February 2019

DETAILED ENERGY AUDIT REPORT

M/s Ernakulam 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

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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
CPD	Central Products Dairy
DEA	Detailed Energy Audit
EE	Energy Efficiency
FCU	Fan Coil Unit
FI	Financial Institution
FO	Furnace Oil
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

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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	ERCMPU Ltd, Ernakulam Dairy, Tripunithura
Name(s) of the Plant Head	Mr. Wilson.J.Puravakkattu - Sr. Manager
Contact person	Mr. Wilson.J.Puravakkattu - Sr. Manager
Constitution	Cooperative Society
MSME Classification	Medium Scale
Address:	Milma, ERCMPU Ltd, Ernakulam Dairy, Tripunithura
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.

- Installation of Condensate recovery system
- Installation Ammonia Feed System
- 30kW Solar PV
- Installation of De-superheater
- Optimized Voltage at Main Incomer
- Maintaining PF close to unity
- Use of Briquette Fired Boiler
- Use of Screw Air Compressors with VFD

CII – Godrej GBC Energy Audit Team conducted Detailed Energy Audit at Ernakulam Dairy Main Plant from 21th October 2018 to 23th October 2018 and final presentation to plant team was given on 24th October 2018.

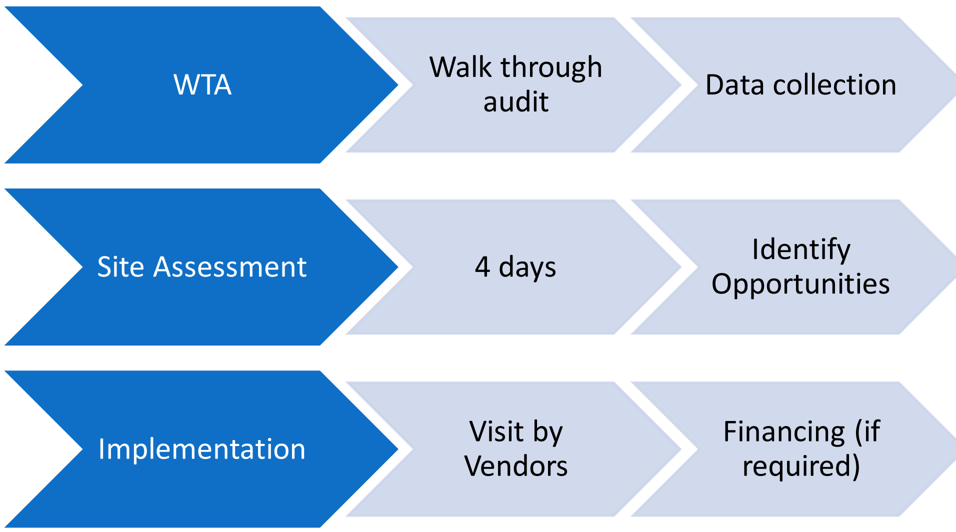
The energy audit included detailed data collection, power measurements of major electrical energy consumers, process measurements, analysis of data, and performance analysis of the equipment and identification of specific energy saving proposals.

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

Ernakulam Dairy plant team and CII energy team have together identified an annual energy saving potential of Rs. 78.66 Lakhs with an investment of Rs 145.98 Lakhs based on energy cost.

Table 2: Summary of savings

Details	No. of Proposals	Annual savings
Total Annual savings	15	78.66
Nil Investment Proposals	3	1.66
Investment Required (Rs. Lakhs)	12	145.98
Pay Back	Months	22

Table 3: Summary of fuel savings

Details	UOM	Annual savings
Total Electricity Savings	kWh	496920
Total Fuel Savings (Briquette)	kgs	5,53,641
Annual TOE Savings	TOE	273
Annual TCO_2	TCO_2	407.5

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	TCO2 savings
1	Installation of new lower capacity boiler of 1 TPH capacity	26.27	30	14		4,10,923	172.59	
2	Modification in MS line and steam distribution line	6.1	3.1	6		29,308	12.31	
3	Condensate recovery from the plant	7.49	6	10		1,13,410	45.36	
4	Installation of new Screw Chiller with VFD	15.38	52	41	279690		0.00	229.3
5	Switching off reciprocating air compressor	0.57	0.00	-	10533		0.91	8.6
6	Replacement of chilled water pump	1.38	1.50	13	13961		1.20	11.4
7	Replacement of existing condenser pump with energy efficient pump	2.30	3.50	18	42474		3.65	34.8
8	Optimize the operation of ETP Agitator motor	0.67	0.00	-	12264		1.05	10.1
9	Installation of Energy Efficient Motors	1.75	2.25	15	31823		2.74	26.1
10	Installation of new 200 TR Evaporative Condenser	11.56	19.46	20	11556		0.99	9.5
11	Installation of VFD for ID Fan	0.27	0.41	18	4927		0.42	4.0
12	Replacement of ceiling fans with BLDC fans	0.17	0.52	37	3212		0.28	2.6
13	Pressure reduction of main plant compressor	0.42	0.00	-	7640		0.66	6.3
14	Installation of energy saver for split ACs	0.32	0.24	9	5840		0.50	4.8
15	Installation of 50kWp Solar roof top	4.01	27.00	81	73000		6.28	59.9
	Total	**78.66**	**145.98**	**22**	**4,96,920**	**5,53,641**	**273.0**	**407.5**

2. INTRODUCTION ABOUT ERNAKULAM DAIRY PLANT

2.1 Unit Profile

Ernakulam Regional Co-operative Milk Producers' Union Ltd. (Ernakulam Milk Union), Milma, was registered on 12.9.1985 with Ernakulam, Thrissur, Kottayam and Idukki Districts in Central Kerala as its area of operation. The Union along with its sister unions (TRCMPU & MRCMPU) is affiliated to the Kerala Co-operative Milk Marketing Federation Ltd.

Ernakulam Dairy is located at Tripunithura, Ernakulam district. The dairy with milk handling capacity of 100000 litres/day caters to cochin – the commercial capital of Kerala. Currently handles about 200000 litres/day. To keep in pace with market demand the dairy is being expanded to 350000 litres/day.

Table 5: Unit Profile

Particulars	Details
Name of Plant	ERCMPU Ltd, Ernakulam Dairy, Tripunithura
Name(s) of the Plant Head	Mr. Wilson.J.Puravakkattu - Sr. Manager
Contact person	Mr. Wilson.J.Puravakkattu - Sr. Manager
Contact Mail Id	ercmpued@milma.com & ercmpuedengg@milma.com
Contact No	+91 9447078010
Constitution	Ernakulam
MSME Classification	Medium Scale
No. of years in operation	26
No of operating hrs/day	15
No of operating days/year	365
Address:	Milma, ERCMPU Ltd, Ernakulam Dairy, Tripunithura
Industry-sector	Dairy
Type of Products manufactured	Milk & Milk Products

2.2 Production Details

The various products manufactured in Ernakulam Dairy Plant are Liquid milk, Ghee, Curd. The graph below shows the milk processed during last one year:

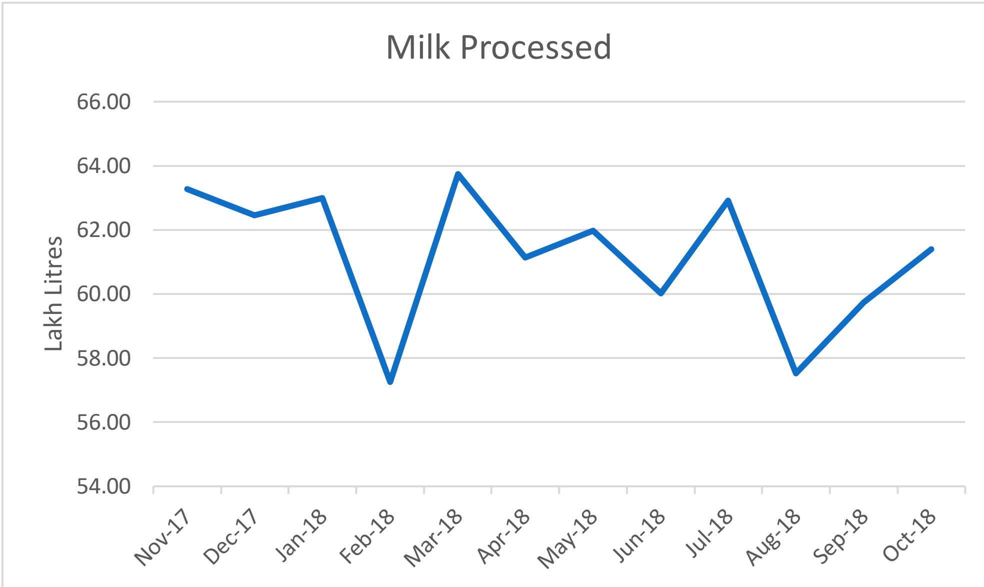


Figure 1: Milk Processed

2.3 Dairy Process Flow Diagram

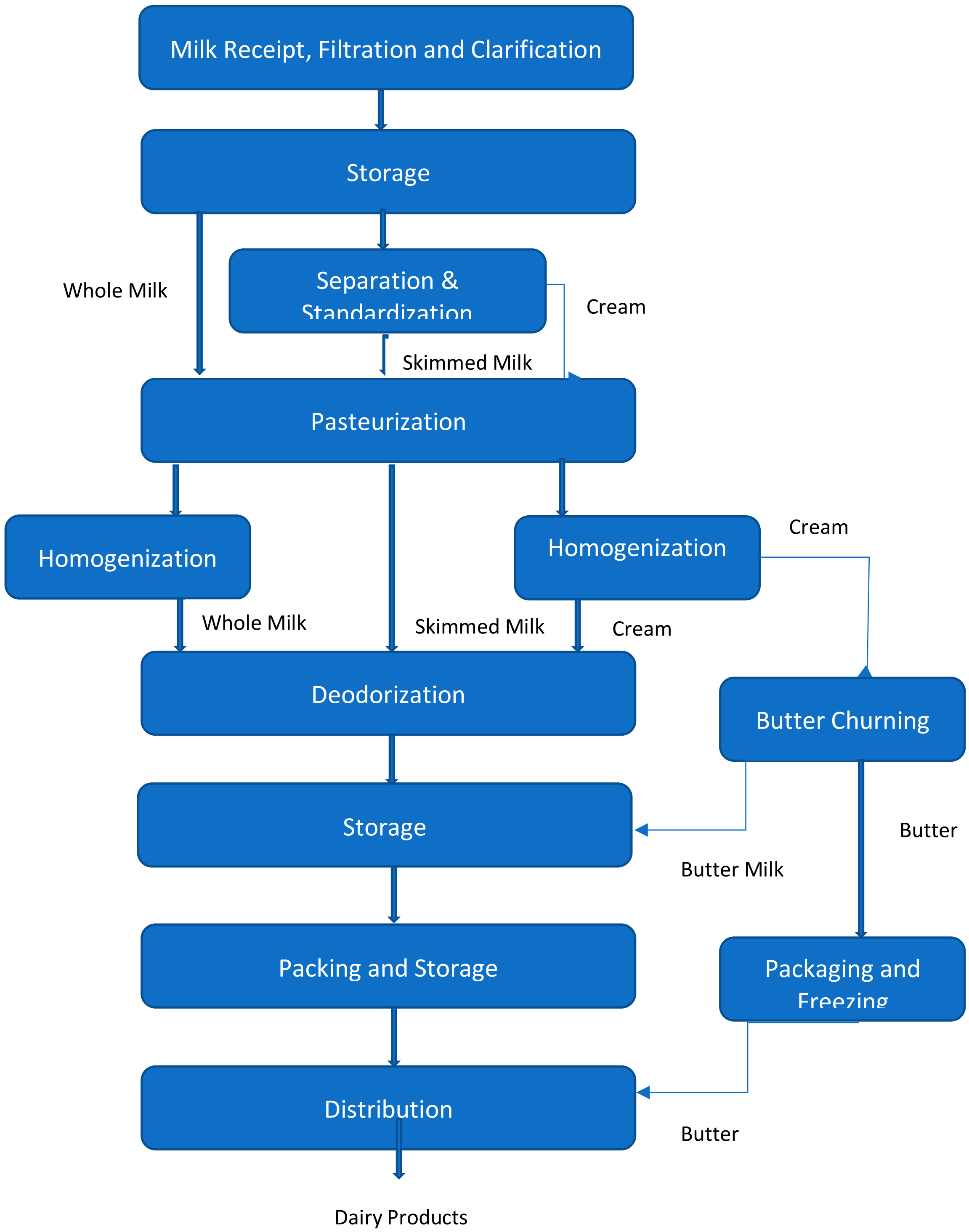


Figure 2: Typical process flow of Milk manufacturing

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 76°C for 15 seconds 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 flavour 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 re-joining. 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	2.25
2	Milk Packaging in Poly Pouches	Lakh Litres per Day	2.15
3	Curd Manufacturing	MT/day	6
4	Butter Manufacturing	MT/day	0.8
5	Ice Cream Manufacturing	MT/day	-
6	Ghee Manufacturing	MT/day	3

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	5.5	-
2	High Speed Diesel	Rs/L	68	10000
3	Briquette	Rs/Kg	7	4000
4	Furnace Oil	Rs/L	39.53	10000

The table below shows the monthly consumption of various fuel used in the plant during the last one year. FO and Briquette is used for boiler and HSD is used as fuel for DG. Electricity is purchased from Kerala State Electricity Board and the contract demand of the plant is 750 kVA.

Table 8: Fuel Consumption Details

Month	Electricity Consumption (kWh)	Fuel Consumption - Briquette (kgs)	Fuel Consumption - Furnace Oil (litre)	Fuel Consumption Fuel- HSD (litre)
May-17	2,80,782	-	40,800	-
Jun-17	2,46,366	714	33,830	-
Jul-17	2,48,175	30,486	22,782	-
Aug-17	2,51,361	88,000	2200	-
Sept-17	2,56,077	95,312	2950	-
Oct-17	2,64,105	76,020	2482	-
Nov-17	2,73,015	80,080	1300	200
Dec-17	2,31,921	82,840	750	1280
Jan-18	2,30,400	78,584	1150	0
Feb-18	2,05,398	65,618	8200	940
Mar-18	2,29,698	86,107	3050	210
Apr-18	2,34,864	84,684	550	240
May-18	2,49,291	54,004	15,563	240
Jun-18	2,30,949	58,662	13,608	680
Jul-18	2,61,891	1,04,296	3250	1300
Aug-18	2,53,062	63,253	15,800	600
Sep-18	2,51,721	91,694	4587	400
Oct-18	2,61,612	98,434	770	60
Total	**44,60,688**	**12,38,788**	**1,73,622**	**6150**

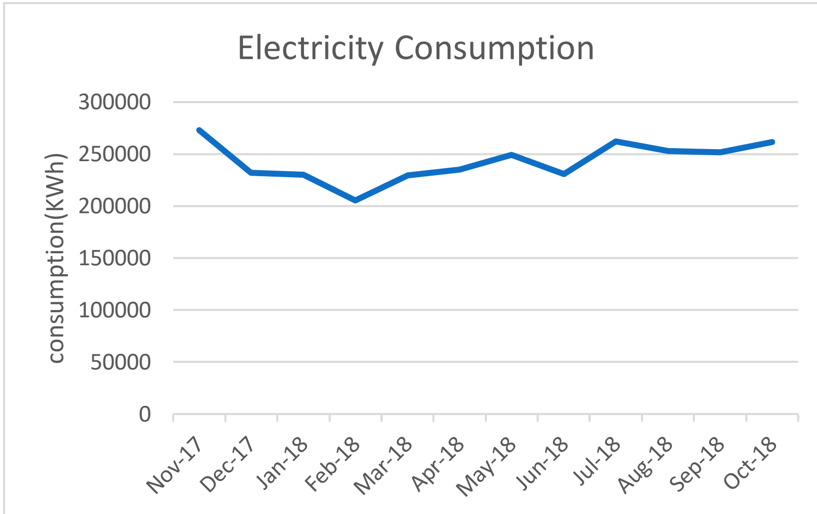


Figure 3 : Electricity consumption profile

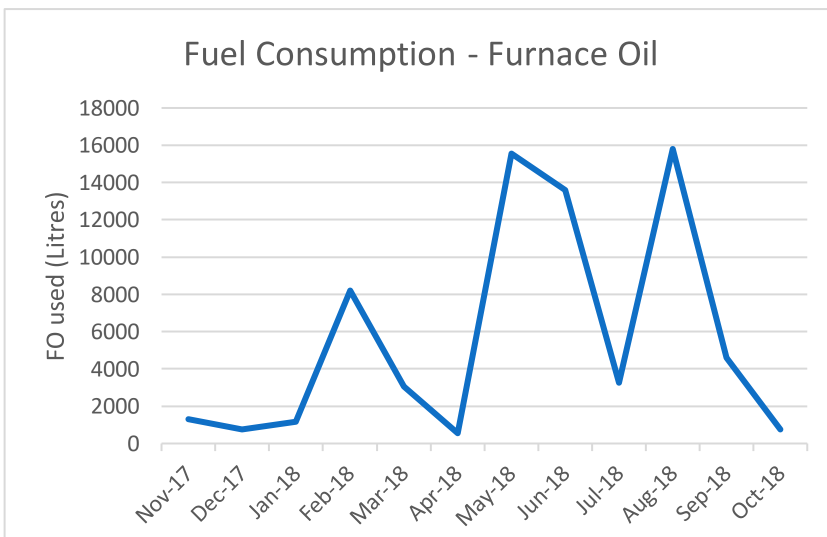


Figure 4: Furnace Oil consumption profile

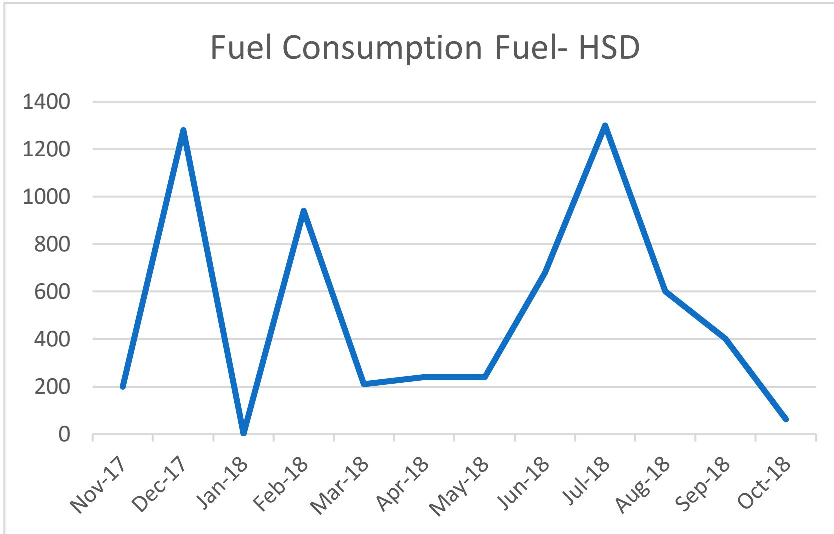


Figure 5: HSD consumption profile

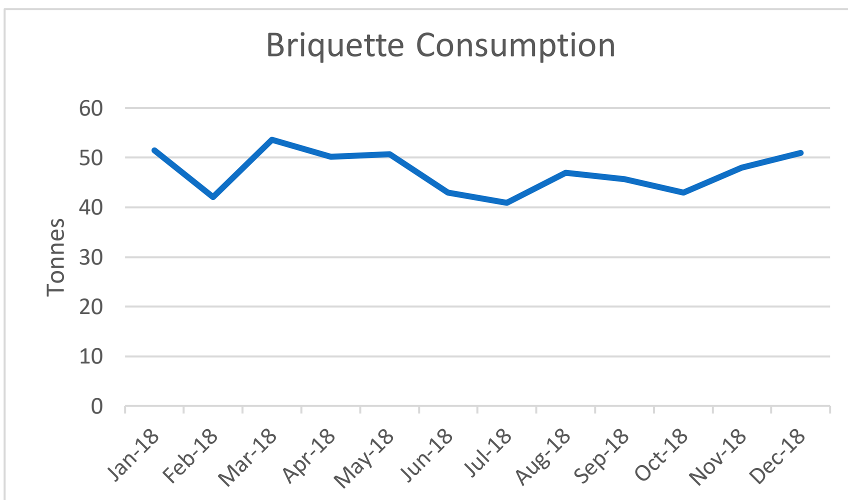


Figure 6: Briquette consumption profile

The energy consumption breakup of the plant both thermal and electrical is shown in the below table. Total energy consumption of the plant is 723 MTOE out of which 66% of the total energy is contributed by thermal and rest only 34% is contributed by electricity.

Table 9: Energy consumption breakup of plant

Sl No	Particulars	UOM	Value
1	Annual Electricity Consumption (kWh)	kWh	2913822
2	Annual Electricity Consumption (kcal)	Kcal	2505886920
3	Annual Electricity Consumption (MTOE)	MTOE	250.58
4	Annual Diesel Consumption (L)	L	6150
5	Annual Diesel Consumption (kcal)	kcal	52275000
6	Annual Diesel Consumption (MTOE)	MTOE	5.22
7	Annual FO Consumption (Litre)	Litre	68578
8	Annual FO Consumption (kcal)	kCal	698466930
9	Annual FO Consumption (MTOE)	MTOE	69.84
10	Annual Briquette Consumption (kg)	kg	948256
11	Annual Briquette Consumption (kcal)	kcal	3982675200
12	Annual Briquette Consumption (MTOE)	MTOE	398.26
13	Total Energy Consumption (kWh)	kWh	2913822
14	Total Energy Consumption (kcal)	kcal	7239304050
15	Total Energy Consumption (MTOE)	MTOE	723.93

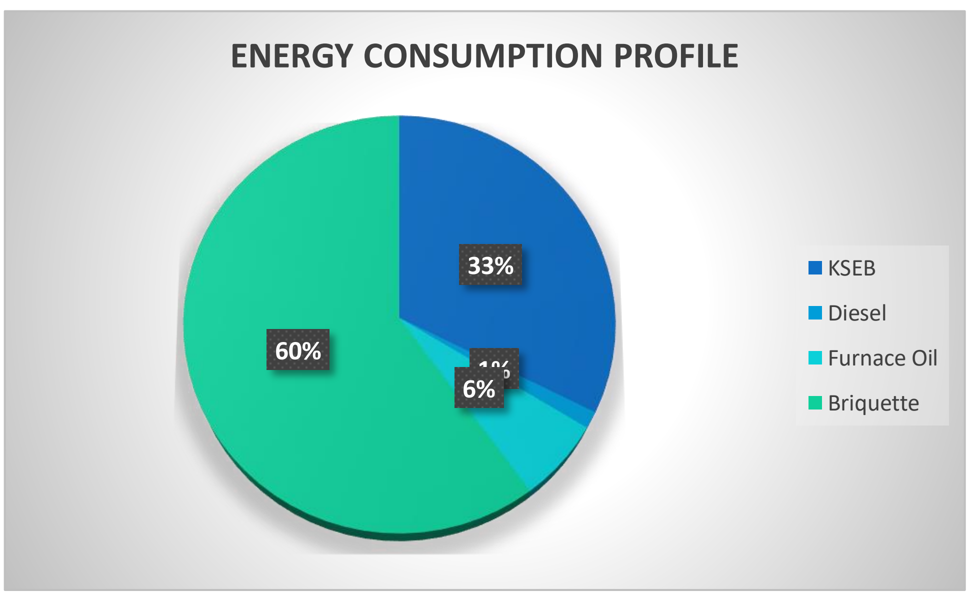


Figure 7: Energy Profile

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 13.4 Lakhs/month whereas the average thermal energy cost is Rs 8.1 Lakhs/month.

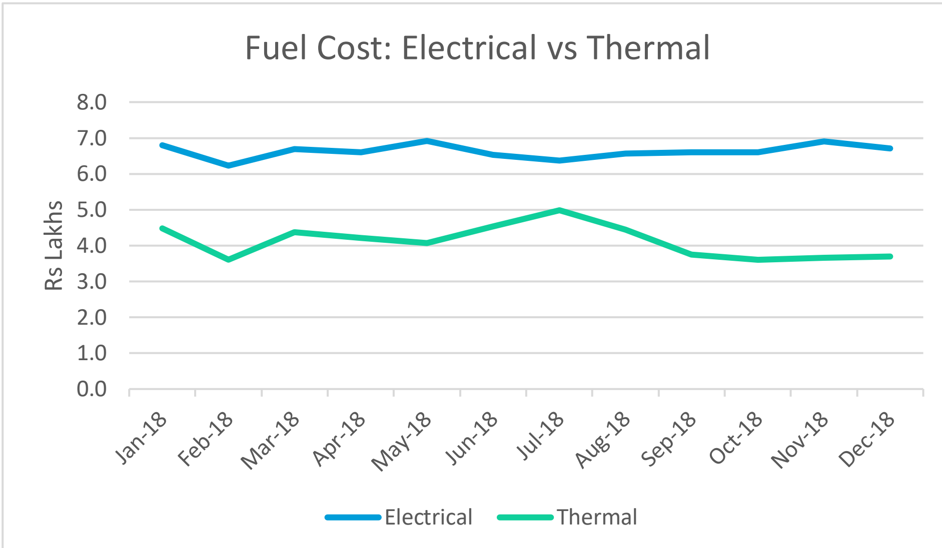


Figure 8: Variation of fuel cost

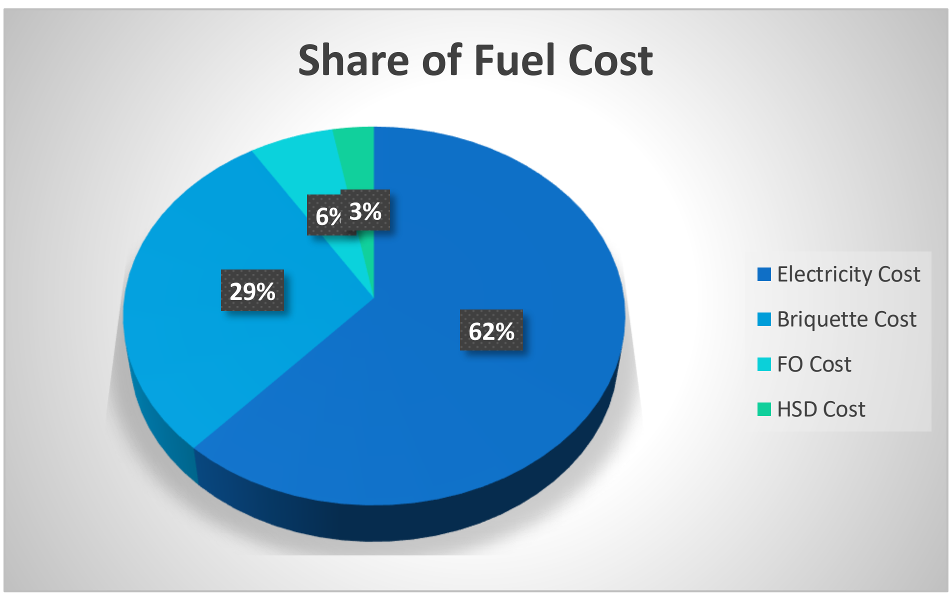


Figure 9: Percentage share of fuel cost

3. PERFORMANCE EVALUATION OF EQUIPMENT/PROCESS

3.1 List of equipment and process where performance testing done

CII during the detailed energy audit at Ernakulam Dairy 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	PF
1	Curd Section	389	13.1	6.9	0.825
2	New 20Kl Pasteurizer	389	20	10	0.75
3	Milk Despatch Pump	405	8	5.7	0.87
4	Silo Agitators	405	5.3	0.78	0.25
5	Cream Pasteurizer 10KL	403	6.7	3.68	0.77
6	Homogenizer	403	104	56.8	0.78
7	Butter Churner		1.5		
8	Curd Packing	406	10.6	4	0.6
9	Milk Pump to pasteurizer			2.5 (rated)	
10	Packing Machine	406	8	3.8	0.65
11	Packing Machine	411	7.5	3.6	0.52
12	Heater Curd Incubation	386	17	7.75	1
13	Deep Freezer 1	398	18.6	3.66	0.49
14	Deep Freezer 2	399	25.1	4.4	0.44
15	ID fan (18.5kW)	406	22	13.4	0.89
16	FD Fan (2.2 kW)	407	3.7	2.2	0.85
17	F/W Pump	409	5.3	3.3	0.88
18	After Rinse Pump (5.5 kW)	405	7.4	4.2	0.81
19	Detergent Pump (5.5kW)	403	7.4	3.6	0.72
20	First Rinse Pump (5.5kW)	406	9.9	5.8	0.84
21	Crate Feeding Conveyor 2	406	4.3	1.28	0.41
22	Crate Feeding Conveyor 1	406	1.4	0.26	0.21
23	Drive Unit motor 1	408	1.5	0.36	0.36
24	Drive Unit motor 2	406	1.7	0.28	0.23
25	Crate Washer Complete	404	43.3	19.5	0.64
26	Etp Aerator 1 (7.5Hp)	402	22	12.4	0.81
27	Etp Aerator 2 (7.5Hp)	403	22.5	12	0.76
28	Etp Aerator 3 (7.5Hp)	400	30.6	16.6	0.77
29	Wet well agitator 1	404	5.6	3.2	0.82
30	Wet well agitator 2	403	6.1	3.3	0.77
31	Raw Effluent Pump 1	404	3.5	1.92	0.77
32	Raw Effluent Pump 2	402	2.6	1	0.6
33	Etp total	402	68	37.2	0.78
34	Air Compressor Screw	380	26.5	14.3	0.81
35	CIP	402	5.4	3	0.8

Table 11: Transformer Measurements

Tr 1 500 KVA	V	I	kW	PF	VTHD	ITD
R	233.6	155.2	35.62	0.97	2.8	10.1
Y	234	94.1	21.99	0.99	2.5	13.7

B	234.1	106	24.9	0.99	3.8	13.2

Tr 2 500 KVA	V	I	kW	PF	VTHD	ITD
R	228	354	67	0.87	1.3	4.8
Y	228	455	97	0.94	1.7	4.9
B	226	417	89	0.95	1.7	4.8

- 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	60	°C
Calorific value of fuel	4200	kCal/kg
Total Steam Flow per shift	3850	kg/hr
Total Fuel Firing Rate per shift	920	kg/hr
Enthalpy of steam at 9.5 kg/cm2	662.5	kCal/kg
Feed Water Enthalpy at 60 °C	60	kCal/kg
Boiler Efficiency	60	%

Table 13: Pump Measurements

Parameter	Chilled Water Pump 1	Chilled Water Pump 2	Condenser Pump
Power kW	5.5	4.6	23.37
Flow (m3/h)	37.2	29.5	155
Head assumed (m)	20	20	31
Efficiency	43.37	41.12	65.91
Design Efficiency	50	50	82

Table 14: Performance of Chiller Compressor

Parameters	UOM	
Rated Refrigeration Capacity (2 x 70 TR)	TR	140
Rated Power (2 x 90 kW)	kW	180
Design SEC	kW/TR	1.29
Condensing Temp	degC	35 to 40
Suction Pressure	psi	35.55
Discharge Pressure	psi	177.79
Discharge Temperature	degC	100 to110
Total Operating Power	kW	122
Total Operating TR	TR	92
Operating SEC	kW/TR	1.33

3.3 Energy Balance of Ernakulam Dairy

During the detailed energy audit at Ernakulam dairy the total load on the plant measured at transformer level was 335 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.

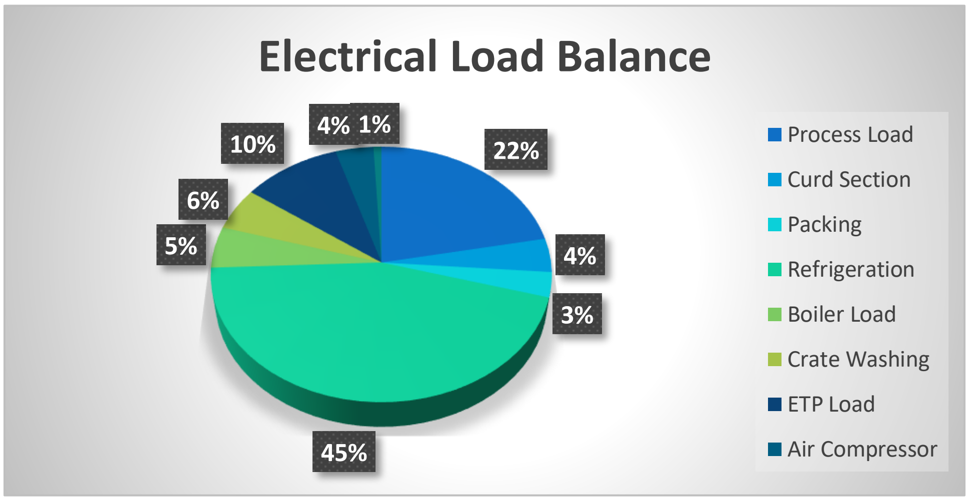


Figure 10: Equipment/Process wise energy breakup

The figure below shows energy balance diagram of Ernakulam dairy

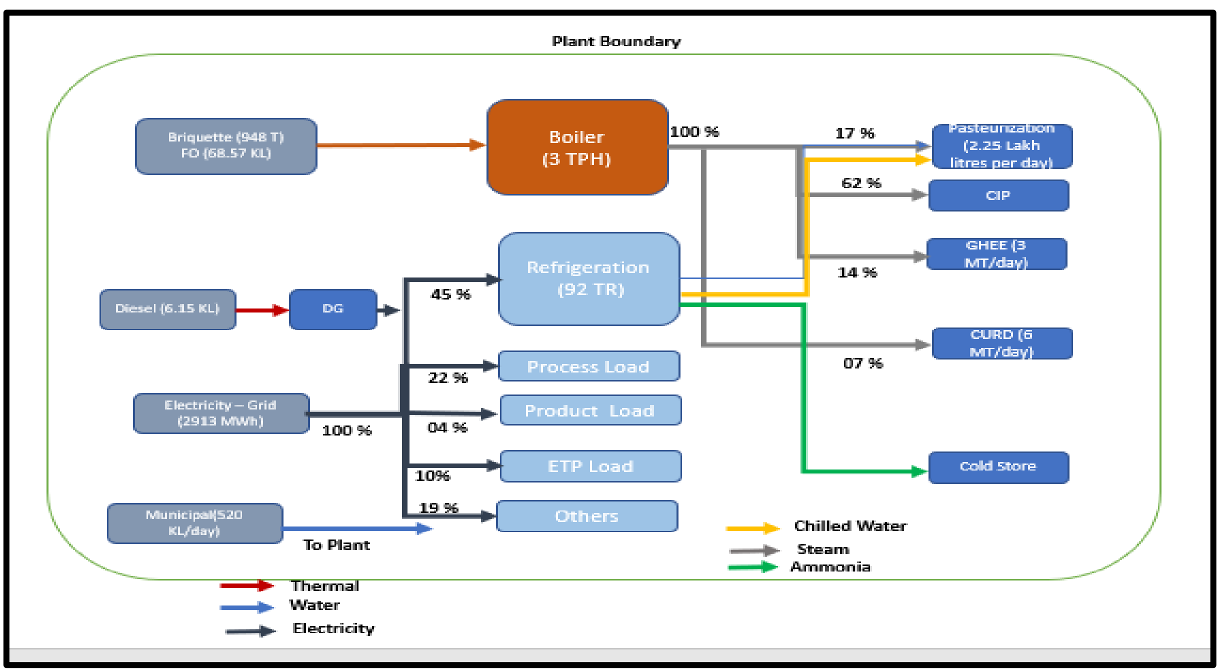


Figure 11: GTG Energy Balance of Ernakulam Dairy

3.4 Water Profile of Ernakulam Dairy

Ernakulam Dairy is purchasing water from municipality at a cost of Rs 41.50/Kl and out of the total quantity 15 % of water is reused. The table below shows the monthly consumption of water in the plant.

Table 15: Monthly water consumption

Monthly Consumption	
	Kilo Litre
Jul-17	12864
Aug-17	12735
Sep-17	9901
Oct-17	7123
Nov-17	6375
Dec-17	2253
Jan-18	5323
Feb-18	11717
Mar-18	11907
Apr-18	13159
May-18	14959
Jun-18	13576
Jul-18	15611
Aug-18	15010
Sep-18	15130
Oct-18	13392
Nov-18	12816
Dec-18	13449
Total	**207300**

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 16: Daily consumption data

Water Data		
Water Source		Municipality
Daily Average Consumption	KL	520
Daily average ETP Load	KL	420
Cost of Water	Rs/L	41.5
% Reused /Recycled	%	15.4

The section wise water consumption is shown in the below graph

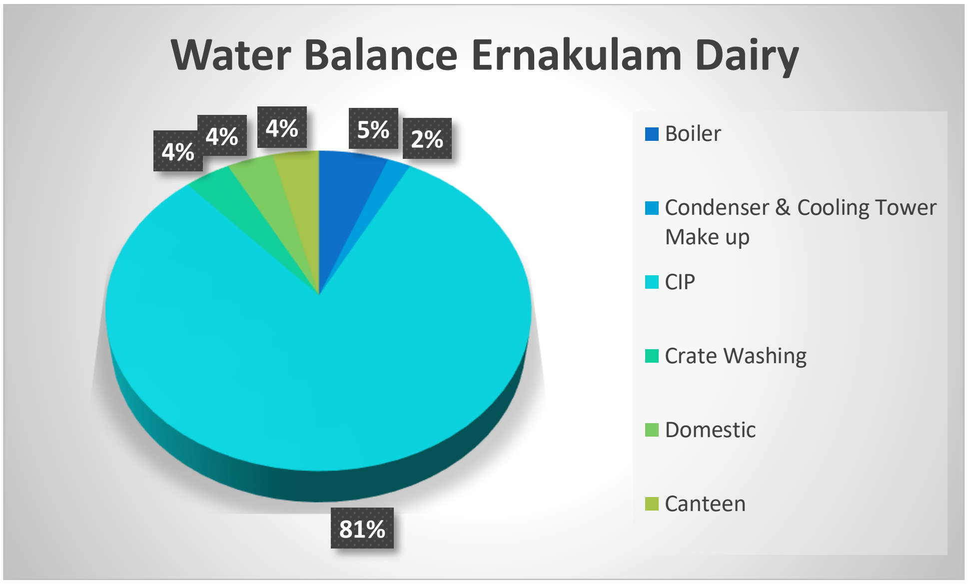


Figure 12: Water profile of Ernakulam Dairy

3.4.1 ETP Details

Sl No	Parameter	Raw Effluent	Treated Effluent
1	Effluent flow rate	20 KL/Hr	20 KL/Hr
2	pH	6.5 to 8.5	6.5 to 8.0
3	Temperature	33 to 40°C	33 to 35°C
4	Chemical Oxygen demand	2500 ppm	110 ppm
5	Biochemical Oxygen demand	1800 ppm	25ppm
6	Oil & Grease	300ppm	1.5 ppm
7	Total Suspended Solids	525 ppm	34ppm

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 17: Specific energy consumption

Sl No	Particulars	UOM	Value
1	Annual Electricity Consumption	kWh	2913822
2	Annual Electrical Energy Consumption	Kcal	2505886920
3	Annual Electricity Consumption	MTOE	250.59
4	Annual Diesel Consumption	L	5228
5	Annual Diesel Energy Consumption	kcal	52275000
6	Annual Diesel Consumption	MTOE	5.23
7	Annual FO Consumption	Litre	66521

8	Annual FO Energy Consumption	kCal	698466930
9	Annual FO Consumption	MTOE	69.85
10	Annual Briquette Consumption	kg	948256
11	Annual Briquette Energy Consumption	kcal	3982675200
12	Annual Briquette Consumption	MTOE	398.27
13	Total Energy Consumption	kcal	7239304050
14	Total Energy Consumption	MTOE	724
15	Total Production	KL	73440
16	**Overall Electrical SEC**	**kWh/KL of Milk**	**40**
17	**Overall Thermal SEC**	**MkCal/KL of Milk**	**0.064**
18	**Overall SEC**	**MkCal/KL of Milk**	**0.099**

3.6 Performance Analysis of Major Processes

3.6.1 Pasteurizing Section

Table 18: Analysis of pasteurizing section

Pasteurisation		
Description	**Unit**	**Pasteuriser I**
Pasteurizer Capacity	KL/hr	20
No. of hours of operation per day	hours/day	9
No of Shifts	Nos	2
Average Shift Time	Hours	8
Average Milk Processed per shift	Litres/shift	85000
Average Milk Processed per day	Litres/day	170000
Incoming milk temperature from Silo	°C	8 to 10
Heating Temperature	°C	76
Steam Pressure	Kg/cm^2 g	3
Holding time	Seconds	15
Regeneration Efficiency	%	90
Cooling Temperature	°C	4
Chilled water temperature	°C	0.5 to 1
Raw Milk Silo Temperature	°C	8 to 10
Process Milk Silo Temperature	°C	6 to 7
Specific Steam Consumption	kg/KL	21.57

3.6.2 Ghee Section

Table 19: Analysis of Ghee Vat

GHEE Section		
Description	**Unit**	**VAT 1**
Ghee VAT Capacity	KL/hr	2

Incoming Cream Temperature	°C	29 to 34
Initial Heating Temperature until boiling starts	°C	
Initial Heating Time until boiling starts	secs	
Final heating temperature	°C	115-120
Holding time	minutes	
Steam Pressure	Kg/cm2 g	3
Holding time in settling tank	hrs	4
No. of hours of operation per day	hrs	4
No of Shifts	Nos	1
Average Shift Time	Hrs	8
Average Ghee Produced per shift	Litres	1200
Average Ghee Produced per day	Litres	1200
Specific Steam Consumption	Kg/KL	172.73

3.6.3 CIP Section

Table 20: CIP Section Analysis

Parameters	UOM	
Hot Water tank capacity	KL	3
Delta T of heating	°C	47
Heating Time	mins	20
Steam Pressure	kg/cm2g	3
Steam Flow Rate for Hot Water tank per batch	kg/hr	829.4
Steam Qty required per batch	kg/hr	276.5
Number of batches per day	No.	4
Acid Water tank capacity	KL	3
Delta T of heating	°C	30
Heating Time	mins	65
Steam Pressure	kg/cm2g	15
Steam Flow Rate for Acid Water tank per batch	kg/hr	3
Steam Qty required per batch	kg/hr	30
Number of batches per day	No. s	Once in 03 months
Alkali Water tank capacity	KL	3
Delta T of heating	°C	40
Heating Time	mins	20
Steam Pressure	kg/cm2g	3
Steam Flow Rate for Alkali Water tank per batch	kg/hr	705.9
Steam Qty required per batch	kg/hr	235.3
Number of batches per day	No. s	4

Total Steam Required per day	Kg/day	2047.1
CIP steam requirement per KL pasteurisation	Kg/KL	40.94

3.6.4 Curd Section

Table 21: Curd Section Analysis

Parameters	UOM	
Capacity	Litres	5000
Incoming Milk Temperature	°C	4
Milk Temp after regenerative heating	°C	72
Heating Temperature	°C	90
Holding Time	Sec	
Steam Pressure	Kg/cm2g	3
Regeneration Efficiency	%	
Incubation Temperature	°C	44
Specific Steam Consumption	Kg/KL	35.29

3.6.5 Crate Washing

Table 22: Crate washing analysis

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	0.21	

4. ENERGY SAVING PROPOSALS

Energy Saving Proposal 1 – Installation of new lower capacity boiler of 1 TPH capacity

Present System

Ernakulam, Tripunithura Dairy Plant has installed 3 boilers. The following are the observations w.r.t the present boiler system

- Three boilers are installed viz.,
  - 3 TPH Briquette fired boiler – operational normally
  - 2.8 TPH FO fired – operational only when 3TPH boiler is under maintenance.
  - 3 TPH FO fired – not operational.
- Boiler is operational with cut off pressure set at 9.5 Kg/cm2 g pressure.
- The GCV of fuel is 4200 Kcal/kg.

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

Table 23: Boiler Details

Boiler	Fuel Type	Design Capacity (TPH)	Make of the company	Operating Pressure (bar)	Operating Condition	Operating hrs
Boiler 1	Briquette Fired	3 TPH	Thermax	9.5	Running	13-14

One of the major applications of steam is pasteurization, CIP and Ghee making process. The following table shows the steam consuming consumption with their peak demands in the plant.

Table 24: Steam Requirement in Plant

Sl No.	Section	Steam Pressure	Steam Flow Rate
		Kg/cm2 g	**Kg/hr**
1	Pasteuriser - 10 KLPH	3.5	350
2	Pasteuriser - 20 KLPH	3.5	500
3	Cream Pasteuriser - 3 KLPH	3	130
4	Pasteuriser - 20 KLPH New	3.5	500
5	Curd	2.5	420
6	Ghee Section - VAT 1	3	
7	Ghee Section - VAT 2	3	140
8	CIP	3.5	400
9	Crate Washing	3	120
10	Cleaning	3	50
	Total Steam Requirement		**2610**

Steam generation and fuel consumption data was taken for a sample of 10 days and detailed analysis was done to estimate the performance of boiler:

Table 25: Boiler performance analysis

Date	Shift	No. of Fuel Bags	Avg Wt per bag	Total Wt. of Fuel	Steam Production	Water consumption	No. of hours of operation	Avg Fuel consumption	Avg Steam Production	Average Evaporation Ratio	Boiler Efficiency
		No.s	KG/bag	Kg of fuel	Kg	Kg	Hours	Kg/hr	Kg/hr		%
10.10.2018	A	10	40	400			3.32	120.48	0.00	0	0.00
	B	39	40	1560			6.17	252.84	0.00	0.0	0.00
	C	27	40	1080	3974	6466	4.8	225.00	827.92	3.7	52.79
11.10.2018	A	14	40	560	1310	318	2.85	196.49	459.65	2.3	33.56
	B	30	40	1200	4081	5694	5.08	236.22	803.35	3.4	48.79
	C	23	40	920	3850	5812	3.88	237.11	992.27	4.2	60.03
12.10.2018	A	6	40	240	464	1306	0.6	400.00	773.33	1.9	27.73
	B	33	40	1320	4922	7023	4.88	270.49	1008.61	3.7	53.49
	C	27	40	1080	4123	5883	5.54	194.95	744.22	3.8	54.76
13.10.2018	A	8	40	320	1238	2373	1.98	161.62	625.25	3.9	55.50
	B	6	40	240	56	311	1.04	230.77	53.85	0.2	3.35
	C	29	40	1160	4250	6050	5.41	214.42	785.58	3.7	52.56
14.10.2018	A	7	40	280	714	1945	1	280.00	714.00	2.6	36.58
	B	33	40	1320	5024	7673	5	264.00	1004.80	3.8	54.60
	C	28	40	1120	3924	5981	4.7	238.30	834.89	3.5	50.26
15.10.2018	A	8	40	320	589	1652	1.29	248.06	456.59	1.8	26.40
	B	27	40	1080	3168	5971	4.44	243.24	713.51	2.9	42.08
	C	31	40	1240	4782	6553	5.02	247.01	952.59	3.9	55.32
16.10.2018	A	7	40	280	584	1675	1.56	179.49	374.36	2.1	29.92
	B	30	40	1200	4066	6090	5.54	216.61	733.94	3.4	48.61
	C	24	40	960	3393	6347	2.85	336.84	1190.53	3.5	50.70
17.10.2018	A	6	40	240	500	1557	0.83	289.16	602.41	2.1	29.89
	B	35	40	1400	5506	8602	6	233.33	917.67	3.9	56.42
	C	32	40	1280	4840	6566	6.13	208.81	789.56	3.8	54.24
18.10.2018	A	5	40	200	530	1350	1.33	150.38	398.50	2.7	38.01
	B	28	40	1120	4237	6053	3.53	317.28	1200.28	3.8	54.27
	C	23	40	920	2589	4453	4.88	188.52	530.53	2.8	40.37

19.10.2018	A	8	40	320	581	2187	1.72	186.05	337.79	1.8	26.05
	B	27	40	1080	3679	5266	5.53	195.30	665.28	3.4	48.87
	C	32	40	1280	5050	6848	5.57	229.80	906.64	3.9	56.60
20.10.2018	A	4	40	160	643	1805	0.88	181.82	730.68	4.0	57.65
	B	27	40	1080	3792	5577	5.2	207.69	729.23	3.5	50.37
	C	30	40	1200	4965	7317	5.07	236.69	979.29	4.1	59.35
21.10.2018	A	8	40	320	692	1703	2.46	130.08	281.30	2.2	31.02
	B	33	40	1320	4875	6651	6.45	204.65	755.81	3.7	52.98
	C	25	40	1000	4064	5788	4	250.00	1016.00	4.1	58.30
22.10.2018	A	11	40	440	400	2484	1.76	250.00	227.27	0.9	13.04
	B	34	40	1360	5204	7465	6.2	219.35	839.35	3.8	54.89
	C	36	40	1440	4967	6923	5.8	248.28	856.38	3.4	49.48
23.10.2018	A	7	40	280	555	1500	1.47	190.48	377.55	2.0	28.43
Total				**34320**	**112181**	**175218**	**151.76**	**226.15**	**739.20**	**3.27**	**46.89**

- The observations from the above tables are as below:
    - The maximum peak steam demand is approximately 2.6 TPH.
    - The load is highly fluctuating, however, the maximum steam demand was only 1.2 TPH. During the sample period, only in 10 shifts, the total steam generation was above 900 Kg/hr.
    - The average steam demand was 740 Kg/hr.
    - The average boiler loading was only 25%.
    - Best average boiler efficiency observed in a shift was 60%, while the overall average boiler efficiency during the sample period was 47%, which is very low, and this is the result of highly fluctuating load.
    - The average evaporation ratio is 3.7 which is much less than the normal recommended range of 4.5 to 5.5.
    - Average steam cost was calculated – Rs. 2.14 per kg steam.

It is evident from above data, that due to very low load conditions, and of fluctuating nature, the boiler is operational at very low efficiency.

Recommendation

It is recommended to install a new boiler of lower capacity. Recommended boiler capacity is 1 TPH. This shall improve the boiler loading up to 74%. Subsequently, boiler running efficiency will be better, and so the evaporation ratio. However, prior planning of production will be required for efficient operation of the system.

Savings

The expected fuel savings by installation of low capacity boiler is 4.1 Lakhs of Briquette annually. The annual monetary saving for this project is ***Rs 26.27 Lakhs with an investment of Rs 30 lakhs and payback for the project is 14 months.***

Detailed savings calculations are given in below table

Table 26: Savings calculation for boiler replacement

Parameter	UOM	
Average Steam demand as per sample data	Kg/hr	740
Installed Boiler Capacity	TPH	3
Running Average Boiler Efficiency in lieu of normal low load conditions	%	47
Steam Cost	Rs./kg	2.14
Capacity of Proposed small boiler	TPH	1
Efficiency possible with 70-80% loading on proposed 1 TPH boiler	%	70
Steam cost with proposed boiler	Rs./kg	1.43
Savings Possibility	Rs./kg	0.71
Running hours per annum	hours	5000
Annual Fuel Savings	Kgs	4,10,923
Monetary Savings	Rs Lakhs	26.27
Investment	Rs Lakhs	30
Pay Back	Months	15
NPV at 70% Debt	**Rs Lakhs**	**119.38**
IRR (%)	**%**	**113.21**
TOE Savings	**TOE**	**172.60**

Energy Saving Proposal 2 – Modification in steam line by installing moisture separators and steam traps

Present System

During the audit at Ernakulam Plant, a few areas were identified where moisture formation and heat loss were prevalent. Moisture formation causes the deterioration of steam quality, due to which additional steam quantity is required for same heat requirements. The areas are listed below:

- 2 numbers of Pressure Reducing Stations are installed one after the other, and the second PRS was found non-functional.
- The number of steam traps on the main steam header were found inadequate.
- There are no moisture separators installed at the inlet of control valves for critical steam consuming equipment like Pasteurisers
- Steam line tapping to the Pasteurisers were found without proper insulation, due to which radiation heat loss is happening.

Steam distribution network of Ernakulam dairy plant I shown below:

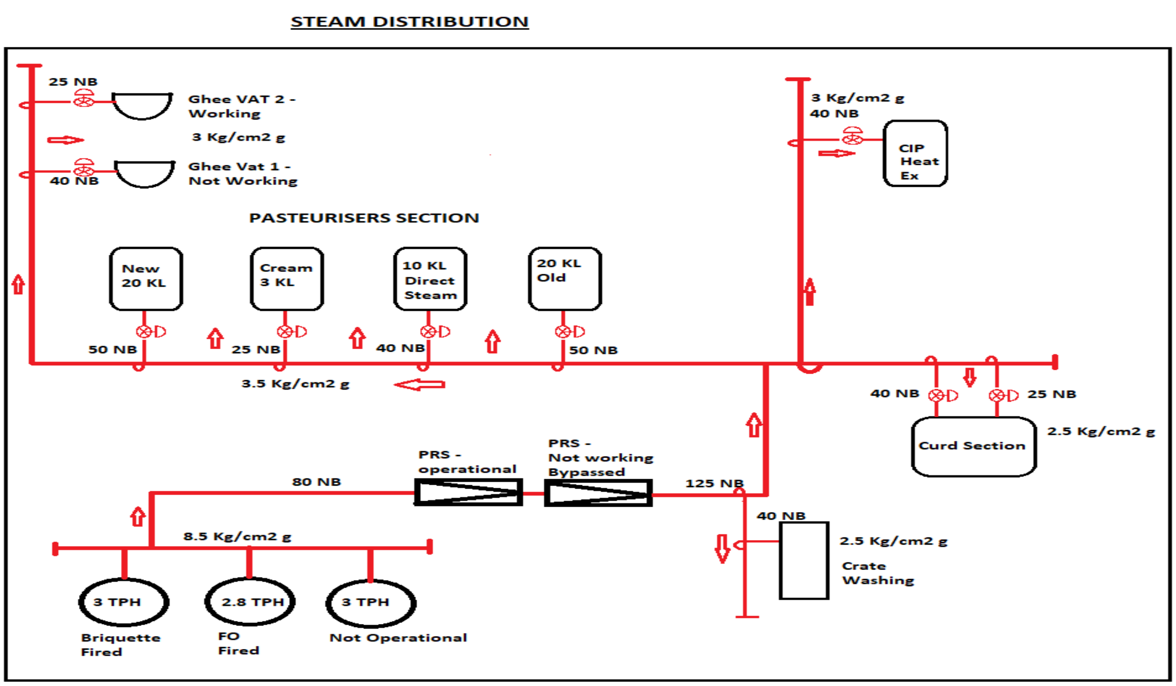


Figure 13: Steam distribution of Ernakulam dairy

Recommendations

- It is recommended to remove the non-functional Pressure Reducing Station from the main steam header line, as this is causing formation of additional moisture in the line.

Table 27: Savings calculation of PRS2 removal

Parameters	UOM	
Enthalpy of Steam after PRS1, at 3.5 kg/cm2 g	Kcal/kg	655
Moisture % due to unwanted PRS2	%	2
Water enthalpy at 3.5 kg/cm2 g	Kcal/kg	148
Latent Heat at 3.5 kg/cm2 g	Kcal/kg	506
Actual enthalpy due to moisture	Kcal/kg	646.84
Heat Loss	Kcal/kg	8.16
Total Heat Loss in 800 kg/hr (average flow)	Kcal/hr	6528
Steam Equivalent	Kg/hr	10.0
Annual Fuel Savings	kgs	12952
Annual Savings by PRS2 removal	Rs Lakhs	0.85
Investment	Rs Lakhs	0.2
Payback	Months	3

- It is recommended to install Thermodynamic Steam Traps in main steam header. As good engineering practice, it is recommended to install 1 steam trap at every 25 – 30 meters length of steam header. The saving calculation is as below:

Table 28: Savings calculation by installing steam trap

Parameters	UOM	
Enthalpy of Steam after PRS1, at 3.5 kg/cm2 g	Kcal/kg	655
Moisture % due to insufficient no of traps	%	3
Water enthalpy at 3.5 kg/cm2 g	Kcal/kg	148
Latent Heat at 3.5 kg/cm2 g	Kcal/kg	506
Actual enthalpy due to moisture	Kcal/kg	643.26
Heat Loss	Kcal/kg	11.74
Total Heat Loss in 800 kg/hr (average flow)	Kcal/hr	3522
Annual Fuel Savings	Kgs	6988
Steam Equivalent	Kg/hr	5.4
No of locations	Nos	5
Investment/trap	Rs Lakhs	0.05
Annual Savings by installing traps	Rs Lakhs	2.30
Investment	Rs Lakhs	0.25
Payback	Months	2

- It is recommended to install Moisture Separators at Control Valve inlet to each of the Pasteuriser. The saving calculation is as below:

Table 29: Savings calculations for moisture separator

Parameters	UOM	
Enthalpy of Steam after PRS1, at 3.5 kg/cm2 g	Kcal/kg	655
Moisture % without moisture separator	%	3
Water enthalpy at 3.5 kg/cm2 g	Kcal/kg	148
Latent Heat at 3.5 kg/cm2 g	Kcal/kg	506
Actual enthalpy due to moisture	Kcal/kg	643.26
Heat Loss	Kcal/kg	11.74
Total Heat Loss in 800 kg/hr (average flow)	Kcal/hr	3522
Annual Fuel Savings	Kgs	6988
Steam Equivalent	Kg/hr	5.4
No of locations	Nos	6
Investment/separator	Rs Lakhs	0.4
Annual Savings by installing separator	Rs Lakhs	2.76
Investment	Rs Lakhs	2.40
Payback	Months	11

- It is recommended to insulate steam lines and accessories at every possible point, as insulation avoids direct radiation heat losses. As a thumb rule, heat loss up to 150 Kcal/hr/meter happens for a 25 NB (1”) steam line. The saving calculation is as below:

Table 30: Savings calculations for insulation of steam line

Parameters	UOM	
Total uninsulated Pipe length	Meters	10
Heat loss happening @ 150Kcal/Hr/m	Kcal/hr	1500
Steam Equivalent at 3.5 bar g	Kg/hr	2.29
Annual Fuel Savings	Kgs	2380
Annual Savings @4000 hrs per annum and 2.14 Rs/kg	Rs. Lakhs	0.19
Investment	Rs. Lakhs	0.25
Payback	Months	16

Savings

The expected fuel savings by modification in steam line is 0.29 Lakhs of Briquette annually. The annual monetary saving for this project is ***Rs 6.1 Lakhs with an investment of Rs 3.1 lakhs and payback for the project is 06 months.***

Table 31: Total Savings Calculation

Parameters	UOM	
Annual Fuel Savings	Kg	29308
Monetary Savings	Rs Lakhs	6.1
Investment	Rs Lakhs	3.1

Pay Back	Months	06
NPV at 70% Debt	**Rs Lakhs**	**29.49**
IRR (%)	**%**	**227.48**
TOE Savings	**TOE**	**12.31**

Energy Saving Proposal 3 – Condensate Recovery from the plant processes

Present System

During the audit at Ernakulam Plant, the following were the observations with respect to the Condensate Recovery System of plant:

- Cost of condensate at the current boiler running efficiency was calculated at 0.28 Rs/kg.
- No complete condensate recovery due to improper recovery system. The following table shows the status of condensate in the plant:

The table below shows the current practice of condensate recovery in the plant:

Table 32: Status of current condensate recovery

Sl No.	Section	Steam Pressure	Steam Flow Rate	Condensate Recovery	Loss per hour of operation	Annual operation hours
		Kg/cm2 g	Kg/hr		Rs./ hour	Hours/year
1	Pasteuriser – 10 KLPH	3.5	350	Not recoverable - direct	0	
2	Pasteuriser – 20 KLPH	3.5	500	Recovered	0	
3	Cream Pasteuriser - 3 KLPH	3	130	Not recovered	36.4	4000
4	Pasteuriser – 20 KLPH New	3.5	500	Not recovered	140	5000
5	Curd	2.5	420	Recovered	0	
6	Ghee Section – VAT 1	3		Not working	0	
7	Ghee Section – VAT 2	3	140	Recovered	0	
8	CIP	3.5	400	Not recovered	112	6000
9	Crate Washing	3	120	Not recovered	33.6	4000
10	Cleaning	3	50	Not recoverable	0	

- There are four areas as shown in the table above, where condensate is being drained out.
- The feed water temperature is 55 degree C, even after heat recovery from the DSH of Ammonia compressor. This is due to an intermediate tank where all the condensate is collected and then pumped to the feed water tank, before feeding to the boiler, due to which

approximately there is a temperature loss of 15 – 20 degree C. As we know, every 6 degree increase in feed water temperature improves the thermal efficiency by 1%. Hence, there is good opportunity available for improving the overall system efficiency. The current schematic is as show below:

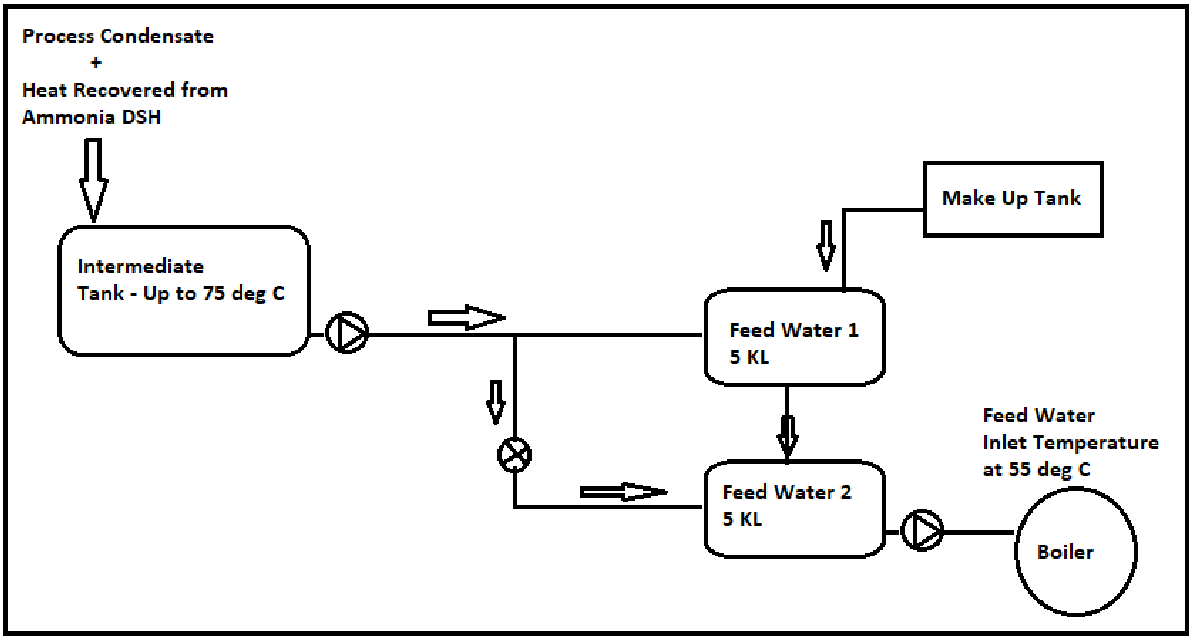


Figure 14: Schematic of hot water sources in the plant

Recommendation 1- Installation of Automatic Pumping Trap for 20KL New Pasteuriser and 3KL Cream Pasteuriser.

It is recommended to recover all the condensate generated out of the 20KL new Pasteurisation process, and Cream Pasteurisation and take to feed water tank. The following are the advantages of condensate recovery to feed water tank:

- Avoiding direct heat and water loss in the plant.
- Recovery of approximate 2-3 Tonnes of high temperature, low TDS water per day.
- Improved feed water temperature, and thus, improved system efficiency.
- Lower boiler blowdown quantity requirement.
- Lower water treatment chemical requirements.

The following systems are required for efficient condensate recovery whose schematic is shown below:

- Automatic Pumping Trap
- Condensate line from Pasteuriser to Feed Water Tank.
- Atmospheric De-aerator on Feed Water Tank.

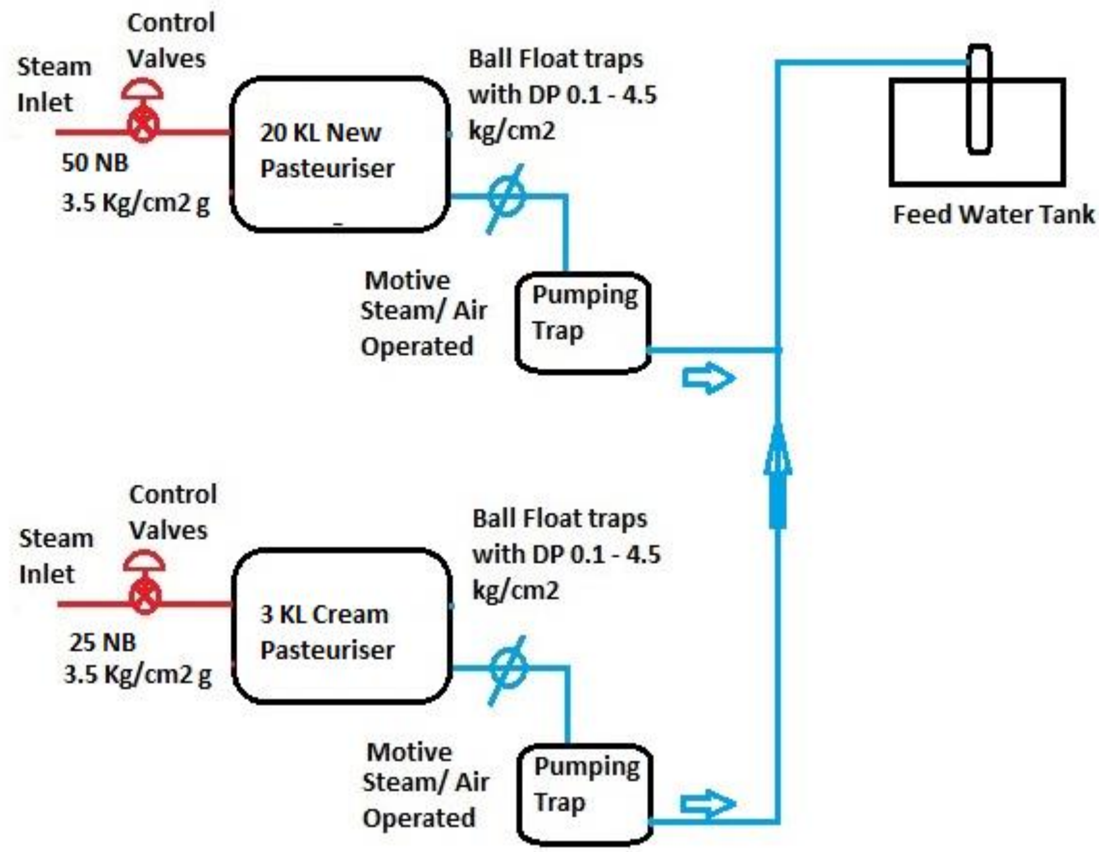


Figure 15: Schematic layout with trap installation

Automatic Pumping Trap provides the excess pressure to the condensate to be pushed to reach the desired location, in this case up to the feed water tank. The additional pressure is provided by the motive steam or compressed air in the automatic pumping trap. With this system in place, the complete high temperature condensate can be pushed to the feed water tank. The savings calculation is given in the below table:

Table 33: Condensate recovery by installing pumping traps

Particulars	Unit	Value
Condensate from 20 KL Pasteuriser	kg/hr	500
Cost of Condensate	Rs. / kg	0.28
No. of hours of operation	Hours	3000
Annual Fuel Savings	Kgs	71428
Savings	Rs. Lakhs	4.25
Investment	Rs. Lakhs	2
Payback	Months	6

Particulars	Unit	Value
Condensate from 3 KL Cream Pasteuriser	kg/hr	130
Cost of Condensate	Rs. / kg	0.28
No. of hours of operation	Hours	3000
Annual Fuel Savings	Kgs	18571
Savings	Rs. Lakhs	1.1
Investment	Rs. Lakhs	2
Payback	Months	23

Recommendation 2- Removal of Intermediate Condensate Collection Tank.

It is recommended to remove the intermediate condensate tank, where all the hot condensate is collected and kept on hold for some time before being pumped to the feed water tank. It is recommended to take all the condensate to the feed water tank directly, so that there is no loss of heat due to time delay and pipeline loss. By this at least 10 degree C increment is expected of boiler feed water. The savings calculation is given below:

Table 34: Savings calculation for removal of intermediate condensate tank

Particulars	Unit	Value
Possible saving in heat	Kcal/kg	10
Average Steam flow rate	kg/hr	700
Average heat saving	kcal/hr	7000
Equivalent steam saving	kg/hr	10.56
Number of hours of boiler operation annually	hours	6000
Annual Fuel Savings	Kgs	13888
Savings per annum	Rs. Lakhs	1.36
Investment for pipeline modifications if any	Rs. Lakhs	1.0
Payback Period	Months	9

Recommendation 3- Insulation of Condensate lines

It is recommended to insulate condensate lines and accessories at every possible point, as insulation avoids direct radiation heat losses. As a thumb rule, heat loss up to 30 Kcal/hr/meter happens for a 25 NB (1") steam line. The saving calculation is as below:

Table 35: Savings calculation for insulation of condensate line

Particulars	Unit	Value
Total Pipe length to be insulated	mtrs	200
Heat loss happening @ 30 Kcal/hr/m	Kcal/hr	6000
Annual Fuel Savings	Kg	9523
Steam Equivalent at 3.5 bar g	Kg/hr	9.1
Savings @4000 hrs per annum and 2.14 Rs/kg	Rs. Lakhs	0.78
Investment	Rs. Lakhs	1.00
Payback	Months	16

Savings

The expected savings by modification in condensate recovery system is 1.11 Lakhs kg of briquette annually. The annual monetary saving for this project is ***Rs 7.49 Lakhs with an investment of Rs 6.00 lakhs and payback for the project is 10 months.***

Table 36: Total Savings Calculation

Parameters	UOM	
Annual Fuel Savings	Kgs	11340
Monetary Savings	Rs Lakhs	7.49
Investment	Rs Lakhs	6.00
Pay Back	Months	10
NPV at 70% Debt	**Rs Lakhs**	**35.21**
IRR (%)	**%**	**152.98**
TOE Savings	**TOE**	**45.36**

Energy Saving Proposal 4 – Installation of Ammonia Screw Chiller with VFD

Present System

Ernakulam Dairy Plant has installed five reciprocating chiller compressors of (90 kW 70 TR) for the chilled water requirement and for the fan coil units at cold storage. Normally two compressors will be running continuously and three will be standby. For the refrigeration purpose vapor compression-based ammonia cycle is used. The table below shows the details of existing compressor in the plant. The table below shows the operating parameters of compressor in the plant.

Table 37:Performance of Chiller Compressor

Parameters	UOM	
Rated Refrigeration Capacity (2 x 70 TR)	TR	140
Rated Power (2 x 90 kW)	kW	180
Design SEC	kW/TR	1.29
Condensing Temp	degC	35 to 40
Suction Pressure	psi	35.55
Discharge Pressure	psi	177.79
Discharge Temperature	degC	100 to110
Total Operating Power	kW	122
Total Operating TR	TR	92
Operating SEC	kW/TR	1.33

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 vapours from the evaporator and pump these to condenser at high pressure and high temperature condition. While flowing through the condenser, the high temperature vapours 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. On throttling the pressure and temperature of refrigerant (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 vapours, 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.

During study, it was observed that the compressors are operating at a SEC of 1.33 kW/TR. Currently the reciprocating compressor is running continuously at full load irrespective of the load variations in the plant. The compressor is mainly used for maintaining the IBT temperature (close to 0^{o}C) and also for the Fan Coil units to maintain the temperature at cold storage. During the morning time when all the processes (mainly pasteurization and pre-chilling of raw milk) are in operation the compressor is 80% to 100% loaded and consumes more power. Once the pasteurization process stops, compressor is running only to maintain the IBT temperature and also for the Fan coil units in cold storage units. During this time the total refrigeration load on the plant is less but still the compressor takes the same power as it was consuming during the peak load as there is no speed control mechanism.

Total compressor power for a system is a function of its suction pressure, discharge pressure, total system load, part load controls and unloading (specifically in the case of screw compressors which do not unload linearly). A lower refrigerant temperature results in lower suction pressure and increased compressor power requirements. A lower condensing pressure, which is a function of the condenser capacity and operations, results in a lower compressor discharge pressure and less compressor power.

Once the evaporator gets wetted with the help of refrigerant and temperature is attained, if there is no speed control the compressor will do the same work to attain lower refrigerant temperature which results in lower suction pressure thereby consuming same power as it is loaded. In such cases VFD can reduce the power consumption with the help of speed control by proper feedback mechanism.

Recommendation

It is recommended to replace the existing reciprocating compressors with 155 TR screw compressor equipped with VFD. The DPR on replacement of existing reciprocating compressor has been made after the OEM did a feasibility study in the dairy and discussed the project with plant team. The table below shows the comparison of screw and reciprocating compressor:

Table 38: Comparison between screw and reciprocating compressor

Comparison Between Screw Compressor and Reciprocating Compressor	
SCREW COMPRESSOR	**RECIPROCATING COMPRESSOR**
1. Fully automatic and has variable capacity control system from 10 to 100%. This means at any % of capacity, screw would operate precisely at this point and power consumption will be linear correspondingly which means compressor perform at peak efficiency under varying load condition.	1. Unloaded step-wise only, that means partial loads operate at lower suction than designed suction which load to lower volume efficiency and high power consumption resting in higher KW / TR.
2. Ideal for larger plant as they can reduce installation cost, installed power and space by eliminating 3 to 4 reciprocating compressor.	2. Ideal for small plant.

3. BKW / TR is on lower side at any suction temperature (kindly see separate work sheet for power saving)□	3. Always on higher compare to screw.
4. Connected motor rating also less.	4. High compare to screw.
5. Direct coupled. No belt loss.	5. Belt direction minimum 3% for belt losses.
6. No tolerance required.	6. Tolerance required at 2.5%.
7. Fewer moving party and simple rotation motor which means less maintenance, vibration levels, less friction loss.	7. Many moving parts. That means high repair cost.
8. Having efficient oil separation system for better oil management and low oil carry loss.	8. Oil carry over more.
9. Having PLC based control panel which constantly monitor the system and maintain most efficient operation condition.	9. Through manual cut-outs.

The screw compressor with VFD proposed for the plant will operate at lower kW/TR of 1.00 compared to 1.33 kW/TR when operating with reciprocating compressor. Also the VFD installed along with compressor will results in smooth control of operation as the suction pressure is given as feedback to the compressor. Based on the refrigeration load the refrigerant temperature required will varies and hence the suction pressure. During the light load condition when the pasteurization process stops compressor runs only to maintain IBT temperature and to maintain the temperature in cold storage. During this time with suction pressure as the feedback. Once the evaporator achieves the desired temperature, with proper feedback the speed of the compressor can be reduced and hence power savings can be achieved.

Some of the unique features of screw compressor that will improve the overall efficiency of the system are:

- The compressor features a unique variable volume ratio control which enables it to always perform at peak efficiency under varying loads and operating conditions.
- Highly accurate control of the compressor is maintained by Frick's Electro – Mechanical / PLC based control panel which constantly monitors the system and maintains the most efficient operating conditions
- Screw Compressor can work at –40 deg C suction and also at 350 psig discharge at 2,950 RPM. Compression difference can go as high as 250 psig.
- Screw Compressors incorporate efficient oil separation system for better oil management and low oil carry over

- Inherent reliability of screw compressor is due to fewer moving parts and simple rotary motion, which means less maintenance, lower noise and vibration levels, less friction losses and lower repair costs
- Screw Compressor is fully automatic and has variable capacity control system from 0 – 100 % and saves a lot of power and gives accurate temperature control for processes with its dual type capacity control system

Savings

The expected savings by installation of Screw Compressor with VFD is 2,79,690 units of electricity annually. The annual monetary saving for this project is ***Rs 15.38 Lakhs with an investment of Rs 52.00 lakhs and payback for the project is 3.44 years***

Detailed savings calculations are given in below table

Table 39: Savings calculation for Screw compressor with VFD

Parameters	UOM	
Rated Refrigeration Capacity (2 x 70 TR)	TR	140
Rated Power (2 x 90 kW)	kW	180
Design SEC	kW/TR	1.29
Condensing Temp	ºC	35 to 40
Suction Pressure	psi	35.55
Discharge Pressure	psi	177.79
Discharge Temperature	ºC	100 to110
Total Operating Power	kW	122
Total Operating TR	TR	92
Operating SEC	kW/TR	1.33
Recommended Design TR	TR	155
Recommended Design Rate Power	kW	159
New SEC	kW/TR	1.02
New Power Consumption	kW	94.19
Power Savings	kW	28
Energy Cost	Rs/kWh	5.5
Operating Hours	hrs	8600
Savings on VFD	%	5.00
Savings on VFD	kW	4.71
Total Power Savings	kW	33
Annual Energy Savings	kWh	279690.37
Annual Cost Savings	Rs. Lakhs	15.38
Investment	Rs. Lakhs	52.9
Pay Back	Years	3.44
NPV at 70% Debt	**Rs Lakhs**	**54.13**
IRR (%)	**%**	**44.74**

TOE Savings	**TOE**	**24.05**
TCO_2 Savings	**TCO_2**	**229.34**

Energy Saving Proposal 5 – Switching off Reciprocating air compressor

Present System

Ernakulam dairy has installed two compressors for catering air for the various instrumentation purpose in the plant. One reciprocating and one screw compressor with VFD is running alternatively in such a way that reciprocating compressor runs 6 hrs daily. The table below shows the power consumption and pressure profile of both these compressors:

Table 40: Compressor details

Compressor	Average Pressure (Bar)	Operating kW
Main Plant Compressor Screw	7	15.28
Main Plant Compressor Reciprocating	7	18.99

It has been observed during the audit that the reciprocating compressor installed is very old and by design its SEC is high. Also, this compressor requires a separate cooling pump for cooling of oil and the pump is consuming 1.1 kW power.

Recommendation

It is recommended to switch off the existing reciprocating compressor and run only screw compressor in the plant. Since the screw compressor is equipped with VFD , it can cater the fluctuating loads in the plant.

Savings

The expected savings by switching off reciprocating compressor is 10533 units annually. The annual monetary saving for this project is ***Rs 0.57 Lakhs with NIL investment.***

Savings calculation is given in the below table:

Table 41: Savings calculation for switching off reciprocating compressor

Parameters	UOM	
Power Consumption of Screw Compressor	kW	15.28
Power Consumption of Reciprocating Compressor	kW	18.99
Power Consumption of cooling pump	kW	1.1
Unit Price	Rs/kWh	5.5
Operating hours	hrs	6
Power savings	kW	4.81
Annual Energy Savings	kWh	10533
Annual savings	Rs Lakhs	0.57
Investment	Rs Lakhs	NIL
TOE Savings	**TOE**	**0.91**
TCO_2 Savings	**TCO_2**	**8.63**

Energy Saving Proposal 6 – Replacement of existing chilled water pump with energy efficient pump

Present System

Ernakulam dairy has installed four chilled pumps for pumping chilled water from IBT to process in which two 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. The figure below shows the schematic of chilled water system in the plant.

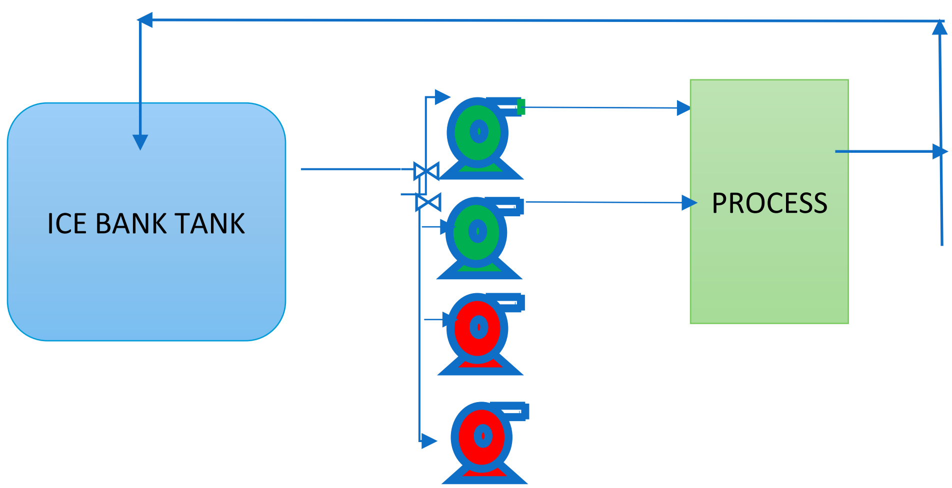


Figure 16: Schematic of chilled water pump

Ice bank tank contains chilled water and small quantity of ice almost all time of day, the temperature of IBT is maintained close to zero degree all time with the help of refrigeration compressor. The chilled water required for the various processes are pumped using a 6.18 kW pump. Chilled water is mainly used in the pre-chiller to cool the incoming milk received from Bulk Milk Coolers by tankers to 4°C to 5°C before going to pasteurization process and in pasteurization process to cool the milk to 4°C. After the process the return water is coming at less than 8 °C. The table below shows the details of chilled water pumps performance installed in the plant.

Table 42: Pump Performance

Parameters	UOM	Pump 1	Pump 2
Power Consumption	kW	5.5	4.6
Flow	m^3/hr	37.2	29.5
Head	m	20	20
Efficiency	%	43.37	41.12
Design Efficiency	%	50	50

The design efficiency of the pump 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 % and 43 % respectively 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 pump 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 43: Proposed pump parameters

Parameters	UOM	Proposed Pump Design
Power Consumption	kW	5.5
Flow	m^3/hr	40
Head	m	22
Efficiency	%	75

Savings

The expected electricity savings by installation of energy efficient chilled water pump is 7542 units annually. The annual monetary saving for this project is ***Rs 1.38 Lakhs with an investment of Rs 1.50 lakhs and payback for the project is 12 months.***

Savings calculation is given in the below table:

Table 44: Savings calculation for EE chilled water pump

Parameters	UOM	CHW 1	CHW 2	Proposed Operating Condition
Power Consumption	kW	5.5	4.6	5.5
Flow	m3/hr	37.2	29.5	40
Head	M	20	20	22
Efficiency	%	43.37	41.12	75
New Motor Power	kW	3.47	3.47	

Power Savings	kW	3.14
Electricity Cost	Rs/kWh	5.5
Operating hours	Hours	8000
Energy Savings	kWh	25120
Cost Savings	Rs Lakhs	1.38
Investment	Rs Lakhs	1.50
Pay Back	Months	13
NPV at 70% Debt	**Rs Lakhs**	**1.38**
IRR (%)	**%**	**1.50**
TOE Savings	**TOE**	**2.16**
TCO_2 Savings	**TCO_2**	**20.59**

Energy Saving Proposal 7 – Replacement of existing condenser pump with energy efficient pump

Present System

Ernakulam dairy has installed PHE condenser for ammonia refrigeration system. The figure below shows the schematic of chilled water system in the plant. The compressor continuously sucks low pressure, low temperature refrigerant vapours from the evaporator and pump these to condenser at high pressure and high temperature condition. While flowing through the condenser, the high temperature vapours release their heat to atmosphere and condense to high pressure liquid state.

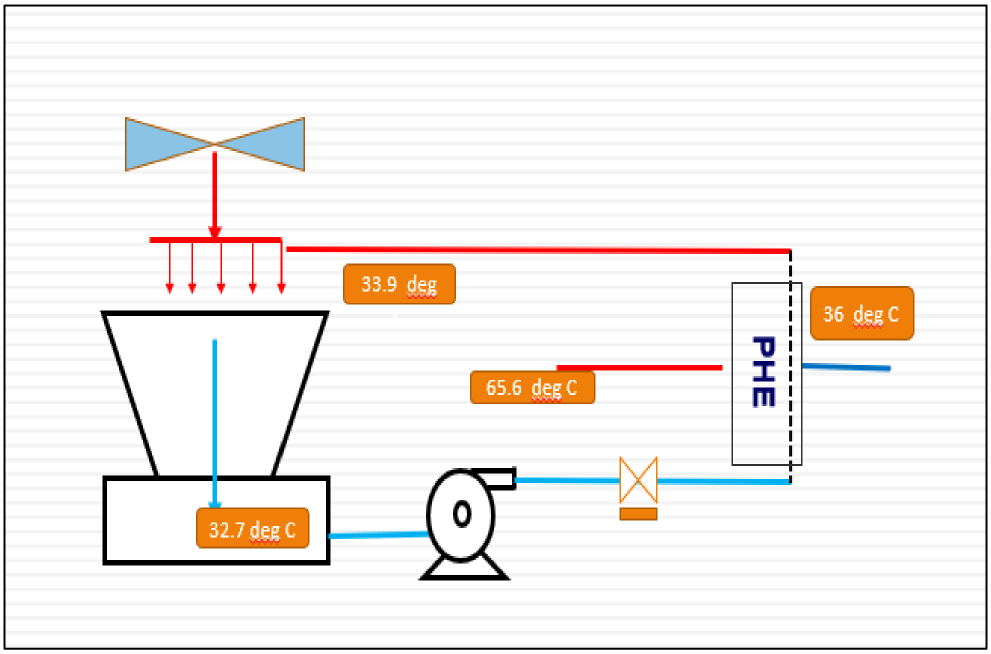


Figure 17: Schematic of PHE Condenser

Water is pumped from the sump of cooling tower using a 23 kW pump to PHE for cooling the ammonia passing through the heat exchanger. The table below shows the details of condenser pumps performance installed in the plant.

Table 45: Pump Performance

Parameters	UOM	Pump 1	Design
Power Consumption	kW	23.37	23.37
Flow	m^3/hr	155	264
Head	m	31	25
Efficiency	%	65.91	82

The design efficiency of the pump is 82% which is high. 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 65.91 % which is lesser than the design efficiency. The reasons for low efficiency of pump is

- Poor operational practices
- Pumps operating point has been shifted away from its best operating point
    - Pump is delivering less flow at higher head which is not matching with the design parameters
    -
- Pump is very old and undergone frequent maintenance
- Poor selection of pump

Recommendation

It is recommended to replace the old condenser water pump 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 46: Proposed pump parameters

Parameters	UOM	Proposed Pump Design
Power Consumption	kW	25
Flow	m^3/hr	200
Head	m	25
Efficiency	%	75

Savings

The expected electricity savings by installation of energy efficient condenser pump is 42474 units annually. The annual monetary saving for this project is ***Rs 2.3 Lakhs with an investment of Rs 3.50 lakhs and payback for the project is 17 months.***

Savings calculation is given in the below table:

Table 47: Savings calculation for EE condenser pump

Parameters	UOM	Present	Proposed Operating Condition
Power Consumption	kW	23.37	25
Flow	m3/hr	155	200
Head	m	31	25
Efficiency	%	65.91	82

Power Savings	kW	5.309
Electricity Cost	Rs/kWh	5.5
Annual Operating hrs	Hrs	8000
Energy Savings	kWh	42474
Cost Savings	Rs Lakhs	2.33
Investment	Rs Lakhs	3.5
Pay Back	Months	18
NPV at 70% Debt	**Rs Lakhs**	**10.20**
IRR (%)	**%**	**89.40**
TOE Savings	**TOE**	**3.65**
TCO_2 Savings	**TCO_2**	**34.82**

Energy Saving Proposal 8 – Optimize the operation of agitator motors in ETP

Present System

During the Detailed Energy Audit at **Ernakulam dairy** detailed study was carried at ETP to find out energy saving potential .Currently three agitator motors are installed in ETP for the aeration purpose in which all running on rotational basis. All motors are rewound multiple times and it has been observed that agitator motor 3 has gear box and bearing failure problem. The power consumption of these motors is given below:

- Agitator 1 – 12.4 kW
- Agitator 2 – 12 kW
- Agitator 3 – 16.6 kW

Recommendation

It is recommended switch off the agitator motor 3 and run the other two agitators continuously as motor 3 is taking higher power due to bearing and gear box failure.

Savings

The expected savings by switching off agitator motor 3 is 12264 units annually considering only 8 hrs of operation. The annual monetary saving for this project is ***Rs 0.67 Lakhs with NIL investment.***

Detailed savings calculations are given in below table

Table 48: Calculation for optimization of ETP agitators

Parameters	UOM	
Total Power consumption Agitator 1 & 2	kW	24.4
Power Consumption of Agitator	kW	16.6
Power Savings	kW	4.2
Operating hours	Hrs/day	8
No of operating days	Days	365
Unit Cost	Rs/kWh	5.5
Energy Savings	kWh	12264
Annual Cost Savings	Rs Lakhs	0.67
Investment	Rs Lakhs	NIL
TOE Savings	**TOE**	**1.05**
TCO_2 Savings	**TCO_2**	**0.67**

Energy Saving Proposal 9- Replace Identified Motors with Energy Efficient Motors

Present Status

During the audit at Ernakulam Dairy electrical parameters of motor were measured and analysed. It was observed that ammonia compressor motor is old and has been rewound more than 3 times. The list of motors that can go for higher efficiency class is given below:

Table 49: Measurements of motor to be replaced

Section	Rated kW	Running Power	Loading %
Chilled Water Pump 1	6.18	5.5	80
Chilled water pump 2	6.18	4.6	67
Agitator 1	15	12.4	68
Agitator 2	15	12	66

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

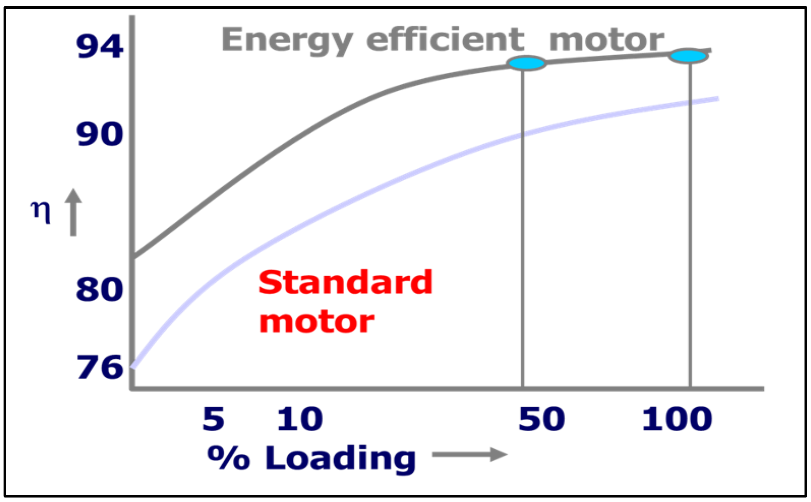


Figure 18: Loading Vs Efficiency curve

Recommendation

It is recommended to replace the ammonia compressor motor with energy efficient motor. 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.

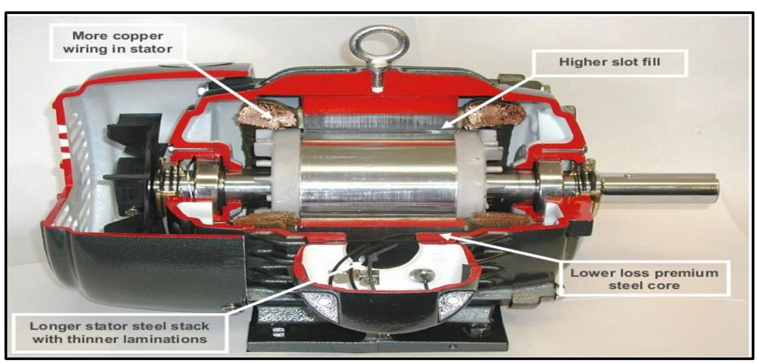


Figure 19: EE Motor features

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.

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

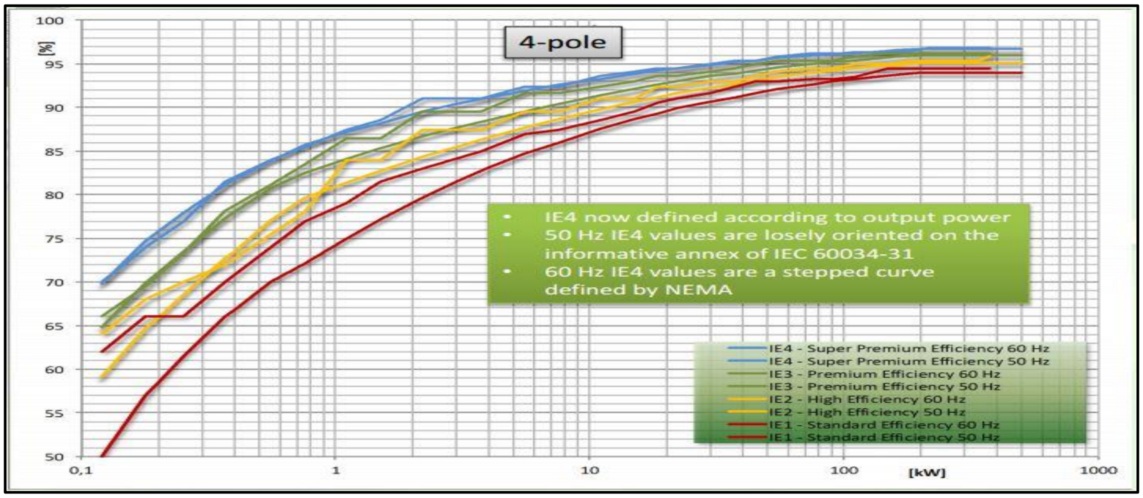


Figure 21: Losses in different classes of motors

Efficiency limit values acc. to IEC 60034-30; October 2008 standard; based on IEC 60034-2-1; 2007 standard

Pot. nominale	Standard Efficiency (IE1, 50 Hz)			High Efficiency (IE2, 50 Hz)			Premium Efficiency (IE3, 50 Hz)		
Rated power	Number of poles			Number of poles			Number of poles		
kW	2	4	6	2	4	6	2	4	6
0.75	72.1	72.1	70	77.4	79.6	75.9	80.7	82.5	78.9
1.1	75	75	72.9	79.6	81.4	78.1	82.7	84.1	81
1.5	77.2	77.2	75.2	81.3	82.8	79.8	84.2	85.3	82.5
2.2	79.7	79.7	77.7	83.2	84.3	81.8	85.9	86.7	84.3
3	81.5	81.5	79.7	84.6	85.5	83.3	87.1	87.7	85.6
4	83.1	83.1	81.4	85.8	86.6	84.6	88.1	88.6	86.8
5.5	84.7	84.7	83.1	87	87.7	86	89.2	89.6	88
7.5	86	86	84.7	88.1	88.7	87.2	90.1	90.4	89.1
11	87.6	87.6	86.4	89.4	89.8	88.7	91.2	91.4	90.3
15	88.7	88.7	87.7	90.3	90.6	89.7	91.9	92.1	91.2
18.5	89.3	89.3	88.6	90.9	91.2	90.4	92.4	92.6	91.7
22	89.9	89.9	89.2	91.3	91.6	90.9	92.7	93	92.2
30	90.7	90.7	90.2	92	92.3	91.7	93.3	93.6	92.9
37	91.2	91.2	90.8	92.5	92.7	92.2	93.7	93.9	93.3
45	91.7	91.7	91.4	92.9	93.1	92.7	94	94.2	93.7
55	92.1	92.1	91.9	93.2	93.5	93.1	94.3	94.6	94.1
75	92.7	92.7	92.6	93.8	94	93.7	94.7	95	94.6
90	93	93	92.9	94.1	94.2	94	95	95.2	94.9
110	93.3	93.3	93.3	94.3	94.5	94.3	95.2	95.4	95.1
132	93.5	93.5	93.5	94.6	94.7	94.6	95.4	95.6	95.4
160	93.8	93.8	93.8	94.8	94.9	94.8	95.6	95.8	95.6
200-375	94	94	94	95	95.1	95	95.8	96	95.8

Figure 20:Efficiency class of IE1, IE2 and IE3 motors

Savings

The expected savings by replacement of old in efficient motors is 31823 units annually. The annual monetary saving for this project is ***Rs 1.75 Lakhs with an investment of Rs 2.25 Lakhs and payback for the project is 15 months.***

Table 50: Saving calculation for EE Motors

Parameters	UOM	
Total Power Consumption	kW	34.5
Current Efficiency	%	81
Proposed Efficiency	%	91
Total Power Saving based on improved efficiency	kW	4.35
Annual operating hrs	hours	7000
Annual Energy Savings	kWh	31823
Electricity Cost	Rs/kWh	5.5
Savings per year	Rs Lakhs	1.75
Investment	Rs Lakhs	2.25
Pay Back	Months	15
NPV at 70% Debt	**Rs Lakhs**	**7.84**
IRR (%)	**%**	**102.47**
TOE Savings	**TOE**	**2.74**
TCO_2 Savings	**TCO_2**	**26.09**

Energy Saving Proposal 10 – Installation of 200 TR Evaporative Condenser for the refrigeration system

Present System

Ernakulam dairy has installed one 250 TR PHE condenser to condense the high temperature refrigerant coming from compressor. Also, the plant has installed a de super heater which is an excellent initiative by the plant team.

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 vapours from the evaporator and pump these to condenser at high pressure and high temperature condition. While flowing through the condenser, the high temperature vapours 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 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 vapours, 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 vapor compression refrigeration system is shown below:

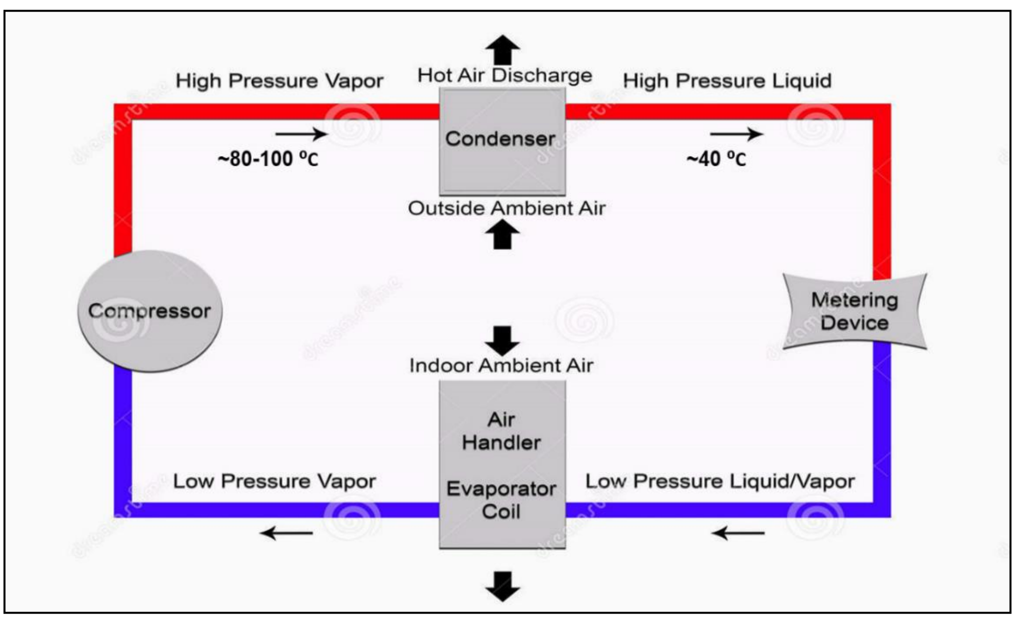


Figure 22: Vapor Compression Cycle

Existing condenser system

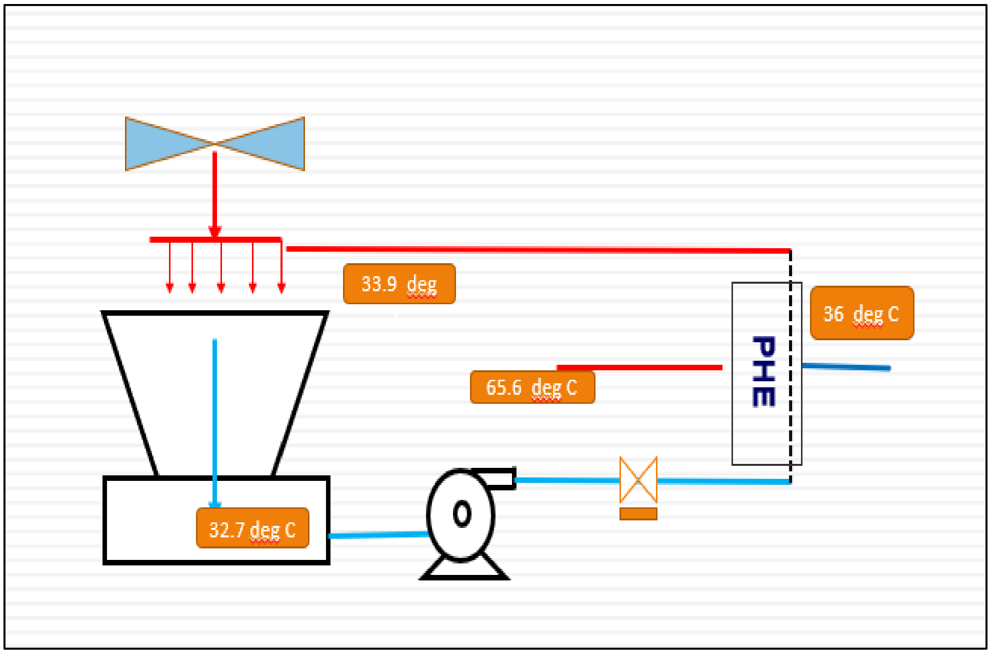


Figure 23: Existing PHE system

Currently plant is having a normal PHE condenser for the chiller. The compressor is running at 36°C condensing temperature. The condenser has a pump and cooling tower arrangement. The total power consumption of the entire system is

- Pump Power – 23.37 kW
- Fan Power – 9.11 kW

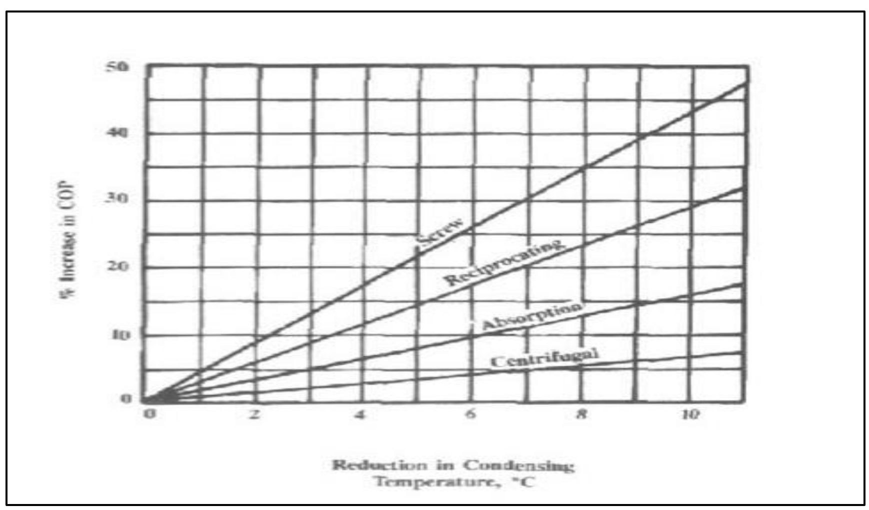


Figure 24: Effect of condensing temperature on COP

At a constant evaporator temperature as the condensing temperature increases, then the enthalpy of refrigerant at the inlet to the evaporator increases. Since the evaporator enthalpy remains constant at a constant evaporator temperature, the refrigeration effect decreases with increase in condensing temperature. The refrigeration capacity also reduces with increase in condensing temperature as both the mass flow rate and refrigeration effect decrease which in turn increases the power consumption of compressor to maintain the same refrigeration load.

Recommendation

It is recommended to install evaporative condenser with combined flow technology to achieve a condensing temperature of 36ºC. Water is sprayed in parallel with the fresh ambient air flowing over the outside of the condensing coil. Parallel air and water paths minimize scale-producing dry spots that may be found on the bottom of the tubes in other, conventional condensers.

The condensing coil rejects heat through both evaporative cooling using the fresh air stream and, more significantly, through sensible cooling of the pre-cooled recirculating spray water. Reducing this evaporative cooling component from the coil section helps to minimize the propensity to form scale on the coil surface.

The recirculating spray water falls from the coil to the fill surface section where it is cooled by a second fresh air stream using evaporative heat transfer.

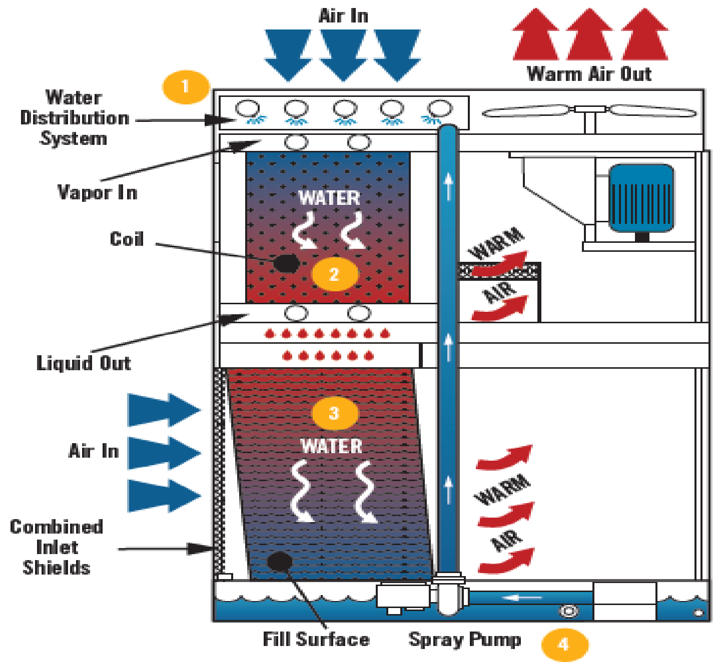


Figure 25: Evaporative condenser

Water is pumped over the condensing coil at a rate greater than 10 USGPM/ft^2 of coil plan area to ensure continuous wetting of the primary heat transfer surface, which enhances heat transfer efficiency and minimizes scale formation.

With the installation of evaporative condenser, condensing temperature of 36ºC can be achieved for the same cooling capacity. As a result, the compressor power will come down drastically at 4ºC lower condensing temperature compared to existing condensing temperature of 41ºC.

Also, the new evaporative condenser will have a total power consumption of 6.2 kW including the recirculation pump and fan.

Benefits

- Reduces Fouling Tendency - Advanced coil technology, applied on Evaporative Condensers, is used to reduce the tendency to accumulate fouling and scale on the coil's exterior surface. Four facets of the unique product design contribute to the reduced tendency for fouling.

- The Air and Water Flow in a Parallel Path - Better water coverage over the coil is maintained because the air and spray water flow in a smooth, parallel, downward path over the coil. With this parallel flow, the spray water is not stripped from the underside of the tubes by the upward air flow, as on other, conventional designs. This eliminates scale-producing dry spots on the coil.
- Increased Water Flow Over the Coil - The spray water flow rate over the coil plan area is more than twice that of conventional units. This heavy coverage provides continuous flooding of the primary heat transfer surface for decreased fouling potential. Improved spray water coverage is provided at no increase in pumping horsepower due to the unique heat transfer system of the design.
- Evaporative Cooling in the fill- They incorporate combined flow technology, using both primary and secondary heat transfer surfaces. The primary heat transfer surface is the serpentine coil, which is the most important and expensive component in the unit. More than 80% of the latent heat transfer occurs in the secondary surface, PVC cooling tower fill, effectively moving the evaporation process away from coil. The coil is protected from detrimental fouling and scale since it relies primarily on sensible conduction/convection heat transfer and, therefore, is less susceptible to scale formation than are other condensers that rely primarily on latent (evaporative) heat transfer.
- Colder Spray Water - Spray water at a colder temperature has a lower propensity to form scale because scale-forming compounds remain in solution, rather than deposit as solids on the coil exterior surface. Spray water flowing over the coil is commonly 6°F to 8°F colder than on other designs due to the addition of the secondary heat transfer surface. Colder spray water alone typically reduces the scaling potential by 25% compared to other designs. This is over and above the fouling reductions achieved by the first three factors described above.

Savings

The expected savings by installation of evaporative condenser is 210240 units annually. The annual monetary saving for this project is ***Rs 11.56 Lakhs with an investment of Rs 19.46 lakhs and payback for the project is 20 months.***

Detailed savings calculations are given in below table

Table 51: Savings calculation for 200 TR Evapco

Sl. No	Parameter	UOM	Conventional System-Shell & Tube-(150 TR	Evaporative Condenser--1 No
1	Tons of refrigeration	TR	150	200 TR @ 40 Deg Condensing Temperature & 29 Deg C WBT
2	Equipments to be maintained		Shell & Tube + Cooling Tower + Valves	1-Evaporative Condenser
3	No of Cooling Towers	No	1	

4	Total Fan Motor Power in kW	kW	9.11	2.2
5	Total Spray pump Power	kW	23.37	4
6	Total Power - Fan Motor & Spray Pump	kW	32.48	6.2
7	Power Savings	kW	26.28	
8	Operating Hours	Hrs	8000	
9	Energy Cost	Rs/kWh	5.5	
10	Annual Energy Savings	kWh	210240	
11	Annual Cost Savings	Rs Lakhs	11.56	
12	Total Initial Investment for BAC	Rs Lakhs	18.75	
13	Payback Period	Months	**20**	
14	**NPV at 70% Debt**	**Rs Lakhs**	**49.99**	
15	**IRR (%)**	**%**	**84.34**	
16	**TOE Savings**	**TOE**	**18.08**	
17	**TCO_2 Savings**	**TCO_2**	**172.39**	

Energy Saving Proposal 11 – Installation of VFD for ID Fan

Present System

Ernakulam Dairy Plant has installed one briquette fired boiler and one 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.

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 25 % 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 50% load which is pulley driven.

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 4927 units annually. The annual monetary saving for this project is ***Rs 0.27 Lakhs with an investment of Rs 0.41 lakhs and payback for the project is 18 months***

Detailed savings calculations are given in below table

Table 52: Savings calculation for VFD in ID fan

Parameters	UOM	
ID Fan	Rated kW	9.3
ID Fan	kW	6
Power Savings	%	15
New Power	kW	5.4
Power Savings	kW	0.60
Power Cost	Rs/kWh	5.5
Energy Savings	kWh	4927
Cost Savings	Rs Lakhs	0.27
Investment	Rs Lakhs	0.41
PB	Months	18
NPV at 70% Debt	**Rs Lakhs**	**1.18**
IRR (%)	**%**	**89.13**
TOE Savings	**TOE**	**0.42**
TCO_2 Savings	**TCO_2**	**4.04**

Energy Saving Proposal 12 – Replacement of Ceiling fans with BLDC fans

Present System

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

Table 53: List of fans

Sl No.	No of Fans	Power Consumption per fan (Watts)	Total Power (kW)
1	22	75	1.65

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.

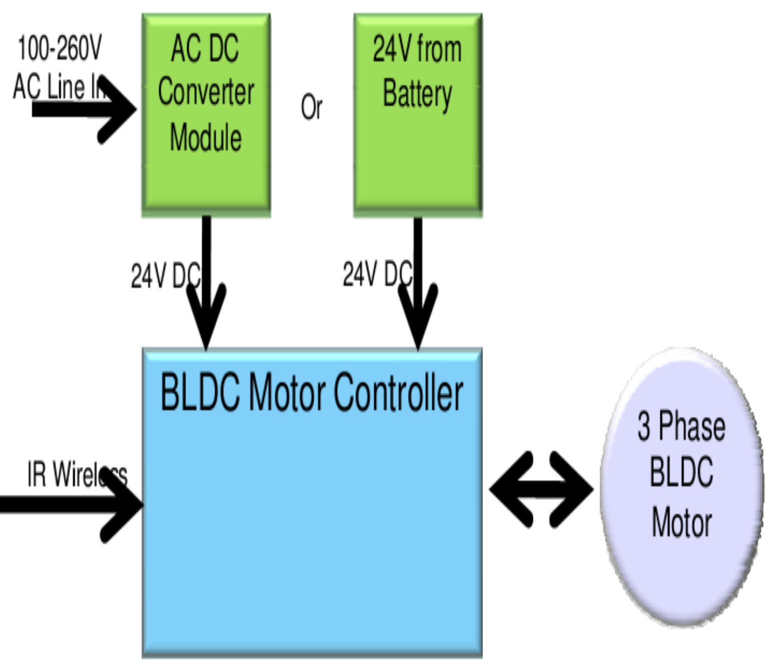


Figure 26: Schematic of BLDC fan

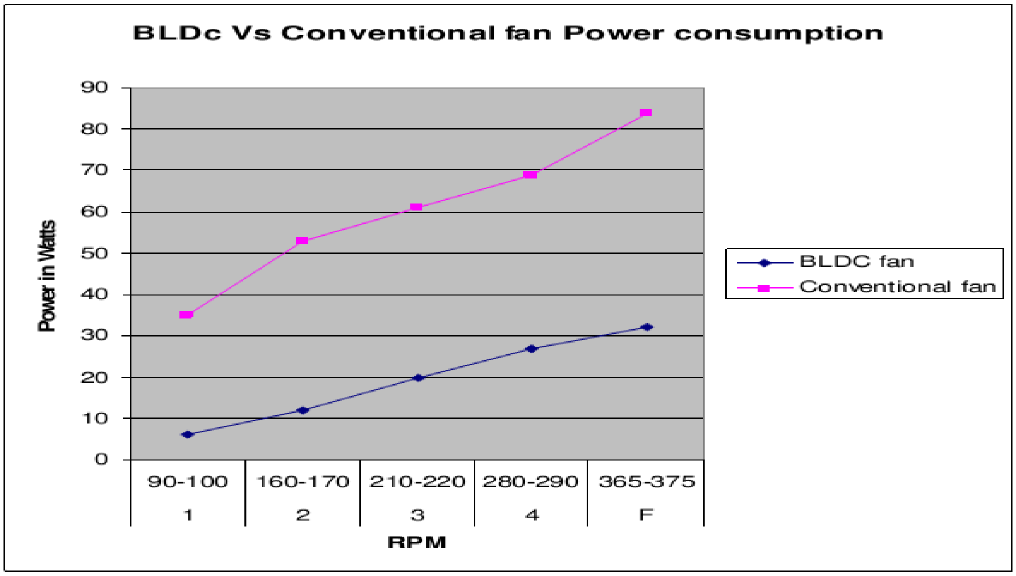


Figure 27: Comparison of normal fan vs BLDC fan

Savings

The expected savings by installation of BLDC fans is 3212units annually. The annual monetary saving for this project is ***Rs 0.17 Lakhs with an investment of Rs 0.52 lakhs and payback for the project is 35 months.***

Detailed savings calculations are given in below table

Table 54: Calculations for BLDC Fan

Parameters	UOM	
No of Fans	Nos	22
Conventional Fan power	Watts	75
Total Power	kW	1.65
BLDC Fan Power	Watts	35
BLDC Fan Power	kW	0.035
Savings	kW	0.88
Electricity Cost	Rs/kWh	5.5
Annual Energy Savings	kWh	3212
Annual Cost Savings	Rs Lakhs	0.17
Investment	Rs Lakhs	0.52
Pay Back	Months	35
NPV at 70% Debt	**Rs Lakhs**	**0.62**
IRR (%)	**%**	**48.96**
TOE Savings	**TOE**	**0.28**
TCO_2 Savings	**TCO_2**	**2.63**

Energy Saving Proposal 13 - Reduce the Generating Pressure of Main Plant Compressor

Present Status

Screw compressor installed in plant 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 55: Operating set points for main plant and product plant compressor

Tag No	Average Pressure (Bar)	Operating kW	Suggested Pressure
Main Plant compressor	7	15.28	6.5

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 0.3 bar. 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

Savings:

The expected savings by reducing the generation pressure is 7640 units annually. The annual monetary saving for this project is ***0.42 Lakhs without any investment.***

Table 56 Savings calculation for compressor pressure reduction

Parameters	UOM	
Loading of Compressor	%	100
Operating Pressure	Bar	7
Power Consumption	kW	15.28
Percentage average pressure reduction in main plant compressor	%	6.25
Power saving in main compressor	kW	0.96
Annual operating Hours	Annually	8000
Annual Energy Savings	kWh	7640
Electricity Cost	Rs/kWh	5.5
Savings per year	Rs Lakhs	0.42

Investment	Rs Lakhs	Nil
Pay Back	Months	Immediate
TOE Savings	**TOE**	**0.66**
TCO_2 Savings	**TCO_2**	**6.26**

Energy Saving Proposal 14- INSTALLATION OF AC ENERGY SAVERS

Present Status

During the detailed energy audit at **Ernakulam 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 2TR capacity at different locations such as admin office and site offices.

In Spit AC and packaged AC 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 57: List of AC units

S. No	Capacity of AC units	Power, kW	Nos.
1	1.5 TR	1.57	3
2	2 TR	2.2	1

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.

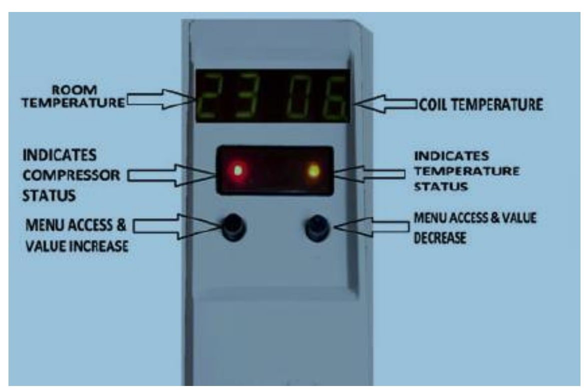


Figure 28: AC Remote controller

Savings

The expected saving after installation of AC energy saver is 5840 units annually. The annual monetary saving for this project is ***Rs 0.32 Lakhs with an investment of Rs 0.24 Lakhs and payback for the project is 09 months.***

Table 58: Saving calculation for AC Energy Saver

Parameters	UOM	
Total No of AC Units	Nos	4
Total AC units power consumption	kW	7.3
Conservative Power Saving after AC energy saver (20% Saving)	kW	1.46
Annual operating hrs	hours	4000
Annual Energy Savings	kWh	5840
Electricity Cost	Rs/kWh	5.5
Savings per year	Rs Lakhs	0.32
Investment	Rs Lakhs	0.24
Pay Back	Months	9
NPV at 70% Debt	**Rs Lakhs**	**1.51**
IRR (%)	**%**	**161**
TOE Savings	**TOE**	**0.50**
TCO_2 Savings	**TCO_2**	**4.78**

Energy Saving Proposal 15 – Installation of 50 kWp Solar Roof Top

Present System

Ernakulam Dairy is purchasing electricity from grid for the operation of various equipment's in the plant. The contract demand of the plant is 750 kVA with electricity price of Rs 5.5/kWh with an average load of 350 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 59: Site Specifications

Parameters	
Effective Rooftop available, sq. ft	5000
Location	Latitude: - 9.94 N, Longitude: - 76.34 E
Altitude above sea level, m	4
Annual in plane irradiation	5.03 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 50 kWp Solar PV power plant which will generate an average of around 0.73 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 50 kWp solar roof top is 73000 units of electricity annually. The annual monetary saving for this project is ***Rs 2.45 Lakhs with an investment of Rs 27.00 lakhs and payback for the project is 82months.***

Detailed savings calculations is given in below table

Table 60: Savings calculation for solar roof top

Parameters	UOM	
Proposed Roof top Solar installation	kW	50
Area Available at Roof	Sq. Ft	5000
Annual units generation per kW of Solar PV	kWh per kW/day	4
Total Energy Generation Per Annum	kWh/year	73000
Electricity Cost	Rs/kWh	5.5
Cost Savings	Rs Lakhs	4.01
Investment	Rs Lakhs	27
Payback period	Months	82
NPV at 70% Debt	**Rs Lakhs**	**7.91**
IRR (%)	**%**	**21.96**
TOE Savings	**TOE**	**6.28**
TCO_2 Savings	**TCO_2**	**59**

5. MANAGEMENT ASPECTS AND CONCLUSIONS

THE OBJECTIVES OF ERNAKULAM DAIRY 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

Ernakulam Dairy 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 Ernakulam Dairy should be to implement the identified proposals and get the savings.

We would recommend Ernakulam Dairy 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.

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, Ernakulam Dairy 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

- Ernakulam Dairy Main Plant and CII – Godrej GBC teams have jointly identified **15** energy saving proposals worth an annual saving potential of **Rs. 78.66 Lakhs**. The investment required for implementation of energy saving proposals is **Rs. 145.98 Lakhs**. The total investment will have a simple payback period of **22 months.**

Table 61: Summary of savings

Details	No. of Proposals	Annual savings
Total Annual savings	15	78.66
Nil Investment Proposals	3	1.66
Investment Required (Rs. Lakhs)	12	145.98
Pay Back	Months	22

Table 62: Summary of fuel savings

Details	UOM	Annual savings
Total Electricity Savings	kWh	4,96,920
Total Fuel Savings (Briquette)	kgs	5,53,641
Annual TOE Savings	TOE	273
Annual TCO_2	TCO_2	407.5

Table 63: Summary of Energy Saving Proposals

Sl. No.	ECM	Annual savings (lakhs)	Investment (lakhs)	Pay back	Electricity Savings (kWh)	Fuel Savings (kg Briquette)	TOE savings	TCO2 savings
1	Installation of new lower capacity boiler of 1 TPH capacity	26.27	30	14		4,10,923	172.59	
2	Modification in MS line and steam distribution line	6.1	3.1	6		29,308	12.31	
3	Condensate recovery from the plant	7.49	6	10		1,13,410	45.36	
4	Installation of new Screw Chiller with VFD	15.38	52	41	279690		0.00	229.3
5	Switching off reciprocating air compressor	0.57	0.00	-	10533		0.91	8.6
6	Replacement of chilled water pump	1.38	1.50	13	13961		1.20	11.4
7	Replacement of existing condenser pump with energy efficient pump	2.30	3.50	18	42474		3.65	34.8
8	Optimize the operation of ETP Agitator motor	0.67	0.00	-	12264		1.05	10.1
9	Installation of Energy Efficient Motors	1.75	2.25	15	31823		2.74	26.1
10	Installation of new 200 TR Evaporative Condenser	11.56	19.46	20	11556		0.99	9.5
11	Installation of VFD for ID Fan	0.27	0.41	18	4927		0.42	4.0
12	Replacement of ceiling fans with BLDC fans	0.17	0.52	37	3212		0.28	2.6

13	Pressure reduction of main plant compressor	0.42	0.00	-	7640		0.66	6.3
14	Installation of energy saver for split ACs	0.32	0.24	9	5840		0.50	4.8
15	Installation of 50kWp Solar roof top	4.01	27.00	81	73000		6.28	59.9
	Total	**78.66**	**145.98**	**22**	**4,96,920**	**5,53,641**	**273.0**	**407.5**

5.7 Ernakulam Dairy 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 pasteurisation 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
66	**Heat Exchangers**	Alfa Laval	Mr Himanshu Sheth	9552544801	himanshu.sheth@alfalaval.com
67	**Heat Exchangers**	Alfa Laval	Ms Varsha Tambe	7774097375	varsha.tambe@alfalaval.com
68	**Heat Exchangers**	Alfa Laval	Mr D.Rama Mohan	9822373561	rammohan.d@alfalaval.com
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
72	**Insulation**	Lithopone insulation paint	Mr Rahman		rahman@choiceorg.com
73	**Insulation**	U P Twiga Fiberglass Limited	Mr Biswajit Roy	011-26460860	biswajit@twigafiber.com
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
76	**IOT**	E-cube energy	Mr.Umesh	9831012510	umesh@eetpl.in

77	**IOT**	Vermigold Eco Tech	Mr.Jaideep Saptarshi	9867300840	jd@vermigold.com
78	**LED**	OSRAM Lighting Pvt. Ltd.	Mr Nitin Saxena	+91 124 626 1300	N.saxena@osram.com
79	**LED**	Kwality Photonics Pvt. Ltd.	Mr. K. Vijay Kumar Gupta	+ 91 40 2712 3555	kwality@kwalityindia.com
80	**LED**	Havells India Ltd	Mr. Sunil Sikka	0120-4771000	sunil.sikka@havells.com
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
101	**Pumps**	Grundfos Pumps India Pvt. Ltd.,	Ms Mahathi Parashuram	44 45966896	mahathi@grundfos.com
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
138	**Refrigeration Compressor**	Frick India	Mr T Krishnamoorthy	9444818846	ttk@frickmail.com

6.3 ESP Implementation Format

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 new lower capacity boiler of 1 TPH capacity	26.27	30	14			
2	Modification in MS line and steam distribution line	6.1	3.1	6			
3	Condensate recovery from the plant	7.49	6	10			
4	Installation of new Screw Chiller with VFD	15.38	52	41			
5	Switching off reciprocating air compressor	0.57		0			
6	Replacement of chilled water pump	1.38	1.5	13			
7	Replacement of existing condenser pump with energy efficient pump	2.30	3.5	18			
8	Optimize the operation of ETP Agitator motor	0.67		0			
9	Installation of Energy Efficient Motors	1.75	2.25	15			
10	Installation of new 200 TR Evaporative Condenser	11.56	19.46	20			
11	Installation of VFD for ID Fan	0.27	0.41	18			
12	Replacement of ceiling fans with BLDC fans	0.17	0.52	37			
13	Pressure reduction of main plant compressor	0.42		0			
14	Installation of energy saver for split ACs	0.32	0.24	9			
15	Installation of 50kWp Solar roof top	4.01	27	81			
	Total	**78.66**	**145.98**	**22**			

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