-consumption of electricity generated by the rooftop project and allows for feeding the surplus into the grid network of the distribution by licensee. The type of ownership structure for installation of such net metering based rooftop solar systems becomes an important parameter for defining the different rooftop solar models. A rooftop photovoltaic power station, or rooftop PV system, is a photovoltaic system that has its electricity-generating solar panels mounted on the rooftop Industry building. The various components of such a system include photovoltaic modules, mounting systems, cables, solar inverters and other electrical accessories. Rooftop mounted systems are small compared to ground-mounted photovoltaic power stations with capacities in the megawatt range. A grid connected rooftop photovoltaic power station, the generated electricity can sometimes be sold to the servicing electric utility for use elsewhere in the grid. This arrangement provides payback for the investment of the installer. Many consumers from across the world are switching to this mechanism owing to the revenue yielded. A commission usually sets the rate that the utility pays for this electricity, which could be at the retail rate or the lower wholesale rate, greatly affecting solar power payback and installation demand.

Recommendation

As per the site feasibility study it was found that plant can install a 30 kWp Solar PV power plant which will generate an average of around 0.45 Lakhs electrical units annually. It is a grid connected net metering based rooftop solar system which is a new concept for MSME industries And in grid connected rooftop or small SPV system, the DC power generated from SPV panel is converted to AC power using power converter and is fed to the grid either of 33 kV/11 kV three phase lines or of

440V/220V three/single phase line depending on the local technical and legal requirements. These systems generate power during the day time which is utilized by powering captive loads and feed excess power to the grid. In case, when power generated is not sufficient, the captive loads are served by drawing power from the grid.

The net metering based rooftop solar projects facilitates the self-consumption of electricity generated by the rooftop project and allows for feeding the surplus into the network of the distribution licensee. The type of ownership structure for installation of such net metering based rooftop solar systems becomes an important parameter for defining the different rooftop solar models. In the international context, the rooftop solar projects have two distinct ownership arrangements.

Savings

The expected savings by installation of 30 kWp solar roof top is 43800 units of electricity annually. The annual monetary saving for this project is ***Rs 2.45 Lakhs with an investment of Rs 15.00 lakhs and payback for the project is 73 months.***

Detailed savings calculations is given in below table

Table 51: Savings calculation for solar roof top

Parameters	UOM	
Proposed Roof top Solar installation	kW	30
Area Available at Roof	Sq. ft	3000
Annual units generated per kW of Solar PV	kWh per kW/year	1533
Total Energy Generation Per Annum	kWh/year	43800
Electricity Cost	Rs/kWh	5.6
Cost Savings	Rs Lakhs	2.45
Investment	Rs Lakhs	15.00
Payback period	Months	73
NPV at 70% Debt	**Rs Lakhs**	**5.55**
IRR (%)	**%**	**24.62**
TOE Savings	**TOE**	**3.77**
TCO_2 Savings	**TCO_2**	**35.9**

5. MANAGEMENT ASPECTS AND CONCLUSIONS

THE OBJECTIVES OF THIRUVANANTHAPURAM DAIRY MAIN PLANT SHOULD BE

- To make energy conservation a permanent activity at the plant
- To achieve power consumption reduction possible in the unit
- To reduce the electrical and thermal energy consumption to the minimum
- To have a firm top management commitment, so that, the company achieves energy conservation on a time bound basis.
- To implement the recommended proposals and reap the maximum benefits

5.1 Approach to an Energy Conservation Idea

Each energy conservation idea should be seen as an opportunity for improvement. The approach must be on how to implement each proposal and overcome the problems, if any. It is easier to say that a proposal is not possible or not implementable, but the benefit comes from the actual implementation, which needs a lot of courage, conviction, will power and perseverance to implement.

5.2 Specific Recommendations

Thiruvananthapuram Dairy Main Plant should form an energy conservation committee. The committee should consist of senior operating, electrical and maintenance personnel.

The committee should meet once in a month with a specific agenda to review the progress of implementation of proposals and to guide the implementation team. Thiruvananthapuram Dairy Main Plant should also select a senior person as energy manager and he should coordinate all the implementation activities. The main responsibility of implementing the proposals and achievement of savings should be with the concerned operating and maintenance personnel and not with the energy manager.

The immediate task of Thiruvananthapuram Main Plant should be to implement the identified proposals and get the savings.

We would recommend Thiruvananthapuram Dairy Main Plant to introduce a suggestion scheme for energy conservation. The energy conservation committee should review all suggestions and good proposals should be implemented. The originator for the good suggestion, which has been successfully implemented, has to be rewarded.

5.3 Assign Specific Responsibility

While the overall responsibility for energy conservation rests with the top management, the concerned plant operating, electrical & maintenance personnel should implement and report progress on energy saving proposals.

While the overall responsibility for energy conservation rests with the top management, the concerned plant operating, electrical & maintenance personnel should implement and report progress on energy saving proposals.

Therefore, each energy saving proposal should be assigned to a specific operating/ maintenance personnel for implementation and monitoring. The suggested format is enclosed as Annexure – B.

Specific time bound action plan is required for implementation and monitoring of energy saving proposals.

5.4 Monitoring of Proposals

All the implemented proposals are to be monitored on a proposal-by-proposal basis for actual achievement of savings on a monthly basis.

5.5 Motivational Aspects

The successful management of energy depends on motivation of technical personnel and their commitment. For this reason, Thiruvananthapuram Dairy Main Plant should carry out the following motivational aspects to sustain energy conservation activities.

- Send operating, electrical and maintenance personnel for training programs in specific areas like:
  - Pumps
  - Refrigeration Compressor
  - Air Compressors
  - Motors
  - Boiler and Steam System
- Organise visits for executives to similar units to know the energy conservation / process development, etc.

5.6 Conclusions

- Thiruvananthapuram Dairy Main Plant and CII – Godrej GBC teams have jointly identified **14** energy saving proposals worth an annual saving potential of **Rs. 37.47 Lakhs**. The investment required for implementation of energy saving proposals is **Rs. 64.12 Lakhs**. The total investment will have a simple payback period of **21 months.**

Table 52: Summary of savings

Details	No. of Proposals	Annual savings
Total Annual savings	14	37.47
Investment Required (Rs. Lakhs)	13	64.12
Pay Back	Months	21

Table 53: Summary of fuel savings

Details	UOM	Annual savings
Total Electricity Savings	kWh	2,85,572
Total Fuel Savings (Briquette)	Kgs	3,22,641
Annual TOE Savings	TOE	153.60
Annual TCO_2	TCO_2	234.20

Table 54: Summary of Energy Saving Proposals

Sl. No.	ECM	Annual savings (lakhs)	Investment (lakhs)	Payback	Electricity Savings (kWh)	Fuel Savings (kg Briquette)	TOE savings	TCO2 savings
1	Installation of condensate recovery system	7.41	11.82	19		112348	44.9	
2	Installation of Automatic Pumping Trap for CIP Section	0.98	1.50	18		11772	4.71	
3	Installation of VFD for ID Fan in 3TPH Boiler	0.31	0.55	21	5640		0.49	4.60
4	Waste heat recovery from chiller compressor	13.10	21.00	19		198521	79.4	0.00
5	Replacement of existing chilled water pumps with energy efficient pumps	1.84	1.65	11	32744		2.82	26.90
6	Replacement of Ceiling fans with BLDC fans	0.78	2.10	32	13961		1.20	11.40
7	Replacement of existing compressor with Screw Compressor	0.67	1.48	27	12000		1.03	9.80
8	Reduce the Generating Pressure of Main Plant Compressor and Product Dairy Compressor	1.02	0.00	0	18270		1.57	15.0
9	Install VFD for Main Plant Compressor to avoid unloading	2.00	2.00	12	36096		3.10	29.6
10	Installation of temperature interlock control for EVAPCO fans	0.65	0.60	11	11556		0.99	9.50
11	Replace Identified Motors with Energy Efficient Motors	3.94	3.89	12	70065		6.03	57.5
12	Replacement of T8 and T12 light with LED	1.37	1.56	14	24430		2.10	20.0
13	Installation of AC Energy Savers	0.95	0.97	12	17010		1.46	13.9
14	Installation of 30 kWp Solar Roof Top PV	2.45	15.00	73	43800		3.77	35.9

	Total	**37.47**	**64.12**	**21**	**2,85,572**	**3,22,641**	**153**	**234**

5.7 Thiruvananthapuram Dairy, Main Plant should

- Assign specific responsibility for implementation of proposals
- Monitor savings achieved on proposal by proposal basis
- Monitor overall auxiliary power consumption and reduction in energy consumption equipment-wise
- Have the goal of becoming the best energy efficient unit in the country

6. ANNEXURE

6.1 Common Monitorable Parameters in Dairy

Sl No	Section	Parameter	Purpose	Monitoring Method	Measurement Unit	Frequency	Reference Range
1	BOILER - STEAM & CONDENSATE	Steam Generation Pressure	For quality of steam produced	By using Pressure Gauge at MSV outlet	Kg/cm2 g	Hourly	Nearer to boiler rated pressure
		Steam Generation Temperature		By using Temperature Gauge at MSV outlet	Deg C	Hourly	Nearer to boiler rated temperature
		Boiler Water TDS / Conductivity	For proper blow down	By using TDS / Conductivity sensor	ppm / microS/cm	Hourly	3200 - 3500 ppm / 4000 - 4500 uS/cm
		Oxygen Level in Flue Gas	For proper fuel combustion	By using O2 analyzer	%	Weekly	FO/NG fired – 2.5% – 3% O2 and Briquette/Wood fired – 4% O2
		Flue gas temperature		By Using Thermocouple	Deg C	Weekly	> 120 deg C & < 180 deg C for package boilers
		Steam to Fuel Ratio / Evaporation Ratio	For estimating boiler efficiency	By using Steam Flow Meters	Ratio	Weekly	Dependent on fuel: 2 - 3.5 for biomass fired boilers 4 - 7 for coal fired boilers 11 - 14 for oil /gas fired boilers
		Specific Steam consumption at each process	For monitoring SEC values	By using Steam Flow Meters	Kg steam / KL milk	Daily	Indirect: 22 - 25 Kg steam / KL milk pasteurization Direct: 17 - 21 Kg steam / KL mil Pasteurization

		Feed Water temperature	For better boiler operation	By Using Thermocouple	Deg C	Hourly	Above 85 deg C
2	**REFRIGERATION SYSTEM**	Chilled Water Supply and Return Temperature	For estimating cooling load	Using IR Temperature gun / EMS	Deg C	Hourly	As per plant operations
		Condenser Water Supply and Return temperature	For estimating heat rejection	Using IR Temperature gun / EMS	Deg C	Hourly	As per plant operations
		Range of Cooling Tower	For comparison of CT performance	Using IR Temperature gun / EMS	Deg C	Bi-weekly	9 - 12 deg C
		Approach of Cooling Tower		Using IR Temperature gun / EMS	Deg C	Bi-weekly	3 - 4 deg C
		Compressor Suction Pressure	For compressor performance	Pressure Guage	Kg/cm2 g	Hourly	As per capacity of compressor
		Compressor Discharge Pressure		Pressure Guage	Kg/cm2 g	Hourly	As per capacity of compressor
		Compressor Discharge Temperature		Thermocouple	Deg C	Hourly	As per capacity of compressor
		SEC Value		Using Power analyzer	kW/Ton	Per Shift	0.8 - 0.9 kW/Ton for Screw Compressors 1.1 - 1.3 kW/Ton for Reciprocating Compressor
		IBT and Cold Room Temperature	For refrigeration compressor performance	Thermocouple	Deg C	Hourly	IBT Temperature - 0 deg C - 0.5 deg C Cold Room temperature based on product stored
3	**Compressed Air System and Pumps**	Compressor Generation Pressure	For keeping lowest pressure possible	Using Pressure gauge at discharge line / Panel	Kg/cm2 g	Hourly	Closest possible to user requirement
		Compressor Loading %	For proper planning of usage	From Panel / By manually noting time	%	Per Shift	7 0 - 90%

		Compressor Unloading %		From Panel / By manually noting time	%	Per Shift	10 - 30 %
		Air Flow Rate	For compressor performance	Conducting FAD	CFM	Per Shift	Dependent on demand
		SEC Value		Using Power Analyzer	kW/CFM	Per Shift	0.18 KW/CFM for Screw Compressors 0.14 KW/CFM for Reciprocating Compressor
		Line Leakages	For immediate rectification	Visual	-	Weekly	Zero Tolerance
		Leakage at Compressed Air Vessel Condensate line		Visual	-	Weekly	Zero Tolerance
		Pump Discharge Pressure	For Pumps performance	Using Pressure Gauges at suction and discharge	Kg/cm2	Quarterly	As per manufacturers recommendation
		Pump Flow Rate		Using flow meter	m3/hr	Quarterly	As per manufacturers recommendation
		Pump Power Consumption		Using Power Analyzer	kW	Quarterly	As per manufacturers recommendation
4	**Pasteurization**	Raw milk inlet temperature	For Regeneration Efficiency Calculation	Using Thermocouple / Panel	Deg C	Monthly	4 - 7 deg C
		Temperature after pre-heating by Regeneration		Using Thermocouple / Panel	Deg C	Monthly	9 - 10 deg lesser than pasteurization T
		Pasteurization Temperature		Using Thermocouple / Panel	Deg C	Monthly	75 - 79 deg, depending on holding time

		Temperature after pre-cooling by Regeneration		Using Thermocouple / Panel	Deg C	Monthly	15 - 20 deg C
		Chilled Milk Temperature		Using Thermocouple / Panel	Deg C	Monthly	3 - 4 deg C
5	**Raw Energy**	Electrical Parameters	For estimating transformer loading, voltage profile, current and voltage imbalances	Using Power Analyzer	kW,V, I, A, PF, Harmonics	Monthly	Plant LT voltage should be 410 V - 415 V PF close to unity Transformer loading - 50% -60% VTHD < 8% at 415 V side ITHD < 15% at 415 V side
		Fuel Consumption / Unit Production	For estimating Thermal System Efficiency	Using Load Cells / Flow Meters	Kg/KL	Monthly	As per equipment supplier recommendation
		Fuel Calorific Value	For estimating fuel quality	From 3rd party report	Kcal/Kg	Monthly	As per supplier specification

6.2 Supplier Details

Sl.No	Equipment	Supplier Name	Contact Person	Contact Number	Mail Address
1	**AC Energy Saver**	Magnetron International	Mr Kishore Mansata	9748727966	indiaenergysaver@gmail.com
2	**AC Energy Saver**	Gloabtel Convergence Ltd	Mr Chirag Morakhia	9324176440	chirag@gloabtel.com
3	**Active Refrigerent Agent**	CITC	Mr Bala S Mocherla	9885293896	m.bala@citcusa.com
4	**Aluminium pipe lines**	Legris Parker	Mr. Joy Dewan	8800452020	joy.dewan@parker.com
5	**Aluminium pipe lines**	Godrej & Boyce Mfg Co. Ltd.	Mr Kiron Pande	9820348824	kcp@godrej.com
6	**APFC**	Crompton Greaves Limited.	Mr Ashok Kulkarni	9713063377	ashok.kulkarni@cgglobal.com
7	**APFC**	In phase Power	Mr Kamalakannan Elangovan	9901599953	kamal.elangovan@inphase.in
8	**APFC**	Process Technique Electronic Pvt ltd	Mr.Venkatesh	9448077736	support@processtechnique.com
9	**ATCS**	Shaw Energy Saving Solutions	Mr.Dilip Shaw	9396661892	shawenergysavingsolutions@gmail.com
10	**ATCS**	ECO GREEN SYSTEMS LLP	Mr Sachin Deshpande	8390525050	sachind@ecogreensys.com
11	**Auto Drain Valves - Level Based**	Summits Hygronics Pvt Ltd	Mr Balakannan S	9600910170	design@airdryer.in
12	**Auto Drain Valves - Level Based**	Beko Compressed Air Technologies Pvt Ltd	Mr Madhusudan Masur	040-23081106	Madhusudan.Masur@bekoindia.com
13	**Automatic voltage controller /Stabiliser**	Jindal Electric & Machinery Corp.		0161-2670250	jemc@jindalelectric.com
14	**BLDC Ceiling Fans**	Atomberg Technologies Pvt Ltd	Ms Roshni Noronha	9987366655	roshninoronha@atomberg.com
15	**BLDC Ceiling Fans**	Versa Drives	Mr Sathish	94885 94382	sathish@versadrives.com
16	**Blowers**	Vacunair Engineering Co. Pvt. Ltd.	Mr. Manan Vadher	9904048822	manan.vadher@vacunair.com

17	**Blowers**	Kay blowers	Mr Garg	011-27671851 // (Direct) 27673016	pkgarg@kayblowers.com
18	**Blowers**	Aerotech Equipments & Projects (p) Ltd.	Mr Vikas Saxena	9810162210	sales@aeppl.com
19	**Blowers**	Envirotech Engineers	Mr Sham Bagde	98235 55397	envirotech_pune@yahoo.com
20	**Boiler Consultant/Pressure Part Supplier**	Venus energy audit system	Mr.K K Partiban	98431 13111	parthi2006@hotmail.com
21	**Continous Emission Monitoring System**	Opsis Gas Monitoring Systems	Mr Kishore Kumar	94440 33220	kishor@opsis.se
22	**Continous Emission Monitoring System**	Chemtrols Industries Ltd.	Mr K Nandakumar	9821042703	nandakumar@chemtrols.co.in
23	**Chemical Free Descaling System**	Mac2Pro Engineers	Mr.Vijayan Lakshmanan	7032178655	vijayanlpr@mac2pro.in
24	**Chillers**	Johnson Controls	Mr Nanthagopalan	9900766800	nantha.gopalan@jci.com
25	**Chillers**	Trane HVAC Systems & Services	Mr. Kallol Datta		kallol_datta@trane.com
26	**Chillers**	Trane HVAC Systems & Services	Mr.Venkatesan Krishna	9963799200	K_Venkatesan@trane.com
27	**Falling Film Chiller for IBT**	Omega Ice Chill	Mr Abhishek Jindal	9990425111	abhishek.jindal@omega-icehill.in
28	**VAM**	Thermax	Mr. Navneetha	9092877626	navaneethakrishnan.R@thermaxglobal.com
29	**Compressors**	Indo Air Compressors	Mr.Kamlesh Bhavsir	9824403616	tech@indoair.com
30	**Compressors**	Kaeser Compressors I Pvt Ltd.	Mr Mohan Raaj	9840844438	mohan.raj@kaeser.com
31	**Compressors**	Ingersoll Rand	Mr Parameswaran Narayanan	080 22166198	vijay_venkatraman@irco.com
32	**Compressors**	Atlas Copco	Mr Latesh	9346280052	latesh.k@in.atlascopco.com
33	**Compressors**	ELGI Equipments	Mr Urjit Joshi	9701990930	urjitj@elgi.com

34	**Compressors**	Kaeser Compressors I Pvt Ltd.	Mr Mohan Raaj	044- 26200425/42172278	mohan.raj@kaeser.com
35	**Compressors**	Denvik Technology Private Limited	Vijay Krishna	9840851800	vijay@denvik.in
36	**Compressors**	Godrej & Boyce Mfg Co.	Mr Swapnil Patade	9819622663	spatade@godrej.com
37	**Compressors**	Kirloskar Pneumatic	Mr Avinash Prabhumirashi	9881495506	prabhu@kpcl.net
38	**Cooling Towers**	Flow Tech Air Pvt Ltd	Mr Ritwick Das	7838978768	ritwickdas@flowtechair.com
39	**Cooling Towers**	Inductokool Systems (P) Ltd	Mr Dilip Govande	9440608322	inductokool@gmail.com
40	**Cooling Tower Fills**	Brentwood	Mr Shravan Misra	9909974878	
41	**Evaporative Condenser**	BAC	Mr Saurin Dave	97270 12111	saurin@vinienterprise.com
42	**Demand Side Controller**	Godrej & Boyce Mfg Co.	Mr Swapnil Patade	9819622663	spatade@godrej.com
43	**EC Fans for AHU**	EBM Papst	Mr.Venkatesh	9551070034	venkatesh.j@in.ebmpapst.com
44	**EMS**	Elmeasure	Mr.Sagar	9963471135	venkatasagar@elmeasure.com
45	**EMS**	Device Concepts	Mr Srinivasan & Mr Ebby Thomas	9901491267; 9705072036	srigsan@yahoo.com
46	**EMS**	E-cube energy	Mr Umesh	9831012510	umesh@eetpl.in
47	**EMS**	Atandra	Ms Sangeetha Mallikarjuna	97902 26888	sangeetha.rm@atandra.in
48	**Energy Efficient Fan**	Reitz India	Mr A Sengupta	9390056162	asg@reitzindia.com
49	**Energy Efficient Fan**	Howden Solyvent (India) Private Limited	K. Krishna Kumar	7358381115	k.krishnakumar@howden.com
50	**Energy Efficient Fan**	Aerotech Equipments & Projects (p) Ltd	Mr. Vikas Saxena	9810162210	sales@aeppl.com
51	**Energy Efficient Fan**	Dustech Engineers Pvt Ltd	Mr Gagan Gupta	9811205058	
52	**Energy Efficient motors**	Kirloskar Electric Company Limited	Mr. Ashok Kshirsagar	9561091892	ashok@pna.vrkec.com

53	**Energy Efficient motors**	Siemens Limited	Mr Parameswaran	9819657247	parameswaran.td@siemens.com
54	**Energy Efficient motors**	ABB India Ltd.	Mr Madhav Vemuri	9901490985	madhav.vemuri@in.abb.com
55	**Energy Efficient motors**	Crompton Greaves Limited	Mr Ashok Kulkarni	9713063377	ashok.kulkarni@cgglobal.com
56	**Energy Efficient motors**	Bharat Bijilee Limited	Mr Saurav Mishra		Saurav.Mishra@bharatbijlee.com
57	**Energy Efficient motors**	Bharat Bijilee Limited	Mr Anil Naik	9821862782	Anil.Naik@bharatbijlee.com
58	**Energy Efficient motors**	WEG Electric	Mr. Satyajit Chattopadhyay	080-4128-2007/2008/2005	chatto@weg.net
59	**Energy Efficient motors**	Baldor Electric India Pvt Ltd	Mr Bhanudas Chaudhari	97663 42483	bchaudhari@baldor.com
60	**Energy Saving Coatings**	Espee India Pvt Ltd	Mr.Pradip Vaidya	8975090551	espee@espeeindia.com
61	**Energy Saving Coatings**	Innovative Surface Coating Technologies	Mr.Pankaj Patil	9326605194	patilpankaj08@yahoo.com
62	**Flat Belts**	Elgi Ultra Industries Ltd.		(422) 2304141	info@elgiultra.com
63	**Flat Belts**	Habasit-Iakoka Pvt. Ltd		422-262 78 79	habasit.iakoka@habasit.com
64	**FRP Fans**	Encon India	Bhavesh Chauhan	9022144400	bc@encongroup.in
65	**Harmonic Filters**	Digicon Automation Pvt Ltd	Mr Sandip Shah	9978903949	sandip@digicon.in
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69	**Heat Pump**	Mechworld eco	Rohit Singhi	9930301188	rohit.singhi@mechworldeco.com

70	**Heat Pump**	Thermax Ltd	Mr.Rohit Prabhakaran	9948076450	rohit.prabhakarakaran@thermaxglobal.com
71	**Insulation**	Permacel	Mr.Venkatesh Kulkarni	9892513453	vkulkarni@prs-permacel.com
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74	**Insulation**	Rockwool India Pvt Ltd	Mr Kevin Pereira		kpereira@rockwoolindia.com
75	**IOT**	ITC Infotech Pvt Ltd	Mr.Uma Shankar	9900765078	Umashankar.SM@itcinfotech.com
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77	**IOT**	Vermigold Eco Tech	Mr.Jaideep Saptarshi	9867300840	jd@vermigold.com
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81	**LED**	Surya Roshi Ltd	Mr Sen	011-47108000/25810093-96	v.sen@ho.surya.in
82	**LED**	Reckon Green Innovations Pvt Ltd	Mr Krishna Ravi	9985333559	krishna@reckongreen.com
83	**LED**	E view Global PVt Ltd	Mr Rajiv Gupta	9757158328	rajiv@eviewglobal.com
84	**LED**	SYSKA LED	Mr. Swapnil Shinde	+91 20 40131000	
85	**LED**	Philips Lighting India Limited (ESCO model available)	Mr. Mohan Narasimhan		Mohan.Narasimhan@philips.com
86	**LED**	FortuneArt Lighting (ESCO model available)	Mr Prasad	98851 15511	arvlines@gmail.com

87	**LED**	Avni Energy Solutions Pvt Ltd (ESCO model available)	Mr Sandip Pandey	76762 06777	sales@avnienergy.com
88	**LED**	Venture Lighting	Mr Karthikeyan	+91 (44) 2262 5567 / 2262 3094 Extn-6200	karthikeyan@vlindia.com
89	**LED**	EESL	Mr Chandra Shekar	9985594441	ybchandrashekar34@gmail.com
90	**Light Pipe**	E-View Global Pvt Ltd	Mr.Rajiv Gupta	9769421112	rajiv@eviewglobal.com
91	**Light Pipe**	Sky Shade	Mr.Paresh Kumar	9394366885	paresh@skyshade.in
92	**Lighting Energy Saver/ Lighting Transformer**	BEBLEC (INDIA) PVT. LTD.			mktg@beblec.com
93	**Lighting Energy Saver/ Lighting Transformer**	Servomax India Limited	Mr Pavan	98484 62496	pavankumar@servomax.net
94	**Lighting Energy Saver/ Lighting Transformer**	Consul Neowatt Private Limited	NA	+91 44 4000 4200	sri@consulneowatt.com
95	**Low Grade WHR**	Promethean Energy Pvt. Ltd.	Mr Ashwin KP	+91 9167516848	ashwinkp@prometheanenergy.com
96	**Low Grade WHR**	Oorja Energy Engg. Services	Mr.Madhusudhan Rao	9000332828	madhu@oorja.in
97	**Online Flow Meters**	Chandak Instruments Pvt. Ltd.	Mr Rohit Chandak	9371270655 / 9860088074	rohit@chandakinstruments.com
98	**PF Boiler Combustion optimizer**	Greenbank Group	Mr Vivek Savarianandam	7880710722	v.savarianandam@greenbankgroup.com
99	**PID Loop Optimisation**	Akxa Tech Pvt Ltd	Mr.Raghu Raj	9243209569	raghuraj.rao@akxatech.com
100	**PID Loop Optimisation**	Akxa Tech Pvt Ltd	Nagesh Nayak	9320266009	nagesh.nayak@akxatech.com
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102	**Pumps**	Grundfos Pumps India Pvt. Ltd.,	Mr.Shankar		shankar@grundfos.com
103	**Pumps**	UT Pumps & Systems Pvt. Ltd	Mr Athul Gupta	0129-4045831	atulgupta@utpsl.in

104	**Pumps**	KSB India	Mr Arora	0120 2541091 - 93 / 2542872 (D)	rajesh.arora@ksb.com
105	**Pumps**	Kirloskar Brothers Limited	Ashish Shrivastava	20-2721 4529 Mobile : 7774049493	Ashish.Shrivastava@kbl.co.in
106	**Pumps**	CRI Pumps India Pvt. Ltd.	Mr Rajesh Magar	804227 9199	rajeshmagar.v@cripumps.com
107	**Pumps**	Shakti Pumps	Mr. Alpesh Kharachriya	7600030825	alpesh.kharachariya@shaktipumps.com
108	**Pumps**	Crompton Greaves	Mr. Vaibhav Jain	9654125359	vaibhav.jain@cgglobal.com
109	**Pumps**	Sulzer Pumps India Ltd	Mr Arvind singh	9971152020	arvind.singh@sulzer.com
110	**Servo voltage Stabiliser**	Globe Rectifiers	Mr Manoj Singh	9818222380	gr@globerectifiers.com
111	**Servo voltage Stabiliser**	Servomax India Pvt Ltd	Mr Pavan	98484 62496	pavankumar@servomax.net
112	**Solar**	Megawatt Solutions Pvt Ltd	Mr.Arjun Deshwal	9205476722	adeshwal@megawattsolutions.in
113	**Solar**	Megawatt Solutions Pvt Ltd	Mr.Siddharth Malik		smalik@megawattsolutions.in
114	**Solar**	Ohms Energy Private Limited	Mr Dhawal Kapoor	9987788335	dhawal.kapoor@ohmsenergy.com
115	**Solar**	Energy Guru®, SharperSun	Ms. Geetanjali Patil Choori	9970319054	uchoori@energy-guru.com
116	**Solar**	Tangent Technologies	Mr. Anurag Gupta	0265-2291264/ 2291568	anurag.gupta@tangent.in
117	**Solar BOOT Model**	Amplus Solar	Ms Ritu Lal	NA	ritu.lal@amplussolar.com
118	**Solar BOOT Model**	Cleanmax	Mr Pritesh Lodha	9920202803	pritesh.lodha@cleanmaxsolar.com
119	**Solar BOOT Model**	Jakson Power	Mr Vaibhav Singhal	9412227430	vaibhav.singhal@jakson.com

120	**Solar BOOT Model**	Think Energy partners	Mr.Kunal	9560004324	kunal.pragati@thinkenergypartners.com
121	**STP**	DCS Techno services	Mr.Madhu Babu	9676939103	madhu@dcstechno.com
122	**Boiler & Steam Systems**	Thermax Ltd	Mr Ashish Vaishnav	8552822277	ashish.vaishnav@thermaxglobal.com
123	**Boiler & Steam Systems**	Forbes Marshall Pvt. Ltd.	Mr Thomas	9895041210	dkuvalekar@forbesmarshall.com
124	**Transvector Nozzle**	General Imsubs P. Ltd	Mr Kaushalraj	9327030174	air@giplindia.com
125	**Turbines**	Arani Power Systems Limited	Mr K Ch Peraiah	040 23040854	peraiahkch@aranipower.com
126	**Turbo Blowers**	Aerzen India	Mr Shailesh Kaulgud		shailesh.kaulgud@aerzenindia
127	**Vaccum Pumps**	Kakati Karshak Industries	Mr.Srikanth	9701863246	srikanth.chepyala@kakatipumps.com
128	**Vaccum Pumps**	Atlas Copco	Mr Vigneswaran	8975090551	n.vigneswaran@in.atlascopco.com
129	**VAM**	Transparent Energy Systems Pvt. Ltd	Mr Ajit Apte	020 24211347	ajit.apte@tespl.com
130	**Heat Pump**	Aspiration Energy	Mr. Sudharshan	98406 19252	sudharsan.r@aspirationenergy.com
131	**VFD**	Danfoss	Mr Nagahari Krishna	9500065867	Nagahari@danfoss.com
132	**VFD**	Siemens	Mr Shanti Swaroop	9000988322	santhiswaroop.m@siemens.com
133	**VFD**	Schneider Electric India Pvt. Ltd.	Mr Amresh Deshpande	0124 - 3940400	Amresh.Deshpande@schneider-electric.com
134	**VFD**	Rockwell Automation India Pvt. Ltd. (Allen-Bradley India Ltd.)	Ms Ruchi Mathur	9711991447	rmathur@ra.rockwell.com
135	**VFD**	ABB Ltd	Mr Madhav Vemuri		madhav.vemuri@in.abb.com
136	**Bio Gas**	FOV Bio Gas	Mr Joseph	9940159968	joseph@nordcleantech.com

FORMAT FOR MONITORING THE IMPLEMENTATION OF ENERGY SAVING PROPOSALS							
Sl. No.	**ECM**	**Annual savings (lakhs)**	**Investment (lakhs)**	**Payback**	**Person Responsible**	**Target Date**	**Remarks**
1	Installation of condensate recovery system	7.41	11.82	19			
2	Installation of Automatic Pumping Trap for CIP Section	0.98	1.50	18			
3	Installation of VFD for ID Fan in 3TPH Boiler	0.31	0.55	21			
4	Waste heat recovery from chiller compressor	13.10	21.00	19			
5	Replacement of existing chilled water pumps with energy efficient pumps	1.84	1.65	11			
6	Replacement of Ceiling fans with BLDC fans	0.78	2.10	32			
7	Replacement of existing compressor with Screw Compressor	0.67	1.48	27			
8	Reduce the Generating Pressure of Main Plant Compressor and Product Dairy Compressor	1.02	0.00	0			
9	Install VFD for Main Plant Compressor to avoid unloading	2.00	2.00	12			
10	Installation of temperature interlock control for EVAPCO fans	0.65	0.60	11			
11	Replace Identified Motors with Energy Efficient Motors	3.94	3.89	12			
12	Replacement of T8 and T12 light with LED	1.37	1.56	14			
13	Installation of AC Energy Savers	0.95	0.97	12			
14	Installation of 30 kWp Solar Roof Top	2.45	15.00	73			
	Total	**37.47**	**64.12**	**21**			

138	**Refrigeration Compressor**	Frick India	Mr T Krishnamoorthy	9444818846	ttk@frickmail.com

6.3 ESP Implementation Format

6.4 List of Energy Audit Equipment

Sl No.	Description	Purpose	Serial No
1	Power Analyzer	Power Measurement	ALM 10 - Krykard
2	Flue Gas Analyzer	Flue Gas Analysis	Optima 7
3	Hygrometer	Cooling Tower DBT, WBT	HD 500
4	Water Flow Meter	Flow Measurement	Precision Flow 190 PD
5	Pyrometer	Temperature Profiling	Fluke 62

6.5 Format for maintaining records

Motor rewinding records

Sr. No	Motor No.	Purchased/Installed Date	Design Eff.	Rated Output (kW)	Rewinding 1 Date	Rewinding 2 Date	Rewinding 3 Date	Rewinding 4 Date

Energy Monitoring

Sr. No	Date	Shift	Energy Consumption (kWh)	Fuel Consumption (Litres)	Production (kg)	KPI	Benchmark	Remarks

Water Consumption

Sr. No	Date	Shift	Water Consumption (litres)	Production (kg)	KPI	Benchmark	Remarks