February 2019

# DETAILED ENERGY AUDIT REPORT

## M/s Kottayam 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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## Disclaimer

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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 |

# ACKNOWLEDGEMENT

Confederation of Indian Industry (CII) would like to express its sincere thanks to United Nations Industrial Development Organization (UNIDO), Global Environment Facility (GEF) and Bureau of Energy Efficiency (BEE) for the role played by them in guiding and steering this prominent assignment - "Promoting energy efficiency and renewable energy in selected MSME clusters in India".

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CII would like to give special gratitude to Kerala Co-operative Milk Marketing Federation Ltd for supporting CII for carrying out this project at Kerala Dairy Cluster and for their constant support and coordination throughout the activity. CII team is also grateful to Mr. Tom Thomas, Dairy Manager and Mr. Abraham Paul, TS (E) for showing keen interest and providing their wholehearted support and cooperation for the preparation of this Detailed Energy Audit Report.

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** | Kottayam Dairy |
| **Name(s) of the Plant Head** | Tome Thomas |
| **Contact person** | Mr. Abraham Paul. TS(E) |
| **Constitution** | Cooperative Society |
| **MSME Classification** | Medium Scale |
| **Address:** | Kottayam Dairy, Vadavathoor, Kottayam |
| **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 fully automatic CIP
- 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 Kottayam Dairy Main Plant from 22nd October 2018 to 23th October 2018 and final presentation to plant team was given on 24th October 2018.**

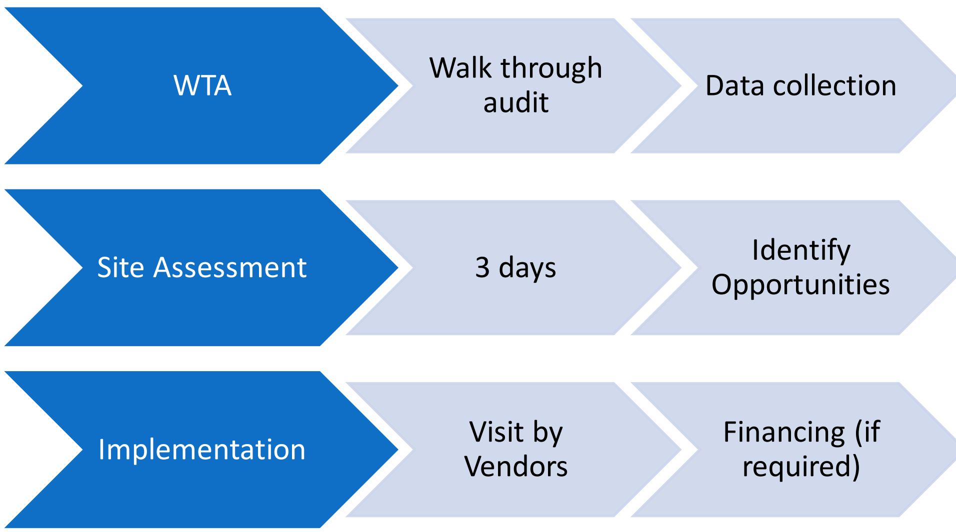
The energy audit included detailed data collection, power measurements of major electrical energy consumers, process measurements, analysis of data, and performance analysis of the equipment and identification of specific energy saving proposals.

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

Kottayam Dairy plant team and CII energy team have together identified an annual energy saving potential of **Rs. 20.26 Lakhs** with an investment of **Rs 46.66** Lakhs based on energy cost.

Table 2: Summary of savings

| Details | No. of Proposals | Rs In Lakhs |
|---|---|---|
| **Total Annual savings** | 16 | 20.26 |
| **Annual savings without investment** | 2 | 1.56 |
| **Annual savings with investment** | 14 | 18.70 |
| **Investment required** | 14 | 46.66 |
| **Simple Pay Back*** | Months | 30 |

*Excluding Nil investment proposals

Table 3: Summary of fuel savings

| Details | UOM | Annual savings |
|---|---|---|
| **Total Electricity Savings** | kWh | 196636 |
| **Total Fuel Savings (Briquette)** | kgs | 105142 |
| **Annual TOE Savings** | TOE | 61.10 |
| **Annual $TCO_2$** | $TCO_2$ | 161.20 |

Table 4: Summary of Energy Saving Proposals

| Sl. No. | ECM | Annual savings (lakhs) | Investment (lakhs) | Payback | Electricity Savings (kWh) | Fuel Savings (Briquette) | TOE savings | TCO2 savings |
|---|---|---|---|---|---|---|---|---|
| 1 | Install of Automatic Blow-down System | 0.97 | 3 | 37 | - | 3486 | 1.46 | - |
| 2 | Arrest all leakages in the steam system. | 0.5 | 0.1 | 2 | - | 7200 | 3.02 | - |
| 3 | Install Auto Pumping Trap for 10 KL Pasteuriser Condensate Recovery | 1.83 | 3.5 | 23 | - | 26250 | 11.03 | - |
| 4 | Curd Pasteuriser Pre-heater replacement | 2.60 | 9 | 42 | - | 27300 | 11.47 | - |
| 5 | Install Condensate Recovery System for CIP and pump the condensate to Hot Water Tank of CIP | 1.55 | 3 | 23 | - | 22050 | 9.26 | - |
| 6 | Install VFD Control for Refrigeration Compressor | 1.47 | 2.7 | 22 | 26727 | | 2.30 | 21.9 |
| 7 | Install waste heat recovery from Chiller Compressor | 2.00 | 3.2 | 19 | - | 18856 | 7.92 | 0.0 |
| 8 | Optimize the operation of cooling units of Cold Storage | 1.69 | 1.17 | 8 | 30727 | - | 2.64 | 25.2 |
| 9 | Reduce the Generating Pressure of Main Plant Compressor | 0.105 | 0 | 0 | 1909 | - | 0.16 | 1.6 |
| 10 | Operate the VFD of Main Plant Compressor in Closed Loop | 1.49 | 0 | 0 | 27091 | - | 2.33 | 22.2 |
| 11 | Install VFD for Aeration Blower | 0.51 | 1 | 24 | 9273 | - | 0.80 | 7.6 |
| 12 | Replace low efficiency Chilled Water Pump with high efficiency pump | 0.48 | 0.65 | 16 | 8727 | - | 0.75 | 7.2 |
| 13 | Replace Identified motors with Energy Efficient Motors | 2.18 | 3.36 | 18 | 39636 | - | 3.41 | 32.5 |
| 14 | Install Energy Saver for Split AC's | 0.22 | 0.23 | 13 | 4000 | - | 0.34 | 3.3 |
| 15 | Install Energy Efficient BLDC fans in Plant | 0.27 | 0.75 | 33 | 4909 | - | 0.42 | 4.0 |
| 16 | Install 30 kWp Solar Roof Top | 2.4 | 15 | 75 | 43636 | - | 3.75 | 35.8 |
| | Total | 20.265 | 46.66 | 28 | 196636 | 105142 | 61.1 | 161.2 |

# 2. INTRODUCTION ABOUT KOTTAYAM DAIRY PLANT

## 2.1 Unit Profile

Kerala Co-operative Milk Marketing Federation Ltd. KCMMF was set up in 1980 as the implementing agency for Operation Flood II in the State of Kerala. Kottayam Dairy falls under Ernakulam Regional Co-operative Milk Producers' Union Ltd. (Ernakulam Milk Union) comprising of mostly of central regions of Kerala i.e. Ernakulam, Thrissur, Kottayam and Idukki Districts.

Kottayam Dairy is located at Vadavathoor, Kottayam. The Dairy was commissioned in 1970 with a milk handling capacity of 6000/day and was expanded to 30000 litres/day in 2002 and is currently handling 75000 litres / day.

Table 5: Unit Profile

| Particulars | Details |
|---|---|
| **Name of Plant** | Kottayam Dairy |
| **Name(s) of the Plant Head** | Dairy Manager |
| **Contact person** | Mr. Abraham Paul.k TS(E) |
| **Contact Mail Id** | ercmpukdengg@milma.com |
| **Contact No** | +91 9847650061 |
| **Constitution** | Kottayam |
| **MSME Classification** | Medium Scale |
| **No. of years in operation** | 40 |
| **No of operating hrs/day** | 16 |
| **No of operating days/year** | 365 |
| **Address:** | Milma, Kottayam Dairy, Vadavathoor, Kottayam |
| **Industry-sector** | Dairy |
| **Type of Products manufactured** | Milk & Milk Products |

## 2.2 Production Details

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

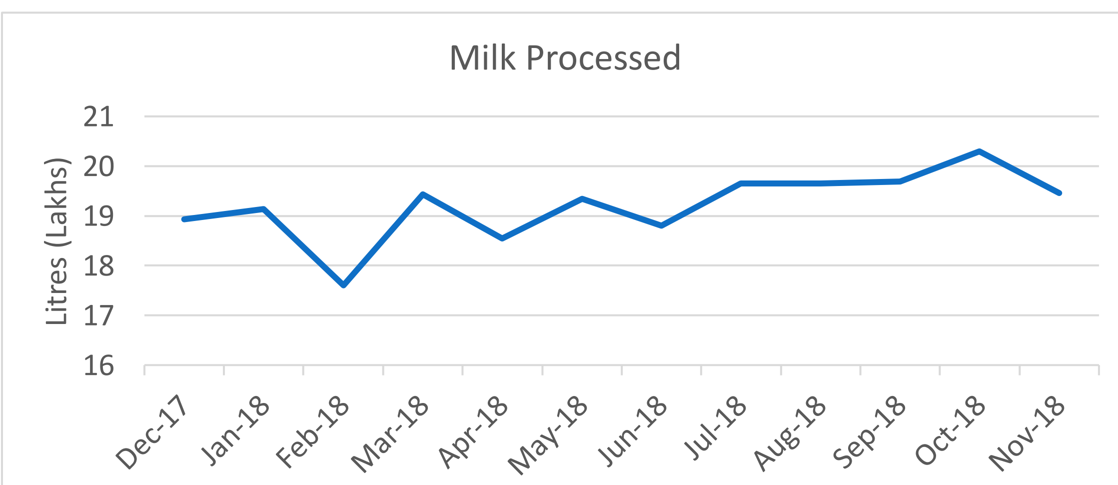



Figure 1: Milk Processed

## 2.3 Dairy Process Flow Diagram

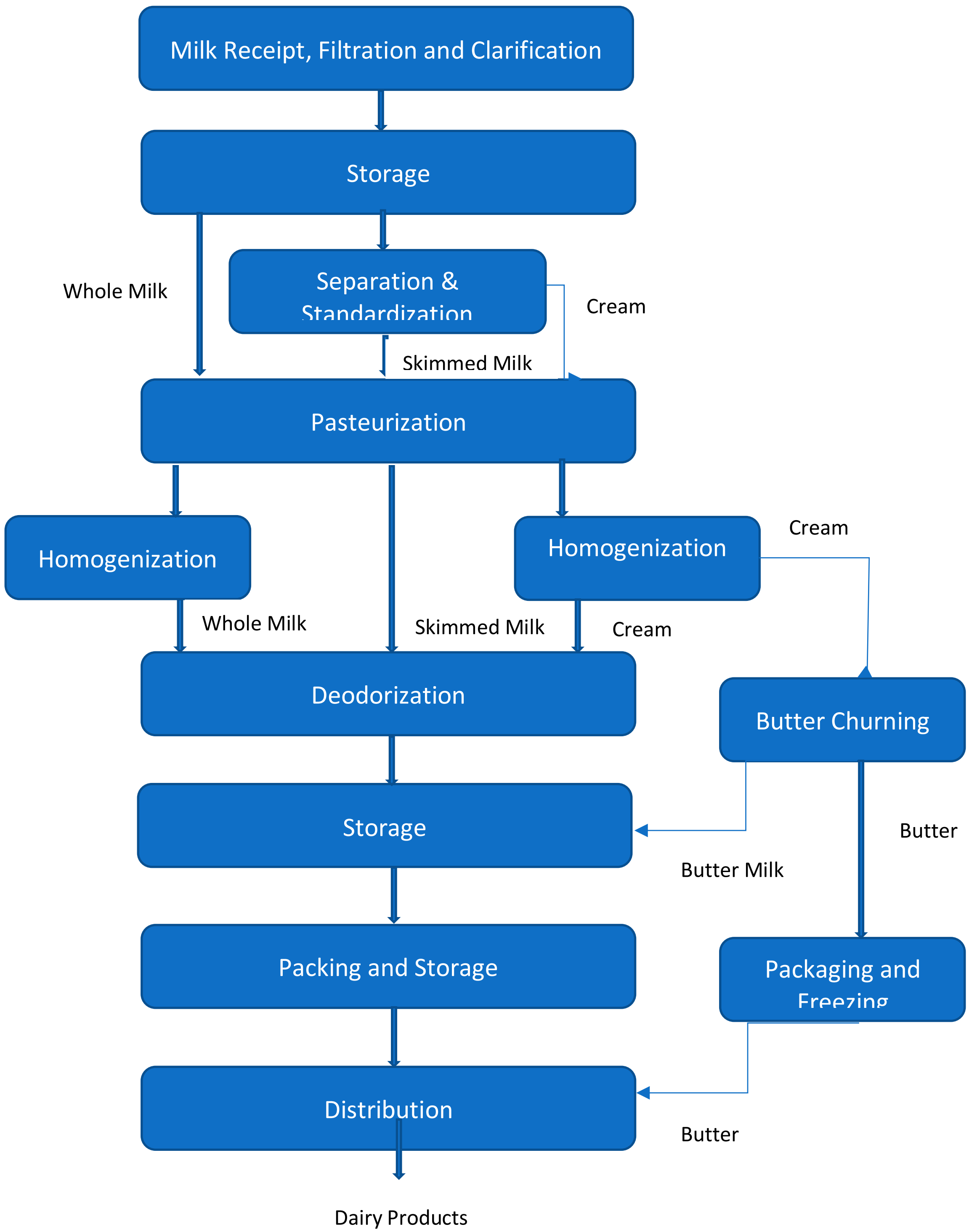



Figure 2: Typical process flow of Milk manufacturing

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 78°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 flavor and creamy texture. Milk is transferred to a piece of equipment called a homogenizer. In this machine the milk fat is forced, under high pressure, through tiny holes that break the fat cells up in to tiny particles, 1/8 their original size. Protein, contained in the milk, quickly forms around each particle and this prevents the fat from rejoining. The milk fat cells then stay suspended evenly throughout the milk.

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

**Table 6: Production Capacity**

| Sl No | Product | UOM | Quantity |
|---|---|---|---|
| 1 | Milk Processing | Lakh Litres per Day | 0.6 |
| 2 | Milk Packaging in Poly Pouches | Lakh Litres per Day | 0.35 |
| 3 | Curd Manufacturing | MT/day | 4 |
| 4 | Butter Manufacturing | MT/day | NIL |
| 5 | Ice Cream Manufacturing | MT/day | NIL |
| 6 | Ghee Manufacturing | MT/day | 0.062 |

## 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 | 64 | - |
| 3 | Briquette | Rs/Kg | 7.04 | 4200 |
| 4 | Furnace Oil | Rs/L | 43.02 | 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 320 kVA.

**Table 8: Fuel Consumption Details 2017-18**

| Month | Electricity Consumption (kWH) | Fuel Consumption - Briquette (Tonnes) | Fuel Consuption - Furnace Oil (litre) | Fuel Consumption Fuel- HSD (litre) |
|---|---|---|---|---|
| **Dec-17** | 95295 | 35450 | 1800 | 788 |
| **Jan-18** | 98078 | 37352 | 600 | 687 |
| **Feb-18** | 98378 | 36112 | 200 | 874 |
| **Mar-18** | 99126 | 36140 | 400 | 1471 |
| **Apr-18** | 100208 | 35551 | 400 | 2280 |
| **May-18** | 98178 | 32559 | 3200 | 200 |
| **Jun-18** | 97664 | 34564 | 1700 | 1795 |
| **Jul-18** | 94531 | 41167 | 525 | 3685 |
| **Aug-18** | 91588 | 45975 | 1000 | 1525 |
| **Sep-18** | 92332 | 38503 | 1500 | 880 |
| **Oct-18** | 84500 | 41781 | 600 | 2035 |
| **Nov-18** | 86319 | 42008 | 1100 | 1060 |
| **Total** | **1136197** | **457162** | **13025** | **17280** |

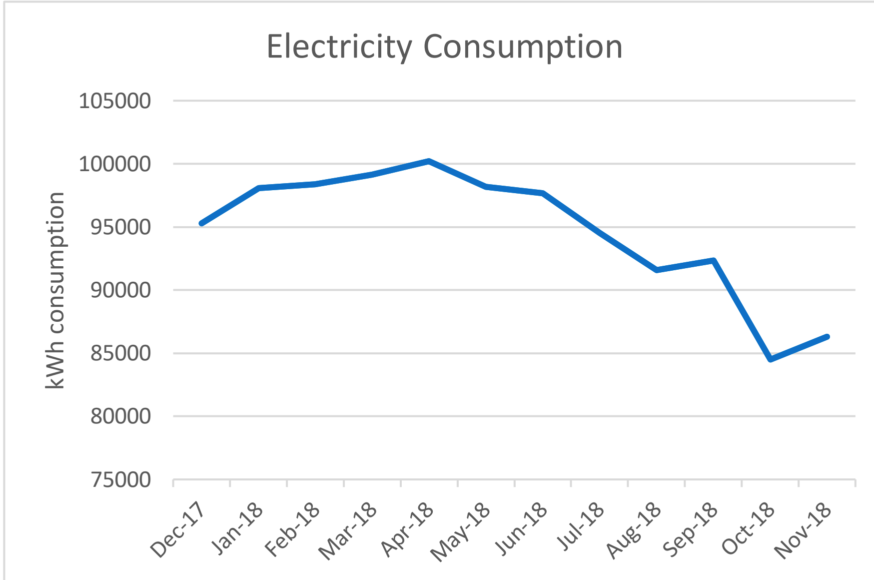



**Figure 3 : Electricity consumption profile**

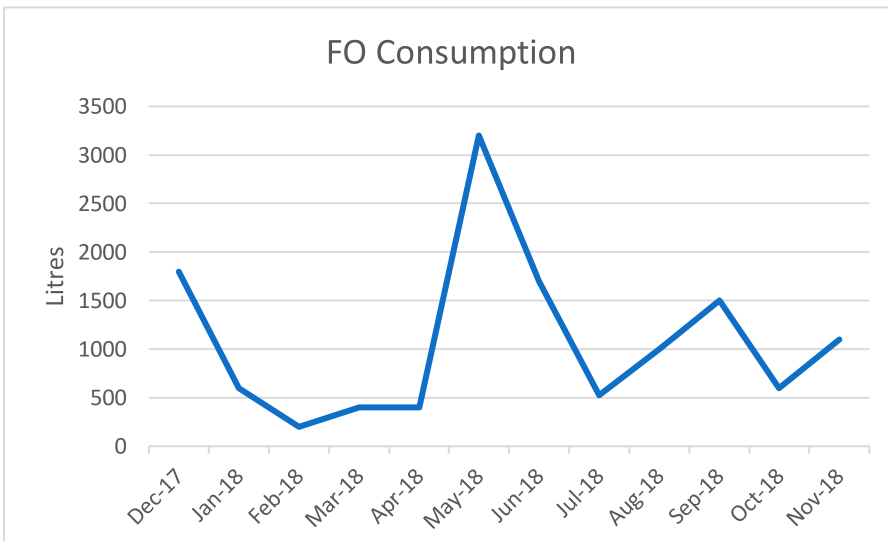



**Figure 4: Furnace Oil consumption profile**

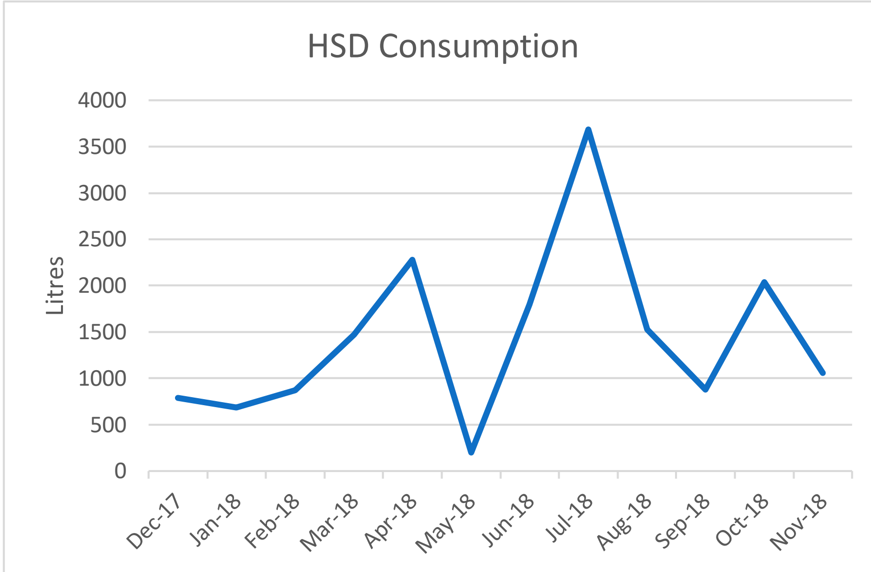



**Figure 6: HSD consumption profile**

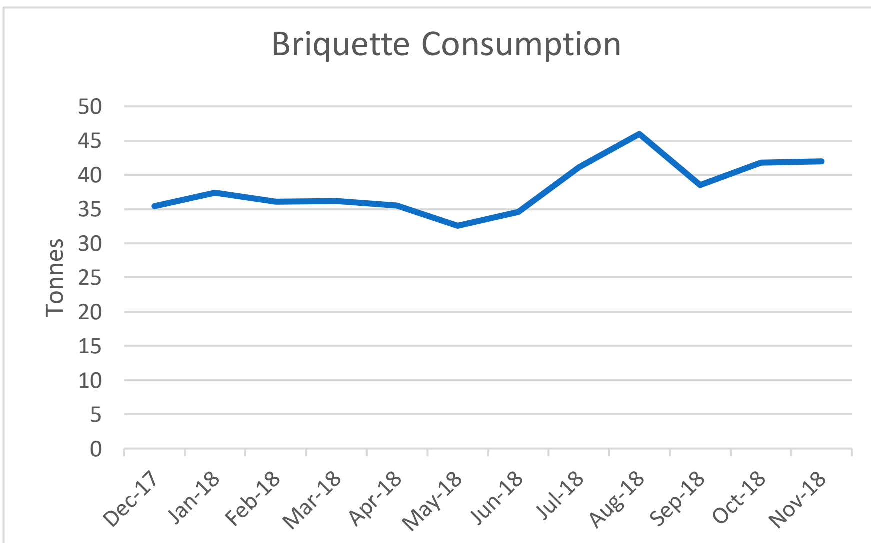



**Figure 5: Briquette consumption profile**

The energy consumption breakup of the plant both thermal and electrical is shown in the below table. Total energy consumption of the plant is 317 MTOE out of which 69% of the total energy is contributed by thermal and rest only 31% is contributed by electricity.

Table 9: Energy consumption breakup of plant

| Sl No | Particulars | UOM | Value |
|---|---|---|---|
| 1 | Annual Electricity Consumption | kWh | 1,136,197 |
| 2 | Annual Electricity Consumption | Kcal | 9,77,129,420 |
| 3 | Annual Electricity Consumption | MTOE | 97.71 |
| 4 | Annual Diesel Consumption | L | 17,280 |
| 5 | Annual Diesel Consumption | kcal | 1,46,880,000 |
| 6 | Annual Diesel Consumption | MTOE | 14.69 |
| 7 | Annual FO Consumption | Litre | 13,025 |
| 8 | Annual FO Consumption | kCal | 1,32,659,625 |
| 9 | Annual FO Consumption | MTOE | 13.26 |
| 10 | Annual Briquette Consumption | kg | 4,57,162 |
| 11 | Annual Briquette Consumption | kcal | 1,920,080,400 |
| 12 | Annual Briquette Consumption | MTOE | 192.01 |
| 13 | Total Energy Consumption | kWh | 1,136,197 |
| 14 | Total Energy Consumption | kcal | 3,176,749,445 |
| 15 | Total Energy Consumption | MTOE | 317.67 |

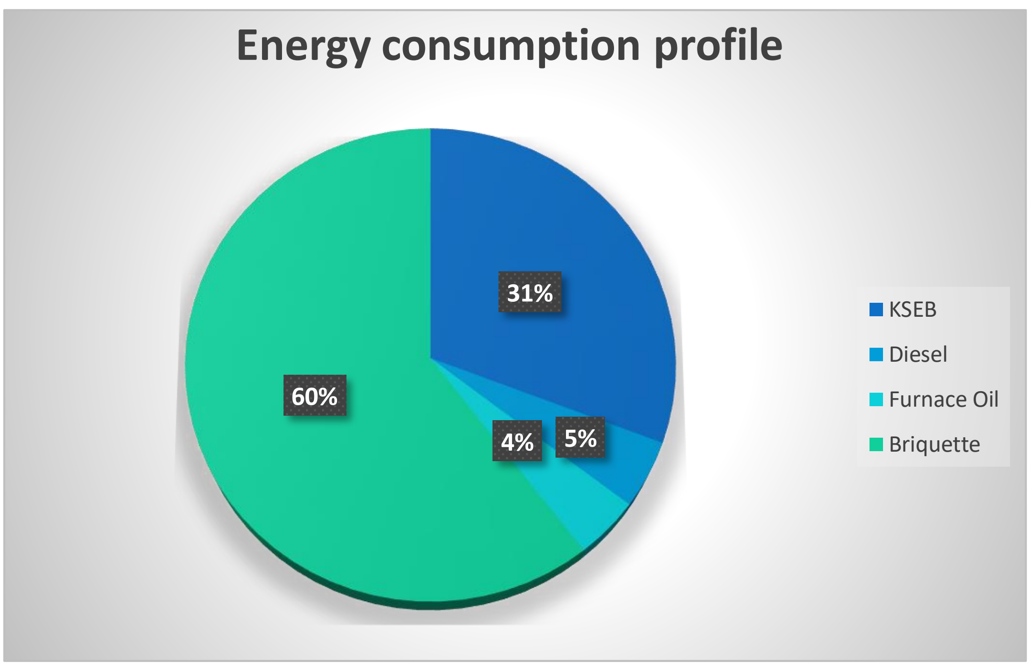



Figure 7: Energy Profile

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 5.3 Lakhs/month whereas the average thermal energy cost is Rs 3.9 Lakhs/month.

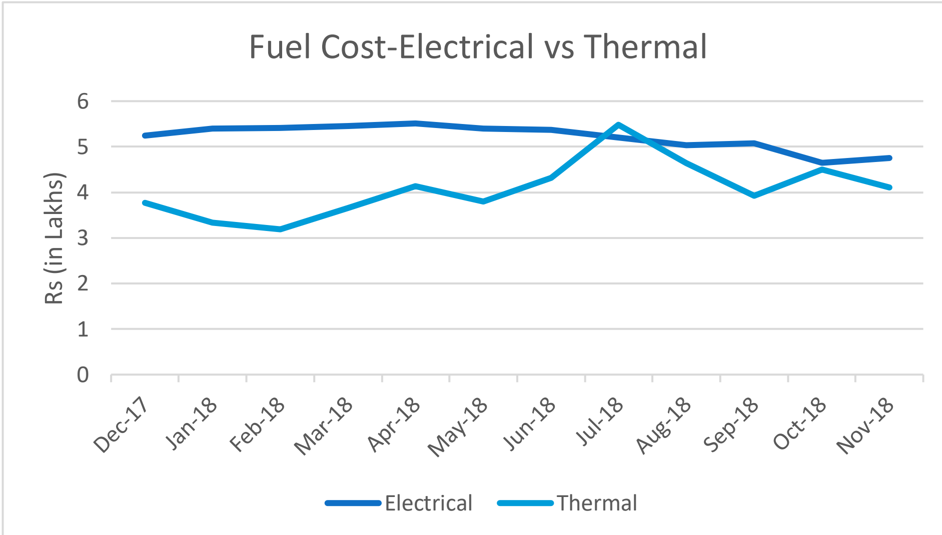



**Figure 8: Variation of fuel cost**

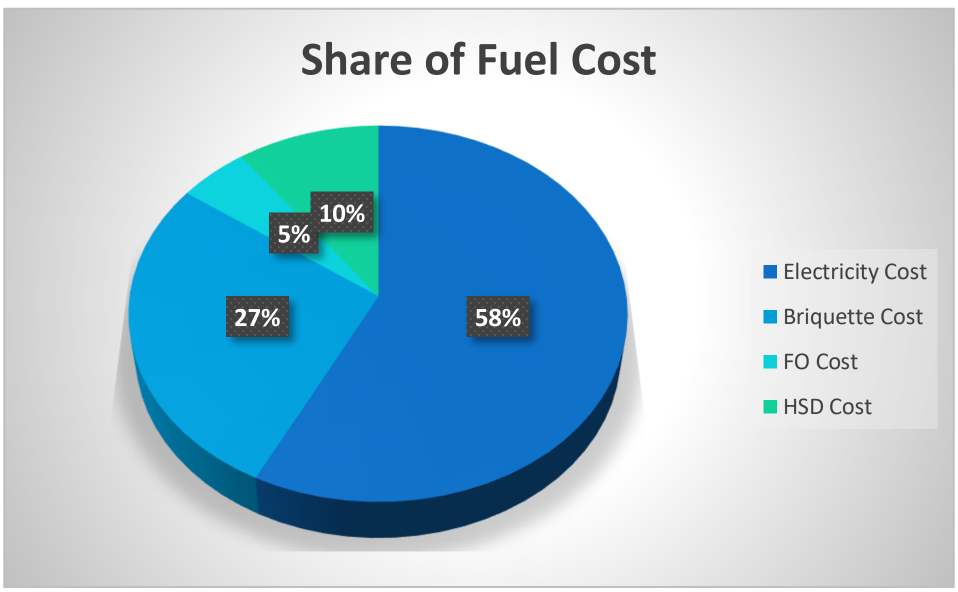



**Figure 8: Percentage share of fuel cost**

# 3. PERFORMANCE EVALUATION OF EQUIPMENT / PROCESS

## 3.1 List of equipment and process where performance testing done

CII during the detailed energy audit at Kottayam 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 | Pasteurizer | 388 | 40 | 21.9 | 0.81 |
| 2 | Cream Separator | 386 | 18.9 | 10.2 | 0.83 |
| 3 | Curd Section | - | - | - | - |
| 4 | Milk Pump | 384 | 5.1 | 2.3 | 0.69 |
| 5 | Hot water pump | 389 | 2.5 | 1.4 | 0.89 |
| 6 | Sump Tank | 386 | 3.4 | 2 | 0.89 |
| 7 | Homogenizer | 386 | 65 | 36 | 0.84 |
| 8 | Ghee vat agitator | 388 | 1.2 | 0.26 | 0.4 |
| 9 | Ghee exhaust | 385 | 0.8 | 0.26 | 0.87 |
| 10 | New Filling Machine | 410 | 1.5 | 0.54 | 0.6 |
| 11 | Filling Machine 1 | 400 | 1 | 0.5 | 0.67 |
| 12 | Filling Machine 2 | 400 | 0.8 | 0.32 | 0.61 |
| 13 | Filling Machine Old | 389 | 3.7 | 1.3 | |
| 14 | CIP | 385 | 16.9 | 9.51 | 0.85 |
| 15 | ID fan (9.2 kW) | 385 | 16.6 | 9.36 | |
| 16 | FD Fan (2.2 kW) | 385 | 3.1 | 1.79 | 0.85 |
| 17 | F/W Pump (2.2 kW) | 382 | 3.2 | 1.96 | 0.88 |
| 18 | After Rinse Pump (3.75 kW) | 391 | 7.1 | 4.9 | 0.91 |
| 19 | Detergent Pump (5.5kW) | 390 | 9.3 | 5.5 | 0.87 |
| 20 | First Rinse Pump ( 3. 75 kW) | 389 | 7.6 | 4.64 | 0.89 |
| 21 | Conveyor motor | 389 | 1.5 | 0.43 | 0.42 |
| 22 | Ammonia Compressor | 376 | 60.5 | 33.3 | 0.84 |
| 23 | Condenser Pump | 381 | 8.4 | 4.95 | 0.81 |
| 24 | Chilled Water Pump | 380 | 8.6 | 4.9 | 0.87 |
| 25 | ETP Blower | 375 | 10 | 5.76 | 0.88 |
| 26 | Agitator 1 | 376 | 1 | 0.22 | 0.35 |
| 27 | ETP Pump | 375 | 2.4 | 1.1 | 0.79 |
| 28 | Clarifier | 375 | 1.1 | 0.15 | 0.3 |
| 29 | Lighting Load | 375.84 | 9.5 | 7.11 | 0.99 |
| 30 | Fres-cold 2 Cold room | 391 | 34 | 15.7 | 0.68 |
| 31 | Fres-cold 1 Cold room | 384 | 38.6 | 19.5 | 0.76 |
| 32 | Blue star Cold room | 384 | 9 | 4.8 | 0.8 |
| 33 | Blue star anti room | 384 | 9.5 | 5.7 | 0.87 |
| 34 | Blue star 2 anti room | 391 | 9.4 | 5.3 | 0.83 |
| 35 | ETP pump plant to ETP | 386 | 1.5 | 0.3 | 0.3 |

Table 11: Transformer Measurements

| Tr 1 500 KVA | V | I | kW | PF | VTHD | ITD |
|---|---|---|---|---|---|---|
| **R** | 223.5 | 269 | 59.84 | 0.99 | 2 | 4.2 |
| **Y** | 225 | 280 | 62.97 | 0.99 | 2.2 | 9 |
| **B** | 225 | 266 | 59.92 | 0.99 | 2 | 5.9 |
| **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%). Harmonics on TR1 is slightly on higher side.
- Plant is operating at good power factor and monthly plant is getting incentive from electricity board

Table 12: Boiler Efficiency

| Boiler Efficiency Direct Method | | |
|---|---|---|
| **Feed Water Temperature** | 55 | °C |
| **Calorific value of fuel** | 4200 | kCal/kg |
| **Feed Water Flow** | 770 | kg/hr |
| **Fuel Firing Rate** | 235 | kg/hr |
| **Enthalpy of steam at 8.5 kg/cm2** | 662 | kCal/kg |
| **Feed Water Enthalpy at 55 °C** | 55 | kCal/kg |
| **Boiler Efficiency** | 47.4 | % |

Table 13: Pump Measurements

| Parameter | Chilled water Pump 1 | Chilled water Pump 2 | Design |
|---|---|---|---|
| **Power kW** | 5.2 | 4.9 | 6.4 |
| **Flow (m3/h)** | 38 | 25 | 72 |
| **Head assumed (m)** | 20 | 20 | 20 |
| **Efficiency** | 46.86 | 32.71 | 62 |

| Parameter | Chilled Water Pump | Design |
|---|---|---|
| **Power kW** | 4.5 | 6.4 |
| **Flow (m3/h)** | 39 | 72 |
| **Head assumed (m)** | 20 | 20 |
| **Efficiency** | 55.57 | 58 |

Table 14: Performance of Reciprocating Air Compressor

| Parameters | UOM | |
|---|---|---|
| **Rated capacity of compressor** | CFM | - |
| **Rated power of compressor** | kW | - |
| **Load Power** | kW | 14 |
| **Unload Power** | kW | 4.8 |
| **Load Pressure** | bar | 6.2 |
| **Unload Pressure** | bar | 6.8 |

Table 15: Performance of Chiller Compressor

| Parameters | UOM | |
|---|---|---|
| **Rated size of compressor** | kW | 45 |
| | TR | 33 |
| **Voltage** | Volts | 376 |
| **Current** | Amperes | 60.5 |
| **Power Consumption of Compressor** | kW | 33.3 |
| **Power Factor** | PF | 0.84 |
| **Suction Pressure** | Psi | 27 |

| | | |
|---|---|---|
| **Discharge Pressure** | Psi | 180 |
| **Discharge Temperature** | °C | 83 |
| **Condensing Temperature** | °C | 38 |
| **Operating Power** | kW | 33.3 |
| **Operating TR** | TR | 23.8 |
| **SEC** | kW/TR | 1.4 |

## 3.3 Energy Balance of Kottayam Dairy

During the detailed energy audit at Kottayam Dairy the total load on the plant measured at transformer level was 230 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.

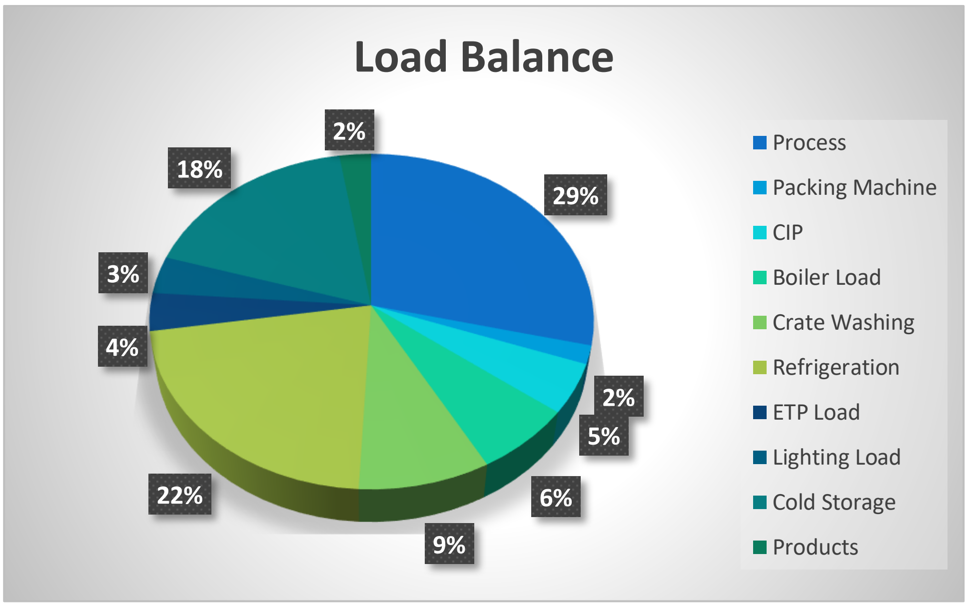



**Figure 9: Equipment/Process wise energy breakup**

The figure below shows energy balance diagram of Kottayam dairy

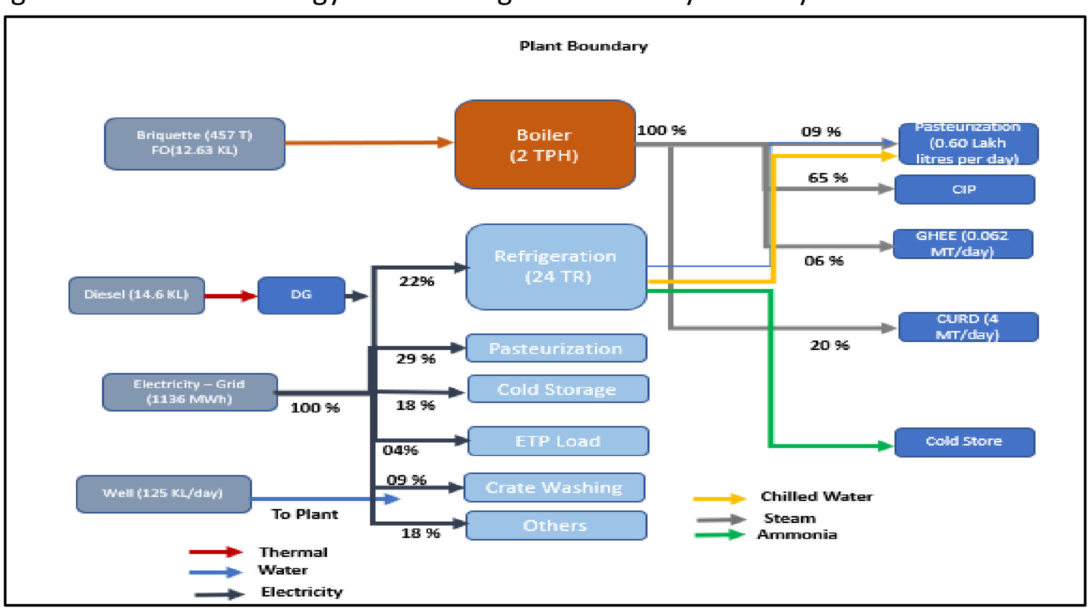



**Figure 10: Energy balance of Kottayam Dairy**

## 3.4 Water Profile of Kottayam Dairy

Kottayam Dairy is having a separate well for the water requirement in the plant. The table below shows the monthly consumption of water in the plant.

**Table 16: Monthly water consumption**

| Monthly Consumption | |
|---|---|
| | **Kilo Litre** |
| **Jul-17** | NA |
| **Aug-17** | NA |
| **Sep-17** | NA |
| **Oct-17** | NA |
| **Nov-17** | NA |
| **Dec-17** | NA |
| **Jan-18** | NA |
| **Feb-18** | NA |
| **Mar-18** | NA |
| **Apr-18** | NA |
| **May-18** | NA |
| **Jun-18** | NA |
| **Jul-18** | NA |
| **Aug-18** | NA |
| **Sep-18** | NA |
| **Oct-18** | NA |
| **Nov-18** | NA |
| **Dec-18** | NA |
| **Total** | - |

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

**Table 17: Daily consumption data**

| Water Data | | |
|---|---|---|
| **Water Source** | | Well |
| **Daily Average Consumption** | KL | 125.8 |
| **Daily average ETP Load** | KL | 100 |
| **Cost of Water** | Rs/L | Nil |
| **% Reused /Recycled** | % | Nil |

The section wise water consumption is shown in the below graph

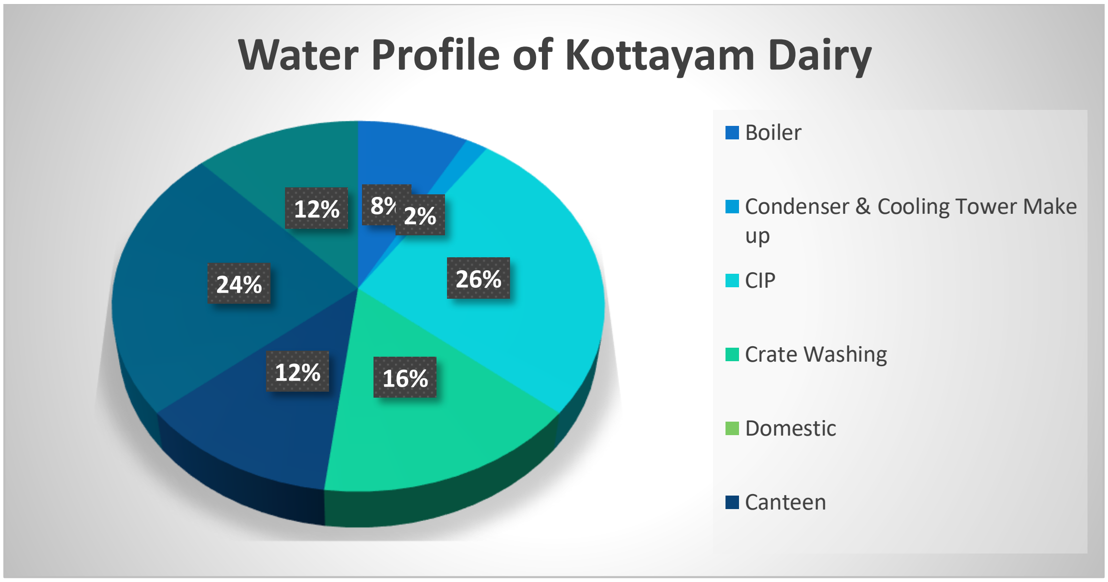



Figure 11: Water profile of Kottayam Dairy

## 3.5 Specific Energy Consumption

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

Table 18: Specific energy consumption

| Sl No | Particulars | UOM | Value |
|---|---|---|---|
| 1 | Annual Electricity Consumption | kWh | 1136197 |
| 2 | Annual Electrical Energy Consumption | Kcal | 977129420 |
| 3 | Annual Electricity Consumption | MTOE | 97.712942 |
| 4 | Annual Diesel Consumption | L | 14688 |
| 5 | Annual Diesel Energy Consumption | kcal | 146880000 |
| 6 | Annual Diesel Consumption | MTOE | 14.688 |
| 7 | Annual FO Consumption | Litre | 12634.25 |
| 8 | Annual FO Energy Consumption | kCal | 132659625 |
| 9 | Annual FO Consumption | MTOE | 13.2659625 |
| 10 | Annual Briquette Consumption | kg | 457162 |
| 11 | Annual Briquette Energy Consumption | kcal | 1920080400 |
| 12 | Annual Briquette Consumption | MTOE | 192.00804 |
| 13 | Total Energy Consumption | kcal | 3176749445 |
| 14 | Total Energy Consumption | MTOE | 317.6749445 |
| 15 | Total Production | KL | 23055.027 |
| 16 | Overall Electrical SEC | kWh/KL of Milk | 49.28 |
| 17 | Overall Thermal SEC | MkCal/KL of Milk | 0.09 |
| 18 | Overall SEC | MkCal/KL of Milk | 0.13 |

## 3.6 Performance Analysis of Major Processes

### 3.6.1 Pasteurizing Section

**Table 19: Analysis of pasteurizing section**

| Pasteurisation | | |
|---|---|---|
| **Description** | **Unit** | **Pasteuriser I** |
| **Pasteurizer Capacity** | KL/hr | 10 |
| **No.of hours of operation per day** | hours/day | 9.5 |
| **No of Shifts** | Nos | 2 |
| **Average Shift Time** | Hours | 8 |
| **Average Milk Processed per shift** | Litres/shift | 51000 |
| **Average Milk Processed per day** | Litres/day | 58000 |
| **Incoming milk temperature from Silo** | °C | 6 |
| **Heating Temperature** | °C | 76 |
| **Steam Pressure** | $Kg/cm^2$ g | 3 |
| **Holding time** | Seconds | 15 |
| **Regeneration Efficiency** | % | - |
| **Cooling Temperature** | °C | 5 |
| **Chilled water temperature** | °C | 1.5-2.5 |
| **Raw Milk Silo Temperature** | °C | 5 |
| **Process Milk Silo Temperature** | °C | 5 |
| **Specific Steam Consumption** | Kg/KL | 21.57 |

### 3.6.2 Ghee Section

**Table 20: Analysis of Ghee Vat**

| GHEE Section | | |
|---|---|---|
| **Description** | **Unit** | **VAT 1** |
| **Ghee VAT Capacity** | KL/hr | 0.1 |
| **Incoming Cream Temperature** | °C | 100 |
| **Initial Heating Temperature until boiling starts** | °C | - |
| **Initial Heating Time until boiling starts** | secs | - |
| **Final heating temperature** | °C | - |
| **Holding time** | mns | - |
| **Steam Pressure** | Kg/cm2 g | 3 |
| **Holding time in settling tank** | hrs | - |
| **No.of hours of operation per day** | hrs | 5 |
| **No of Shifts** | Nos | 1 |
| **Average Shift Time** | Hrs | 7 |
| **Average Ghee Produced per shift** | Litres | - |
| **Average Ghee Produced per day** | Litres | - |
| **Specific Steam Consumption** | Kg/.KL | 157.03 |

### 3.6.3 CIP Section

**Table 21: CIP Section Analysis**

| Parameters | UOM |
|---|---|

| | | |
|---|---|---|
| **Hot Water tank capacity** | KL | 3 |
| **Delta T of heating** | ºC | 55 |
| **Heating Time** | mins | 20 |
| **Steam Pressure** | kg/cm2g | 3 |
| **Steam Flow Rate for Hot Water tank per batch** | kg/hr | 970.6 |
| **Steam Qty required per batch** | kg/hr | 323.5 |
| **Number of batches per day** | No. | 3 |
| | | |
| **Acid Water tank capacity** | KL | 3 |
| **Delta T of heating** | ºC | 35 |
| **Heating Time** | mins | 20 |
| **Steam Pressure** | kg/cm2g | 3 |
| **Steam Flow Rate for Acid Water tank per batch** | kg/hr | 617.6 |
| **Steam Qty required per batch** | kg/hr | 205.9 |
| **Number of batches per day** | No.s | 2 |
| | | |
| **Alkali Water tank capacity** | KL | |
| **Delta T of heating** | ºC | |
| **Heating Time** | mins | |
| **Steam Pressure** | kg/cm2g | |
| **Steam Flow Rate for Alkali Water tank per batch** | kg/hr | |
| **Steam Qty required per batch** | kg/hr | |
| **Number of batches per day** | No.s | |
| | | |
| **Total Steam Required per day** | Kg/day | 1382.4 |
| **CIP steam requirement per KL pasteurisation** | Kg/KL | 138.24 |

## 3.6.4 Curd Section

**Table 22: Curd Section Analysis**

| Parameters | UOM | |
|---|---|---|
| **Capacity** | Liters | 5000 |
| **Incoming Milk Temperature** | ºC | 5 |
| **Milk Temp after regenerative heating** | ºC | 70 |
| **Heating Temperature** | ºC | 90 |
| **Holding Time** | Sec | 15 |
| **Steam Pressure** | Kg/cm2g | 3 |
| **Regeneration Efficiency** | % | - |
| **Incubation Temperature** | ºC | 45 |
| **Specific Steam Consumption** | Kg/KL | 100.50 |

## 3.6.5 Raw Milk Pre Chilling

**Table 23: Raw Milk Pre-chilling Analysis**

| Parameters | UoM | |
|---|---|---|
| **Capacity** | KL | 5 |

| | | |
|---|---|---|
| **Incoming Raw Milk Temperature** | °C | 6 |
| **Pre-Chilled Milk Temperature** | °C | 5 |
| **Refrigeration requirement** | TR/KL | 0.33 |

# 4. ENERGY SAVING PROPOSALS

## Energy Saving Proposal 1 – Install of Automatic Blow-down System

### Present System

Kottayam Dairy Plant has installed one briquette fired boiler of capacity 2 TPH. The following are the observations w.r.t the present boiler blow-down:

- Boiler is operational above 8.5 Kg/cm2 g pressure.
- Average steam generation is 600 Kg/hr.
- Blow-down is manual, and is done twice a day for approximately 45 - 60 seconds.
- The boiler TDS level is being maintained at 2300 ppm, while the permissible limit is at 3500 ppm as per the boiler manufacturer.
- There is no condensate recovery from process, and feed water is at atmospheric temperature.
- Feed water TDS level is in the range of 200 ppm.

It is evident from above data, that excessive blow-down is happening which is resulting heat loss due to additional unwanted blow down. Also, the following are the drawbacks of manual blow-down system:

- Boiler Blow down, though a critical activity is dependent mainly on the operator's attention. With manual boiler blow down control, operators do not understand when to conduct blow down or for how long.
- Sudden pressure fluctuations occur in the system during manual blowdown, and it takes some amount of time for boiler and steam system to recover to the required operational conditions.
- Feed water parameters vary due to degeneration of water treatment system and seasonal changes. So the amount of blow down given may be inaccurate.

### Recommendation:

It is recommended to install Automatic Blow-down System with Heat Recovery.

**AUTOMATIC BLOW-DOWN SYSTEM:**

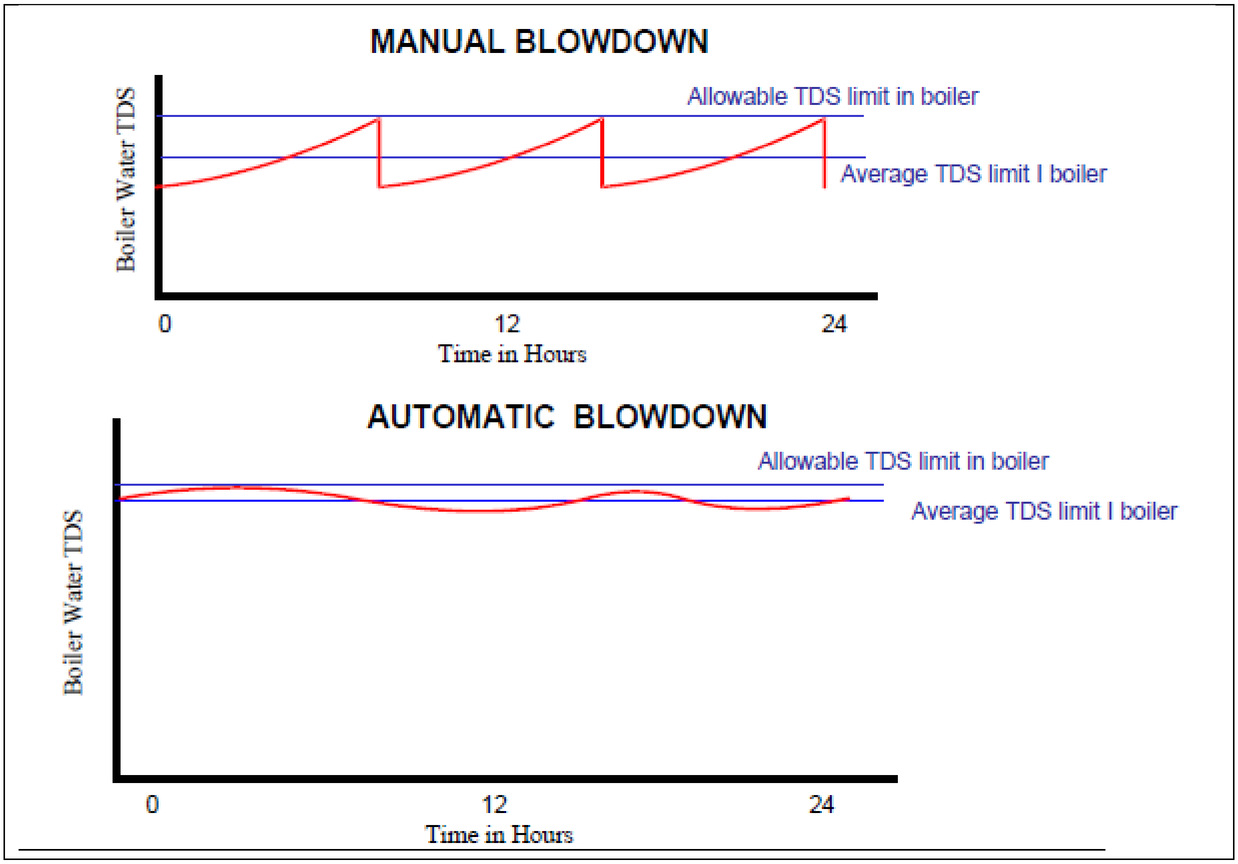
When the feed water quality is not constant, there comes up a necessity to measure and keep a track of the quality of boiler water on a constant basis. For such cases, conductivity probes are used to indicate the water quality (TDS) and also provide a control to blow down if the limits are exceeded. Such type of system is called as Automatic blow down system.

**Working principle**

- Most automatic blow down systems operate on the basis of Conductivity variations. Conductivity is near zero for pure water and increases with the increment of the TDS in water.
- At higher temperatures, the conductivity goes up substantially. Therefore, provision of temperature compensation for the conductivity measurement becomes mandatory.

- The Auto-blow down system actuates the blow down valve pneumatically or electrically to relieve the right quantity of water to maintain the TDS in the boiler water.
- Auto blowdown system maintains conductivity of boiler water within 5% of set point consistently.

The below figure shows the difference in operation between manual and automatic blow-down.




The following are the advantages with the system:

- Boiler blowdown required level will be maintained
- Feed water temperature can be raised by
- Flash steam heat recovery
- Increase in boiler safety and efficiency
- Reduced make up water requirement
- Real time conductivity sensing

## TYPICAL BOILER BLOW DOWN CALCULATIONS – AN EXAMPLE

% Blow down required to be provided for a boiler is calculated as under:

$$Blowdown\% = \frac{F}{B - F} \times 100$$

Where,

F = Feed water TDS, ppm

B = Recommended Boiler Water TDS, ppm

For example, if the Feed water TDS is 225 ppm, then the percentage Blow down calculated is,

$$\frac{225}{3500 - 225} \times 100 = 6.87\ \% \text{ (Say 7 \%)}$$

Now considering full load of 3000 kg/hr then actual blow down shall be $\frac{3000 \times 7}{100}$ = 210 kg/ hr.

Considering the condensate recovery of 80 %, actual blow down will be,

| | |
|---|---|
| Quantity of condensate recovered | = 2400 kg/hr |
| TDS of the condensate | = 5 ppm. |
| The make-up water required | = 600 kg/hr. |
| TDS of make-up water | = 225 ppm. |

FW TDS or Resultant TDS is calculated as below

$$TDS_{mixture} = \frac{TDS_{cond} \times Qty_{cond} + TDS_{makeup} \times Qty_{makeup}}{Qty_{cond} + Qty_{makeup}}$$

In our case, the Final TDS = $\frac{(5x2400) + (225x600)}{2400 + 600}$ = 49 ppm

$$Blowdown\% = \frac{49}{3500 - 49} \times 100 = 1.41\ \%$$

| | |
|---|---|
| Quantity of Proposed Blow Down | = 1.41 x 3000/100 |
| | = 42.3 kg/hr (Say 43 kg/hr) |

Thus, with 80% condensate recovery the blow down quantity reduces to the tune of 75%.

However the muck, sludge and other suspended solids, which are settled at the bottom of the boiler, have to be removed by opening the bottom blow down valve at least once in a shift. The size of this blow down valve varies with capacity of the boiler

The below figure shows the schematic for auto blow down system with heat recovery:

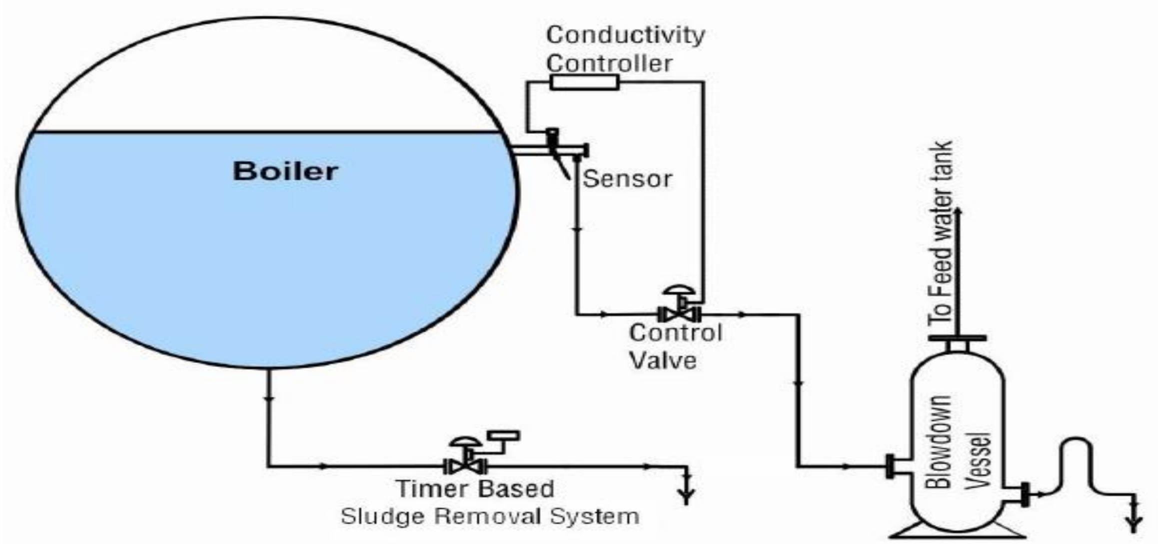



Figure 12 Auto blowdown system with heat recovery

## Savings

The expected fuel savings by installation of Auto Blow-down system with Heat Recovery is 14 Tonnes of Briquette annually. The annual monetary saving for this project is **Rs 0.97 Lakhs** with an investment of **Rs 3 lakhs** and payback for the project is **37 months.**

## Savings Calculation

Detailed savings calculations are given in below table

**Table 24 Auto blowdown with heat recovery calculation sheet**

| **I - Heat lost due to excess blowdown** | | |
|---|---|---|
| **Parameters** | **Values** | **Remark** |
| Boiler Capacity (kgs/hr) | 2000 | |
| Steam generation (kgs/hr) | 600 | Actual Required |
| Working pressure (kg/cm2) | 9 | |
| Feed water TDS (ppm) | 200 | |
| Blowdown line size (mm) | 40 | |
| Rate of water flow (kg/sec) | 8 | from the graph |
| No of hours per shift (nos) | 8 | |
| Total valve opening time per shift (sec) | 45 | |
| Annual working days | 330 | |
| Efficiency of the boiler (%) | 70 | |

| | | |
|---|---|---|
| Cost of Fuel (Rs/kg) | 7.04 | |
| Enthalpy of water at 9 kg/cm2 (g) (kCal/kg) | 663 | |
| CV of Fuel (kcal/kg) | 4200 | |
| Allowable TDS in boiler water (ppm) | 3500 | |
| Mandatory blowdown (%) | 6.06 | Actual required |
| Mandatory blowdown (kgs/hr) | 36 | Actual required |
| Valve opening time for each blowdown per hour (sec) | 5 | |
| | | |
| Parameters | Manual Blowdown | Auto Blowdown |
| No of shifts per day (nos) | 2 | 2 |
| Frequency of blowdown per shift (nos) | 1 | Continuous |
| Blowdown time (sec) | 45 | Continuous |
| Total valve opening time per shift (sec) | 45 | Continuous |
| Boiler water blowdown per shift (kgs/shift) | 360 | 291 |
| Boiler water Drained per day (kg) | 720 | 582 |
| Total heat loss per day (kCal) | 477360 | 385745 |
| Total fuel loss per day in Blowdown (kg) | 162 | 131 |
| Fuel cost per day (Rs) | 1143 | 924 |
| Fuel cost per annum (Rs) | 377212 | 304818 |
| Annual Saving with Correct Blowdown (in Lacs) | 0.72 | |
| II - Heat recovery from flash steam | | |
| Parameters | | Values |
| Water pressure at the inlet of the flash vessel (kg/cm2) | | 9 |
| Enthalpy of water at the inlet pressure (kCal/kg) | | 177.5 |
| Flash steam pressure (kg/cm2 (g)) | | 0.5 |
| Enthalpy of water at the inlet pressure (kCal/kg) | | 110.8 |
| Enthalpy of steam at the inlet pressure (kCal/kg) | | 642.8 |
| Waste water quantity from blowdown (kgs/day) | | 582 |
| Recoverable water quantity from blowdown @ 80% (kgs/day) | | 465 |
| Flash steam generated (%) | | 10 |
| Flash steam generated (kgs/day) | | 48 |
| Total heat recovered (kcal/day) | | 31053 |
| Total heat recovered (kcal/year) | | 10247642 |
| Total fuel recovered (kgs/annum) | | 3486 |
| Total cost saving due to flash heat recovery(Lacs/annum) | 0.25 | |
| Total Saving with Automatic Blowdown (Lacs/annum) | 0.969 | |
| **Payback (Months)** | 37 | |

| | | |
|---|---|---|
| **NPV at 70% Debt** | **Rs Lakhs** | **3.54** |
| **IRR (%)** | **%** | **48.48** |
| **TOE Savings** | **TOE** | **1.46** |
| **$TCO_2$ Savings** | **$TCO_2$** | **-** |

**Graph 1: Blow-down discharge w.r.t boiler pressure and blow-down valve size.**

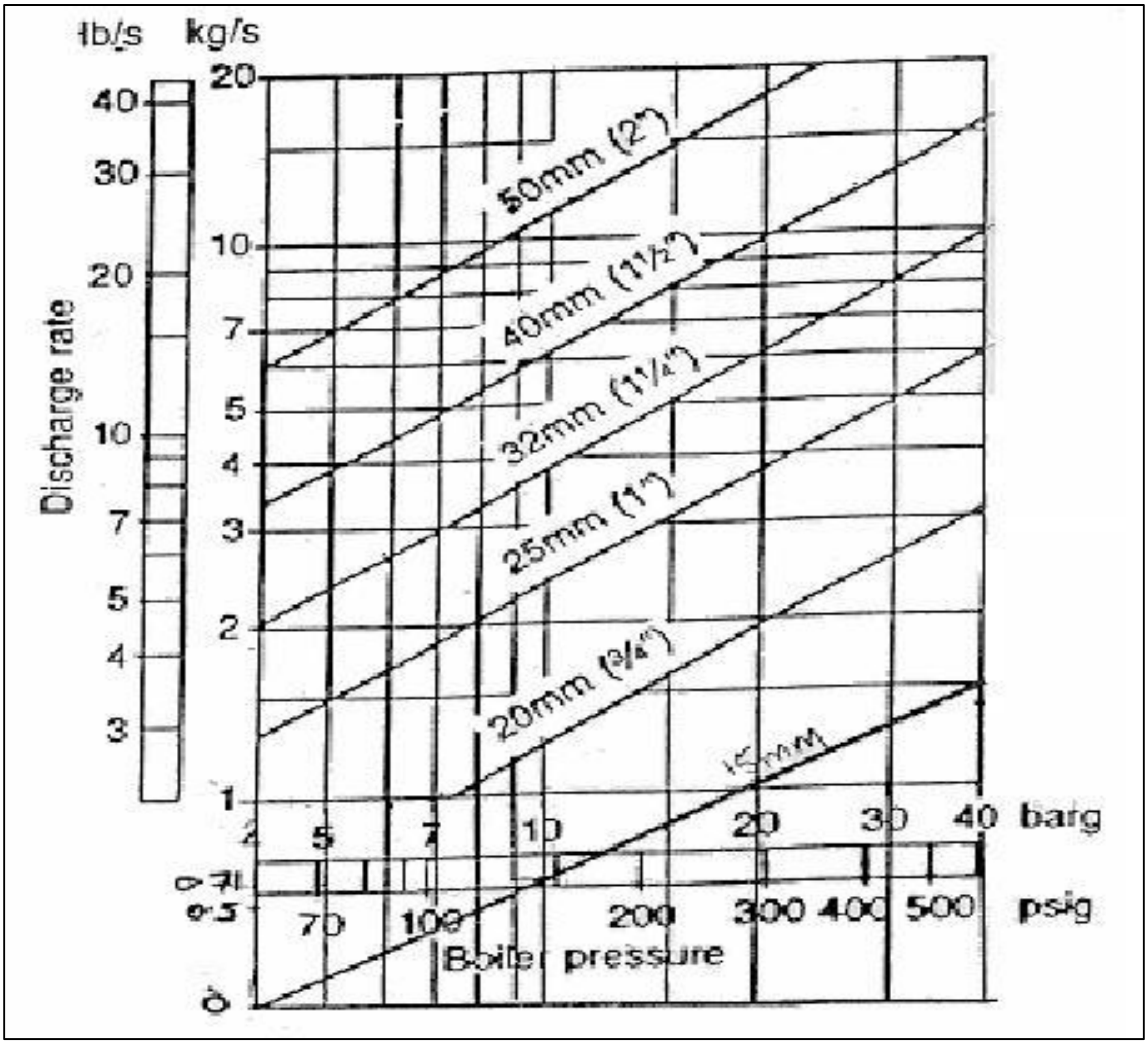



Figure 13 Blow down discharge w.r.t boiler pressure and blow down valve size

## Energy Saving Proposal 2 – Arrest all leakages in the steam system

### Present status

During the audit at Kottayam Plant, a few areas were identified where steam leakage was found due to faulty operations of equipment.

- Gland leakage was found at the inlet isolation valve and the bypass valve of the main Pressure Reducing Station.
- The Thermodynamic Trap of the moisture separator in the main Pressure Reducing Station was also found leaking high pressure steam.

### Recommendation:

It is recommended to replace the glands of leaking valves as an immediate measure. However, for long term, it is recommended to replace the leaking valves, which are standard Globe Valves, with 100% leak proof gland less valves.

The advantages of Glandless Valves are as follows

- These are maintenance free **Globe Valves** with zero leak.
- No need to tighten or replace gland packing
- Smooth hand wheel operation
- Indicating stem design

Secondly, it is recommended to replace the passing Thermodynamic Trap on the Moisture Separator immediately.

### Savings:

Savings potential by Steam leak arrest – Rs. 50,000/- per annum
Required investment - Rs. 10000/-
Payback period - 3 months.

### Savings Calculation:

For a globe valve operating at 8 - 9 Kg/cm2 g pressure, roughly any value between 4 – 8 kg/hr of steam leakage is possible.

Similarly, for a steam trap having 4mm diameter orifice, operating at 8 – 9 kg/cm2 g pressure, and discharging the condensate to atmosphere, approximately 7 to 10 kg/hr of steam loss happens for rapid cycle.

Now considering a minimum 4 kg/hr steam loss from above mentioned points:

Total Steam Loss per annum - 4 kg/hr x 24 hrs x330 days = 32.6 Tonnes of steam

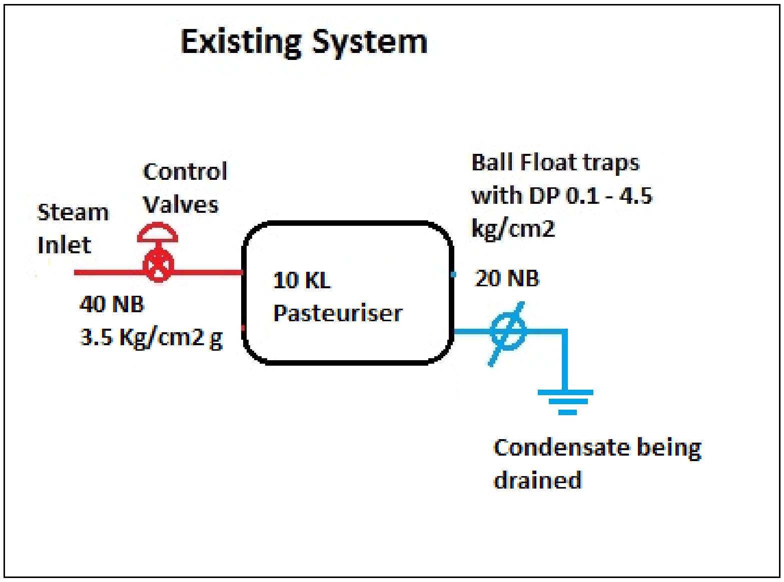
This is equivalent to approximately 7.2 Tonnes of briquette (fuel).

Table 25 Calculation sheet- Leakage arresting

| Parameters | UOM | Value |
|---|---|---|
| Savings Per annum | Lakhs / annum | 0.50 |
| Investment | Rs Lakhs | 0.10 |
| Pay Back | Months | 2 |
| **NPV at 70% Debt** | **Rs Lakhs** | **2.49** |
| **IRR (%)** | **%** | **534** |
| **TOE Savings** | **TOE** | **3.02** |
| **$TCO_2$ Savings** | **$TCO_2$** | **-** |

# Energy Saving Proposal 3 – Install Auto Pumping Trap for 10 KL Pasteuriser Condensate Recovery

## Present System




During the audit at Kottayam Plant, the following were the observations with respect to the operations of 10 KL Milk Pasteuriser:

- Raw milk is heated from 4 degree C to 63 degree C by the way of regeneration in the pasteuriser.
- Pasteurisation temperature is maintained at 76 degree C.
- Pasteurisation temperature is attained by indirect steam heating above 63 degree C to 76 degree C, by using Shell and Tube heat exchanger.
- Incoming steam line size is 40 NB, and steam pressure is 3.5 kg/cm2 g.
- The Steam Control Valve skid is uninsulated.
- 40 NB steam control valve is installed at inlet to Pasteuriser.
- 20 NB Ball float trap is installed in the condensate outlet line of heat exchanger.
- Condensate is being drained out.
- The table below shows the calculation for an approximate steam requirement for 10 KL pasteurisation based on the operating conditions at plant:

Table 26 Steam requirement for pasteurisation

| Parameter | Value | UOM |
|---|---|---|
| **Pasteuriser Milk Delta T required by steam heating** | 14 | deg C |
| **Raw Milk Flow Rate** | 10000 | kg/hr |
| **Heat required** | 140000 | Kcal/hr |

| | | |
|---|---|---|
| **Latent heat at 3.5 bar g** | 506 | Kcal/kg |
| **Thus, minimum steam requirement at 3.5 bar** | 276.68 | Kg/hr |
| **Factor 1.2** | 332.02 | Kg/hr |
| **Operation hours per day** | 6 | hours |
| **Hence, total condensate quantity per day** | 1992.09 | kg/day |

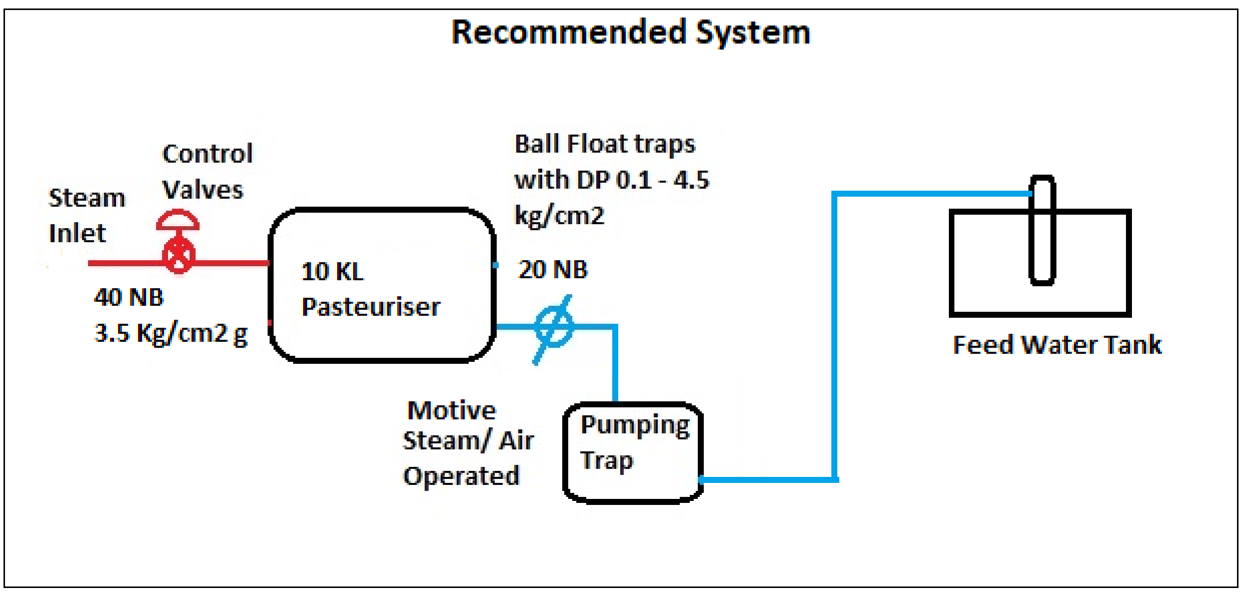
## Recommendation:

It is recommended to recover all the condensate generated out of the Pasteurisation process 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 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.

## System Required:

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



## Operation:

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.

## Savings:

The expected monetary savings by installation of Automatic Pumping Trap system is **Rs 1.83 Lakhs** annually. Investment of **Rs 3.50 lakhs** approximately and payback for the project is **23 months.**

## Savings Calculation

Detailed savings calculations are given in below table

**Table 27 Condensate recovery calculation sheet**

| Parameters | UOM | Value |
|---|---|---|
| Operating Hours | Hrs per day | 6 |
| Operating days per annum | Days/year | 350 |
| Condensate quantity | Kg per day | 1992 |
| Condensate Pressure | Bar g | 0.5 |
| Enthalpy of condensate | Kcal/kg | 110 |
| GCV | kCal/kg | 4200 |
| Fuel Cost | Rs/kg | 7.04 |
| Boiler Efficiency | % | 68 |
| Fuel Saving by Condensate recovery | Kg/day | 75 |
| Savings Per annum | Lakhs / annum | 1.83 |
| Investment | Rs Lakhs | 3.50 |
| Pay Back | Months | 23 |
| **NPV at 70% Debt** | **Rs Lakhs** | **7.67** |
| **IRR (%)** | **%** | **73.43** |
| **TOE Savings** | **TOE** | **11.03** |
| **$TCO_2$ Savings** | **$TCO_2$** | **-** |

## Energy Saving Proposal 4 – Replace Curd Pasteuriser Pre-heater

### Present System

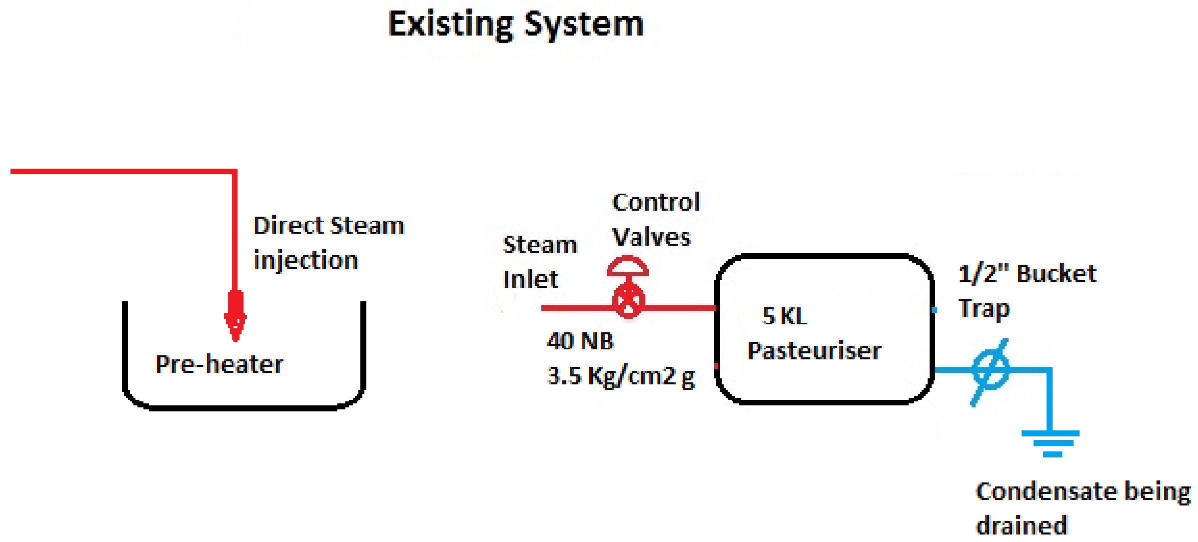



Figure 14 Present Curd pasteuriser system

During the audit at Kottayam plant, the following were the observations with respect to the operations with 5KL Curd Pasteuriser:

- The milk is first pre-heated up to 45 degree C in a separate vessel.
- Direct steam is used to pre-heat, which is an unhygienic and inefficient method of processing.
- The pre-heated milk is then taken to curd pasteuriser and heated up to 93 degree C before taking to incubation room.
- Heating in the Curd Pasteuriser is using a Plate Heat Exchanger and steam at 3.5 Kg/cm2 g is used for indirect heating.
- Inlet steam line is 40 NB, and 15 NB Bucket Trap is installed in the condensate line.
- Condensate is being drained out.
- The process in not operational continuously, the steam requirement at  start up is 3-4 times the steam requirement at normal condition.

- The below table shows the current steam requirement for Curd Pasteurisation

Table 28 Steam requirement for steam pasteurisation

| Parameters | Value | UOM |
|---|---|---|
| Direct Heating | | |
| Milk Delta T required | 40 | deg C |
| Milk Flow Rate | 4500 | Kg/hr |
| Heat required | 180000 | Kcal/hr |
| Steam Pressure | 3.5 | Kg/cm2 g |
| Enthalpy of steam at 3.5 barg | 655 | Kcal/kg |
| Steam required at 3.5 barg | 275 | Kg/hr |
| Factor 1.2 | 330 | Kg/hr |
| Number of batches per day | 1 | batch |

| Parameters | Value | UOM |
|---|---|---|
| **Indirect Heating** | | |
| **Milk Delta T required** | 50 | deg C |
| **Milk Flow Rate** | 4500 | kg/hr |
| **Heat required** | 225000 | Kcal/hr |
| **Steam Pressure** | 3.5 | Kg/cm2 g |
| **Latent Heat of steam at 3.5 bar** | 506 | Kcal/kg |
| **Steam requirement min at 3.5 bar** | 444.66 | Kg/hr |
| **Factor 1.2** | 533.60 | Kg/hr |
| **Pasteuriser operation hours per batch including start up** | 3 | hours |
| **Condensate total per day** | 1600.79 | kg/day |

## Recommendation:

The following are the recommendations at the Curd Pasteurisation Section:

- Replace direct steam injection pre-heating with indirect heating using Plate Heat Exchanger.
- Then, recover condensate from both the heat exchangers of the curd pasteuriser by using automatic pumping trap and take to the feed water tank.

## System Required:

1. Plate Heat Exchanger with Automatic Pumping Trap for pre-heating up to 45 deg C.
2. Install Automatic Pumping Trap at the condensate line of existing PHE.
3. Condensate line from Pasteuriser to feed water tank.
4. Atmospheric De-aerator on feed water tank.

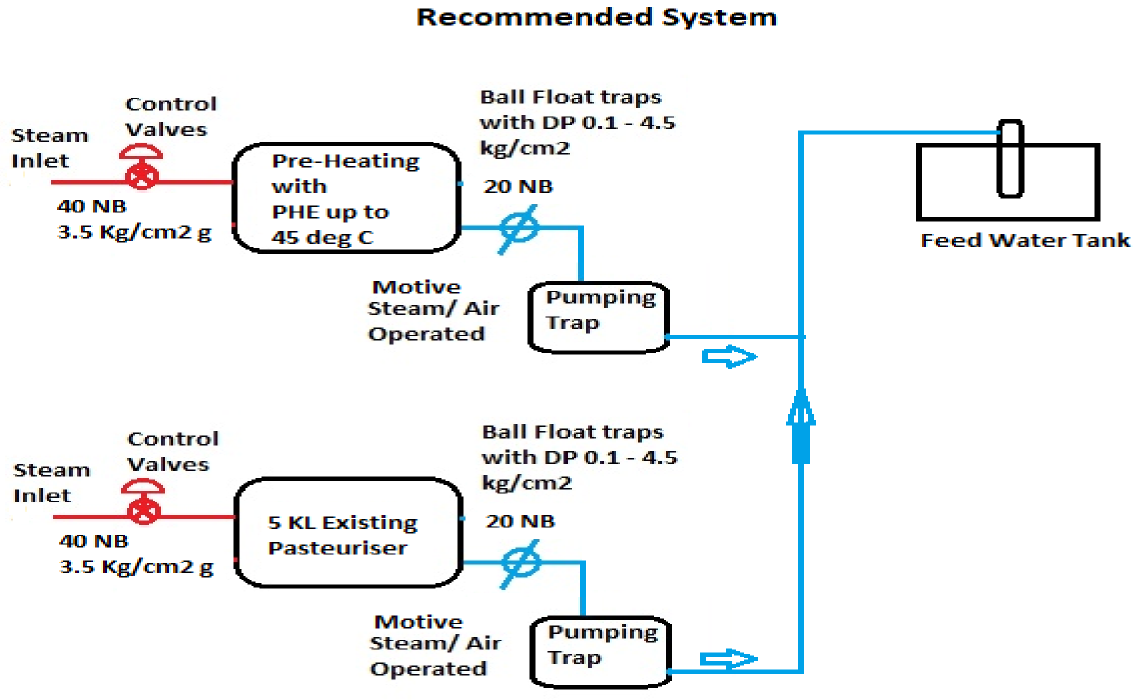



Figure 15 Recommended curd pasteurisation preheater system

## Savings

The expected savings by installation of above system is by the recovery of complete condensate, which is currently being drained out. Detailed savings calculations are given in below table

Table 29 Curd pasteurisation preheater system calculation sheet

| Parameters | UOM | Value |
|---|---|---|
| Saved Condensate quantity | Kg per day | 1900 |
| Condensate Pressure | Bar | 1.5 |
| Enthalpy of condensate | Kcal/kg | 120 |
| GCV | kCal/kg | 4200 |
| Fuel Cost | Rs/kg | 7.04 |
| Boiler Efficiency | % | 68 |
| Fuel Saving by Condensate recovery | Kg/day | 78 |
| Savings Per annum | Lakhs / annum | 2.6 |
| Investment | Rs Lakhs | 9.0 |
| Pay Back | Months | 42 |
| **NPV at 70% Debt** | **Rs Lakhs** | **9.06** |
| **IRR (%)** | **%** | **43.79** |
| **TOE Savings** | **TOE** | **11.47** |
| **$TCO_2$ Savings** | **$TCO_2$** | **-** |

# Energy Saving Proposal 5 – Install Condensate Recovery System for CIP and pump the condensate to Hot Water Tank of CIP

## Present System

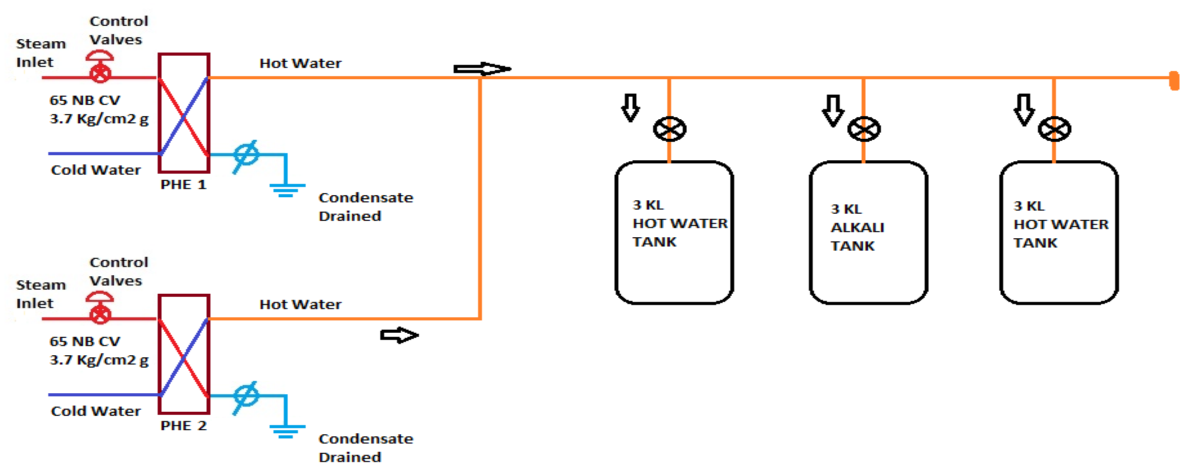



Figure 16 Present condensate flow diagram

During the audit at Kottayam Plant, the following were the observations with respect to operations at the CIP plant:

- The CIP system is used only for Silo washing. Only Lye CIP is happening and not Full CIP.
- There are 3 tanks viz. 3 KL Hot water tank for 90 degree C water, 3 KL alkali at 70 degree C, and 3 KL Hot water for 90 degree C water. Tank 1 & 2 are operated for 2 batches of 20 minutes each, while Tank 3 is operated for 1 batch of 20 minutes.
- 2 numbers of Plate Heat Exchangers are in use for heating water and alkali.
- Steam is available at 3.7 kg/cm2 g pressure at the inlet of Control Valves.
- All the condensate is being drained out.
- The below table shows the approximate steam requirement for the process:

Table 30 Steam requirement sheet

| Parameters | VALUE | UOM |
|---|---|---|
| Hot water delta T requirement in Tank 1 | 60 | deg C |
| Flow per day with 2 times operation | 6000 | kg |
| Heat requirement per day | 360000 | Kcal |
| Steam requirement per day | 711.4625 | Kg |
| Heating time each batch | 20 | mins |
| No. of batches per day | 2 | |
| Steam flowrate required | 1067.194 | Kg/hr |
| Alkaline water delta T requirement in Tank 2 | 40 | deg C |

| | | |
|---|---|---|
| Flow per day with 2 times operations | 6000 | kg |
| Heat requirement per day | **240000** | **Kcal** |
| Steam requirement per day | **474.3083** | **Kg** |
| Heating time each time | **20** | **mins** |
| No. of batches per day | **2** | |
| Steam flowrate required | **711.4625** | **Kg/hr** |
| Acid water del T requirement | **60** | **deg C** |
| Flow per day with 1 times operation | **3000** | **kg** |
| Heat requirement per day | **180000** | **Kcal** |
| Steam requirement per day | **355.7312** | **Kg** |
| Heating time each time | **20** | **mins** |
| No. of batches per day | **1** | |
| Steam flowrate required | **1067.194** | **Kg/hr** |
| CIP Condensate per day which is drained | **1541.502** | **Kg/day** |

## Recommendation:

It is recommended to use the hot condensate in hot water tank by using steam operated condensate recovery system.

## Savings:

The expected savings by installation of above system is by the recovery of complete condensate, which is currently being drained out. Detailed savings calculations are given in below table

Table 31 Condensate recovery calculation sheet

| Parameters | UOM | Value |
|---|---|---|
| Saved Condensate quantity | Kg per day | 1540 |
| Condensate Pressure | Bar g | 1.5 |
| Enthalpy of condensate | Kcal/kg | 120 |
| GCV | kCal/kg | 4200 |
| Fuel Cost | Rs/kg | 7.04 |
| Boiler Efficiency | % | 68 |
| Fuel Saving by Condensate recovery | Kg/day | 63 |
| Savings Per annum | Lakhs / annum | 1.55 |
| Investment | Rs Lakhs | 3.0 |
| Pay Back | Months | 23 |
| **NPV at 70% Debt** | **Rs Lakhs** | **6.48** |
| **IRR (%)** | **%** | **72.69** |
| **TOE Savings** | **TOE** | **9.26** |
| **$TCO_2$ Savings** | **$TCO_2$** | **-** |

# Energy Saving Proposal 6 – Install VFD Control for Refrigeration Compressor

## Present System

Kottayam Plant has installed two number of reciprocating chiller compressors of 60 Hp (33 TR) for the chilled water requirement. The main compressor is running continuously and the second compressor kept as stand by. For the refrigeration purpose vapor compression based ammonia cycle is used. The table below shows the details of existing compressor in the plant:

Table 32 Ammonia compressor measurement sheet

| Parameters | UOM | |
|---|---|---|
| Rated size of compressor | kW | 60 |
| | TR | 33 |
| Power Consumption of Compressor | kW | 33.3 |
| Suction Pressure | bar | 27 |
| Discharge Pressure | bar | 185 |
| Discharge Temperature | ºC | 83 |
| Operating Power | kW | 33.3 |
| Operating TR | TR | 23.8 |
| SEC | kW/TR | 1.40 |

In a refrigeration cycle, when the compressor is run, the refrigerant starts flowing through the system i.e., the system starts it's working. The compressor continuously sucks low pressure, low temperature refrigerant vapors from the evaporator and pump these to condenser at high pressure and high temperature condition. While flowing through the condenser, the high temperature vapors release their heat to atmosphere and condense to high pressure liquid state. After condenser this high-pressure liquid enters the expansion valve where it is throttled to low pressure. 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 vapors, which are again sucked by compressor. In this way all these processes go on continuously and as long as the compressor runs, the system produces cooling around the evaporator.

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 0ºC) 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. But during afternoon 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 install a 75 Hp VFD for the existing reciprocating compressor with suction pressure as the feedback for speed control. Based on the refrigeration load the refrigerant temperature required will varies and hence the suction pressure. During the light load condition ie afternoon 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 achieve the desired temperature, with proper feedback the speed of the compressor can be reduced and hence power savings can be achieved.

## Savings

The expected electricity savings by installation of VFD for chiller compressor is 30,960 units annually. The annual monetary saving for this project is Rs 1.24 Lakhs with an investment of Rs 3.00 lakhs and payback for the project is 29 months.

Detailed savings calculations is given in below table:

**Table 33 VFD installation in ammonia compressor- Measurement sheet**

| Parameters | UOM | |
|---|---|---|
| Size of compressor | kW | 60 |
| | TR | 33 |
| Power Consumption of Compressor | kW | 33.3 |
| Power Savings | % | 10[1] |
| Power Consumption after installing VFD | kW | 30 |
| Power Savings | kW | 3.3 |
| Annual operating hours | hours per year | 8000 |
| Annual Energy Savings | kWh | 26664 |
| Electricity Cost | Rs/kWh | 5.5 |
| Savings per year | Rs Lakhs | 1.47 |
| Investment | Rs Lakhs | 2.7 |

[1] Guaranteed savings by supplier

| | | |
|---|---|---|
| Pay Back | Months | 22 |
| **NPV at 70% Debt** | **Rs Lakhs** | **6.21** |
| **IRR (%)** | **%** | **75.79** |
| **TOE Savings** | **TOE** | **2.3** |
| **$TCO_2$ Savings** | **$TCO_2$** | **21.9** |

## Energy Saving Proposal 7 – Install waste heat recovery from Chiller Compressor

### Present System

Kottayam Plant has installed one 33 TR reciprocating chiller compressors for the chilled water requirement in the plant. Installed compressor is running for 24 hours per day for refrigeration.

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

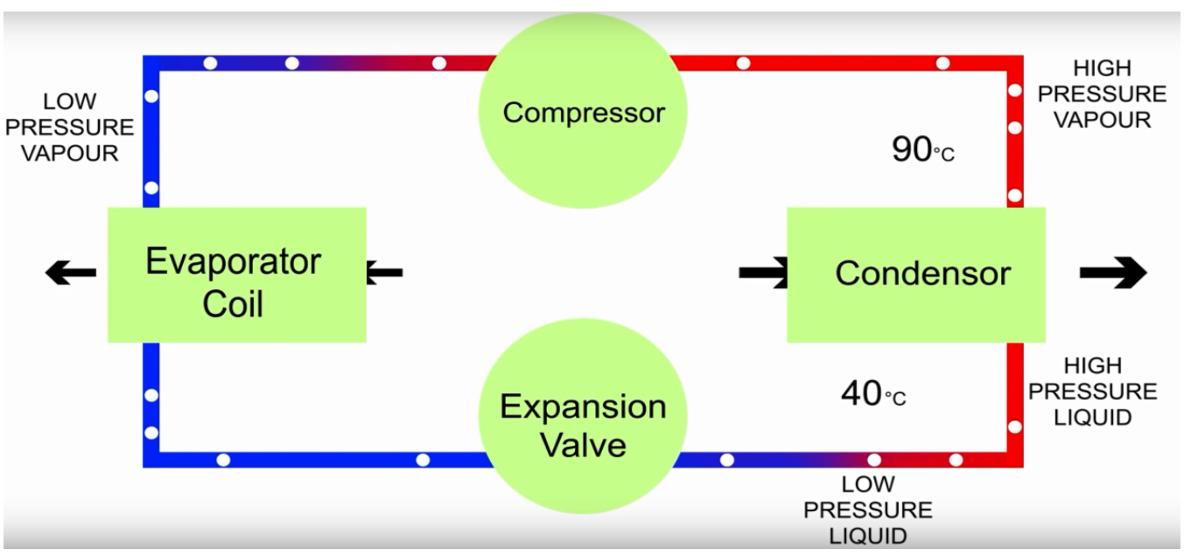



Figure 17 Vapor Compression Cycle 1

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

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

## Recommendation:

De-super heater is proposed to be installed on chiller compressors to harness waste heat of ammonia gas. De superheater is installed on discharge side of $NH_3$ compressor. The temperature of $NH_3$gas observed to be 85-90 °C. This ammonia gas is expected to be cooled to 60°C and the recovered heat will be used to heat water from 30 °C to 70 °C. This hot water is proposed to be used in the boiler feedwater. The design of the de superheater has to ensure that you recover adequate heat with the required temperature lift. Apart from the direct energy saving after getting hot water, the heat load on condenser is expected to come down, and if the design is done appropriately, the condensing pressures can also marginally reduce, leading to reduction in power consumption of compressors.

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

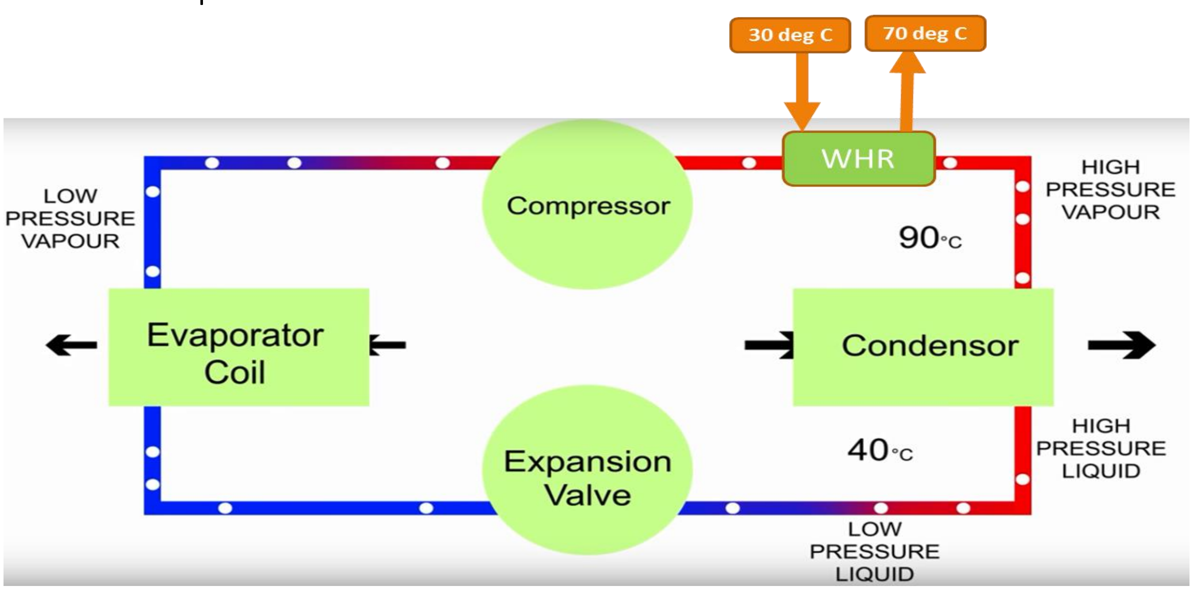



Figure 18 Vapor Compression Cycle 2

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

Table 34: Technical parameters of desuperheater

| Item | Value |
|---|---|
| Temperature of ammonia gas in/out | 85 °C/60 °C |
| Temperature of water in/out | 30°C /70 °C |
| Amount of water that can be heated | 387 litre/hr |
| Heat load recovered | 18 kW |

## Savings

The annual monetary saving for this project is **Rs 2 Lakhs** with an investment of **Rs 3.20 lakhs** and payback for the project is **20 months.**

## Savings Calculation

Detailed savings calculations are given in below table

Table 35: Savings Calculation for waste heat recovery

| Parameters | UOM | |
|---|---|---|
| Size of compressor | kW | 45 |
| Heat Recovery possible | kW | 18 |
| Heat Recovery possible | kCal/hr | 15498 |
| Amount of hot water available for process (from 30°C to 70°C) | litre per hour of water at 70°C | 387 |
| Hours of operation | hours per day | 14 |
| Days of operation | days per year | 365 |
| Total heat recovery possible | kCal/year | 79194780 |
| Cost of Briquette | Rs/kg | 7.04 |
| Calorific value | kCal/kg | 4200 |
| Boiler efficiency | % | 68% |
| Annual Cost Savings | Rs Lakhs | 2 |
| Investment | Rs Lakhs | 3.2 |
| Pay Back | Months | 20 |
| **NPV at 70% Debt** | **Rs Lakhs** | **8.67** |
| **IRR (%)** | **%** | **85.31** |
| **TOE Savings** | **TOE** | **7.92** |

# Energy Saving Proposal 8 – Optimize the operation of cooling units of Cold Storage

## Present System

Kottayam Plant has installed a separate cooling unit for cold storage. There are three cold storage units are there in the pant for storage purpose. In each rooms 2-4 compressors are installed for cooling the room. Details given in below table,

Table 36 Cold room compressor list

| Location | Compressor details | Status |
|---|---|---|
| Cold storage 1 | 2 Fras cold Compressor of 9 TR | one running |
| Cold storage 2 | 4 Scroll Compressor of 5 TR | 2 running |
| Cold storage 2 | 2 Scroll Compressor of 3 TR | 2 running |

Variation of cold room temperature during entire day is given below,

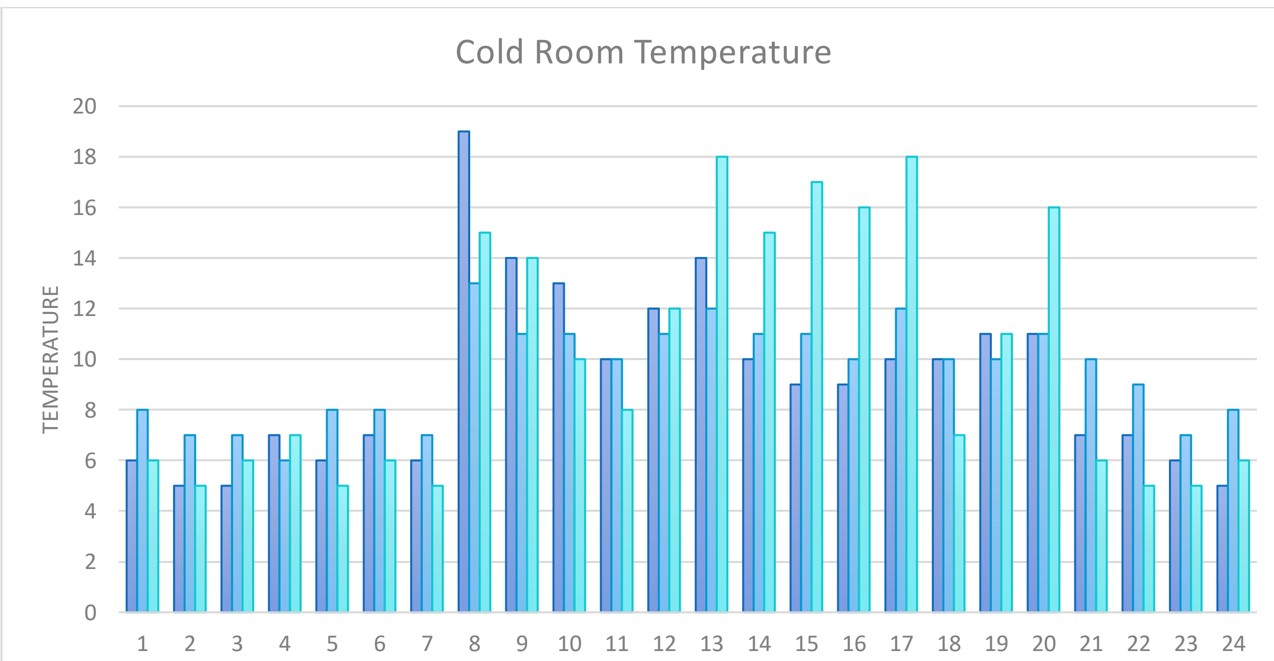



Figure 19 Cold room temperature variation graph

From the above figure, it is observed that plant is maintaining cold room temperature as low as 5 °C during night time. During day time, cold room temperature is raising upto 18 °C.

## Recommendation:

Install VFD Control for Cold Room Units with PLC with cold room temperature as feedback

- Keep 8 °C as the cut off
    - If the temperature goes above 8 °C compressor will run at full speed
- Helps in better and smooth operation of compressor
- PLC helps in bettering monitoring parameters like temperature, pressure so that performance can be analyzed

## Savings

The annual monetary saving for this project is **Rs 1.69 Lakhs** with an investment of **Rs 1.17 lakhs** and payback for the project is **9 months.**

Table 37 Saving calculation- Optimization of cold storage room

| Parameters | UOM | |
|---|---|---|
| Total Power Saving | kW | 3.84 |
| Annual operating hrs | hours | 8000 |
| Annual Energy Savings | kWh | 30727 |
| Electricity Cost | Rs/kWh | 5.5 |
| Savings per year | Rs Lakhs | 1.69 |
| Investment | Rs Lakhs | 1.17 |
| Pay Back | Months | 9 |
| **NPV at 70% Debt** | **Rs Lakhs** | **8.03** |
| **IRR (%)** | **%** | **173.49** |
| **TOE Savings** | **TOE** | **2.64** |
| **$TCO_2$ Savings** | **$TCO_2$** | **25.2** |

# Energy Saving Proposal 9 – Reduce the Generating Pressure of Main Plant Compressor

## Present System

During the course of the energy audit at **Kottayam Dairy Plant,** compressors utilization and distribution was studied in detail for possible energy savings. The plant consumes compressed air average pressure of 6.5 bar for various applications different sections such as process and instrumentation purposes.

| Name | Average Pressure | Required Pressure |
|---|---|---|
| **Main plant Compressor** | 6.5 | 6 |

All applications required a pressure of 6.00 bar or less. But the plant compressor loading pressure is 6 bar and unloading pressure is 7 bar.

The operating pressure of the compressor is directly proportional to the power consumed by the compressor.

Thus there is good potential to reduce the generation pressure further.

This proposal has been implemented in many industries and is common practice.

## Recommendation:

It is recommended to reduce the generation pressure of compressor in steps of 0.1-0.2 bar and check the performance. Try to bring down the generation pressure to 6 bar and reduce the settings further if possible, without affecting the process.

## Savings

The annual savings potential is **Rs. 0.11 Lakhs** shall be achieved. This doesn't require any investment.

## Savings Calculation

**Table 38 Pressure reduction in compressor- calculation sheet**

| Parameters | UOM | |
|---|---|---|
| Compressor type | | Screw |
| Percentage loading | % | 29.28 |
| Percentage unloading | % | 70.72 |
| Average pressure | Bar | 6.5 |
| Loading power | kW | 14 |
| Unloading power | kW | 4.8 |
| Suggested pressure after reduction | Bar | 6 |
| Percentage reduction | % | 6.67 |
| Power savings | kW | 0.27 |

| | | |
|---|---|---|
| Operating hours | Hrs/annum | 7000 |
| Annual savings | Rs Lakhs | 0.105 |
| Investment | Rs Lakhs | Nil |
| **TOE Savings** | **TOE** | 0.16 |

# Energy Saving Proposal 10 – Operate the VFD of Main Plant Compressor in Closed Loop

## Present System

During the course of the energy audit at **Kottayam Dairy Plant,** detailed study was carried out on all the compressors in the plant and explored for further capacity optimization and thus power saving with the help of VFD.

During the it is observed that VFD is installed in the compressor and is running in open loop.

Table 39 Main plant compressor measurement sheet

| TAG NO. | Running hrs | Average pressure | Loading % | Unloading % | Loading Power (kW) | Unloading Power (kW) |
|---|---|---|---|---|---|---|
| Main Plant Compressor | 8000 | 6.5 | 29 | 71 | 14 | 4.8 |

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

The unload time indicates excess capacity of the compressor. There is a good potential to optimize the capacity of the compressors. The capacity of the compressors can be optimized by operating VFD in closed loop.

With conventional control for maintaining a required average pressure, certain loading and unloading point has to be set. It is represented by the following graph.

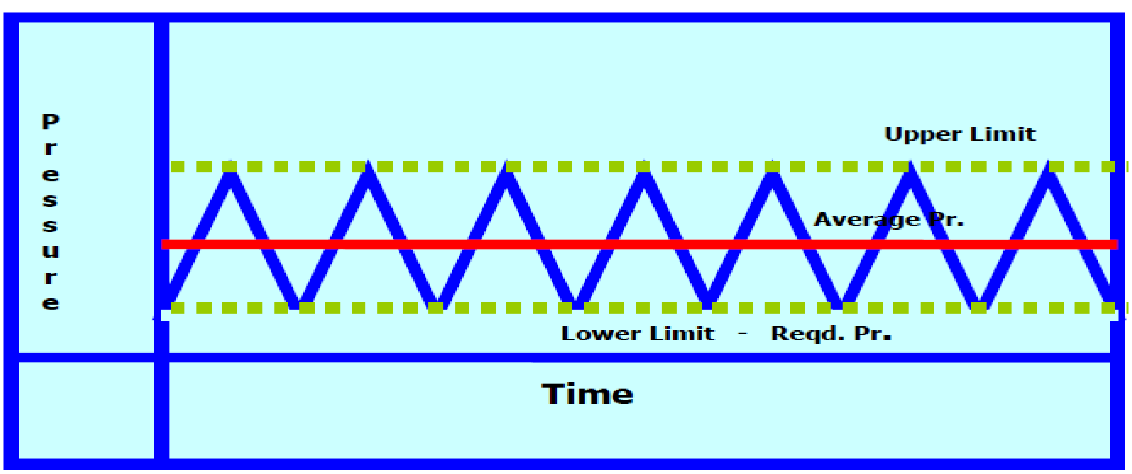



Figure 20 Conventional control

By installing VFD the average operating pressure can be set at ±0.1 bar of the required pressure. It can also avoid the unloading of the compressor also. The graphical representation is show below.

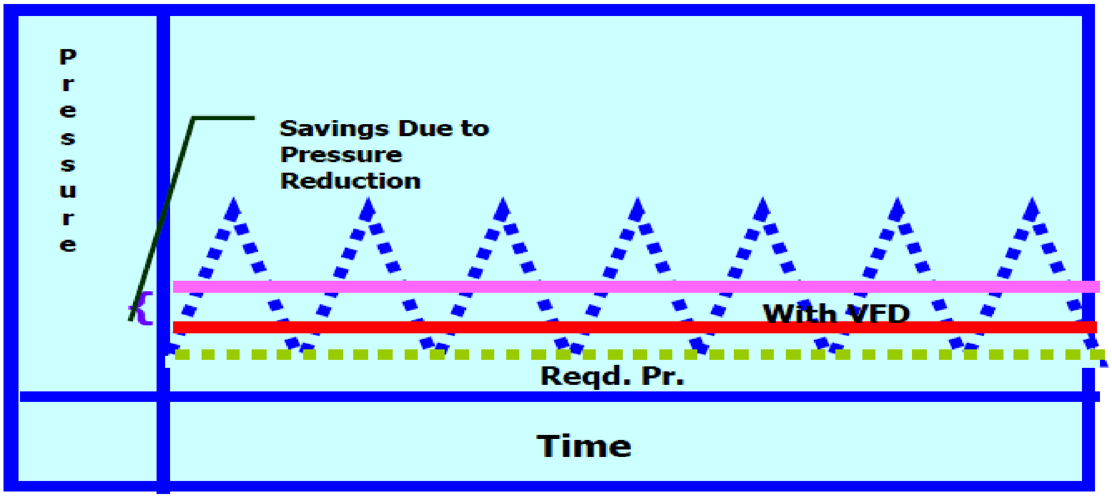



Figure 21 VFD control

## Recommendation:

It is recommended to operate VFD in closed loop for the compressors to avoid the unloading of the compressors. The feedback for VFD can be given as required receiver pressure.

## Savings

The annual energy saving potential by optimizing the compressor operation using VFD would result in annual savings of Rs**. 1.49 Lakhs**. This doesn't require any investment since VFD is already installed in the compressor.

| Parameters | UOM | |
|---|---|---|
| Total Power Saving | kW | 3.39 |
| Annual operating hrs | hours | 8000 |
| Annual Energy Savings | kWh | 27091 |
| Electricity Cost | Rs/kWh | 5.5 |
| Savings per year | Rs Lakhs | 1.49 |
| Investment | Rs Lakhs | - |
| Pay Back | Months | - |
| **NPV at 70% Debt** | **Rs Lakhs** | **7.55** |
| **IRR (%)** | **%** | **-** |
| **TOE Savings** | **TOE** | **2.33** |
| **$TCO_2$ Savings** | **$TCO_2$** | **22.2** |

# Energy Saving Proposal 11 – Install VFD for Aeration Blower

## Present System

During the course of the energy audit at **Kottayam Dairy Plant,** detailed study was carried out on all the blowers in the plant and explored for further capacity optimization and thus power saving with the help of VFD. Detailed measurement is given below,

Table 40 Aeration blower measurement sheet

| TAG NO. | Running hrs | Average pressure | Operating power | Power Savings |
|---|---|---|---|---|
| Aeration blower | 8000 | 0.35 | 5.76 | 1.16 |

Aeration Blower is installed to maintain BOD level of treated water at ETP. Currently aeration blower is running continuously and No meter to sense the BOD of water

## Recommendation:

- Install BOD meter and sensor to monitor BOD level
- Install VFD for the blower
- Give BOD as feedback for VFD

## Savings

The annual energy saving potential by optimizing the blower operation using VFD would result in annual savings of Rs**. 0.51 Lakhs**. This require an investment of **1 Lakhs** for investing VFD and the simple payback for the proposal will be **24 months**

Table 41 Savings calculation - Installation of VFD in blower

| Parameters | UOM | |
|---|---|---|
| Total Power Saving | kW | 1.16 |
| Annual operating hrs | hours | 8000 |
| Annual Energy Savings | kWh | 9273 |
| Electricity Cost | Rs/kWh | 5.5 |
| Savings per year | Rs Lakhs | 0.51 |
| Investment | Rs Lakhs | 1 |
| Pay Back | Months | 24 |
| **NPV at 70% Debt** | **Rs Lakhs** | **2.13** |
| **IRR (%)** | **%** | **71.9** |
| **TOE Savings** | **TOE** | **0.80** |
| **$TCO_2$ Savings** | **$TCO_2$** | 7.6 |

# Energy Saving Proposal 12 – Replace low efficiency Chilled Water Pump with high efficiency pump

## Present System

CPD, Kottayam has installed two chilled water pumps for pumping chilled water from IBT to process in which one is running and others are standby. The chilled water is mainly used in pasteurization process and pre chiller where the milk is cooled to 4°C. The figure below shows the schematic of chilled water system in the plant.

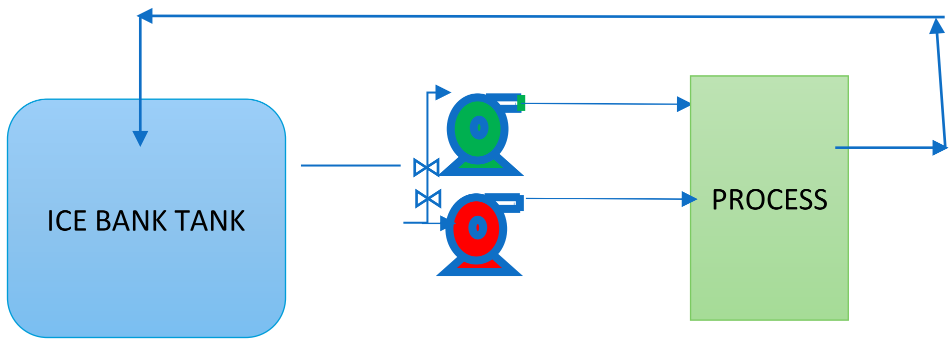



**Figure 22: Schematic of chilled water pump**

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 6.4 kW pump. Chilled water is mainly used in the pre chiller – cool the incoming milk received from Bulk Milk Coolers by tankers to 4°C to 5°C before going to pasteurization process and also in pasteurization process to cool the milk to 4°C. After the process the return water is coming at 6°C to 8°C The table below shows the details of chilled water pumps performance installed in the plant.

**Table 42: Pump Performance**

| Parameters | UOM | Design | Chilled water pump 1 | Chilled water pump 2 |
|---|---|---|---|---|
| Power Consumption | kW | 6.4 | 5.2 | 4.9 |
| Flow | $m^3$/hr | 72 | 38 | 25 |
| Head | m | 19.5 | 20 | 20 |
| Efficiency | % | 61 | 46.86 | 32.71 |

The design efficiency of the pump is 61 %. 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 pumps are 33 % & 47 % 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 pumps are given in the below table:

Table 43: Proposed pump parameters

| Parameters | UOM | Present | Proposed Pump Design |
|---|---|---|---|
| Power Consumption | kW | 6.4 | 5.2 |
| Flow | $m^3$/hr | 72 | 45 |
| Head | m | 19.5 | 20 |
| Efficiency | % | 61 | 65 |

## Savings

Annual monetary saving for this project is **Rs 0.48 Lakhs with an investment of Rs 0.65 lakhs and payback for the project is 17 months.**

Savings calculation is given in the below table:

Table 44: Savings calculation for EE chilled water pump

| Parameters | UOM | Present | Proposed Operating Condition |
|---|---|---|---|
| Power Consumption | kW | 5.2 | 5.2 |
| Flow | m3/hr | 38 | 45 |
| Head | m | 20 | 20 |
| Efficiency | % | 46.8 | 65 |
| Power Savings | kW | 1.1 | |
| Electricity Cost | Rs/kWh | 5.5 | |
| Operating hrs | hrs/year | 8000 | |

| | | |
|---|---|---|
| Energy Savings | kWH | 8800 |
| Cost Savings | Rs Lakhs | 0.48 |
| Investment | Rs Lakhs | 0.65 |
| Pay Back | Months | 16 |
| **NPV at 70% Debt** | **Rs Lakhs** | **2.13** |
| **IRR (%)** | **%** | **98.11** |
| **TOE Savings** | **TOE** | **0.75** |
| **$TCO_2$ Savings** | **$TCO_2$** | **7.22** |

# Energy Saving Proposal 13 – Replace Identified motors with Energy Efficient Motors

## Present Status

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

Table 45: Measurements of motor to be replaced

| Section | Rated kW | Running Power | Loading |
|---|---|---|---|
| Condenser Pump | 5.5 | 4.5 | 64 |
| Aeration Blower | 5.5 | 5.7 | 83 |
| Compressor Ammonia | 45 | 33.33 | 61 |

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

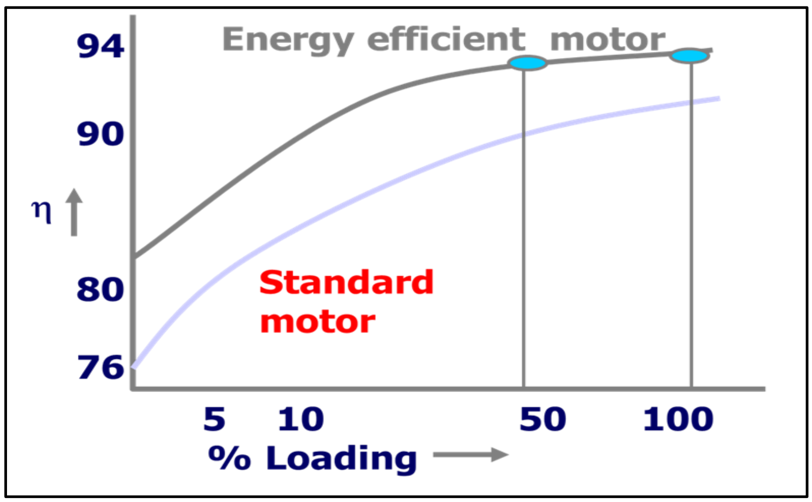


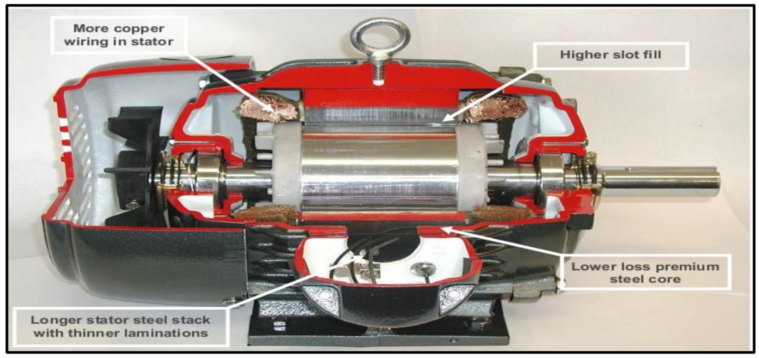

Figure 23: Loading Vs Efficiency curve

## Recommendation

It is recommended to replace identified low efficiency motors 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.

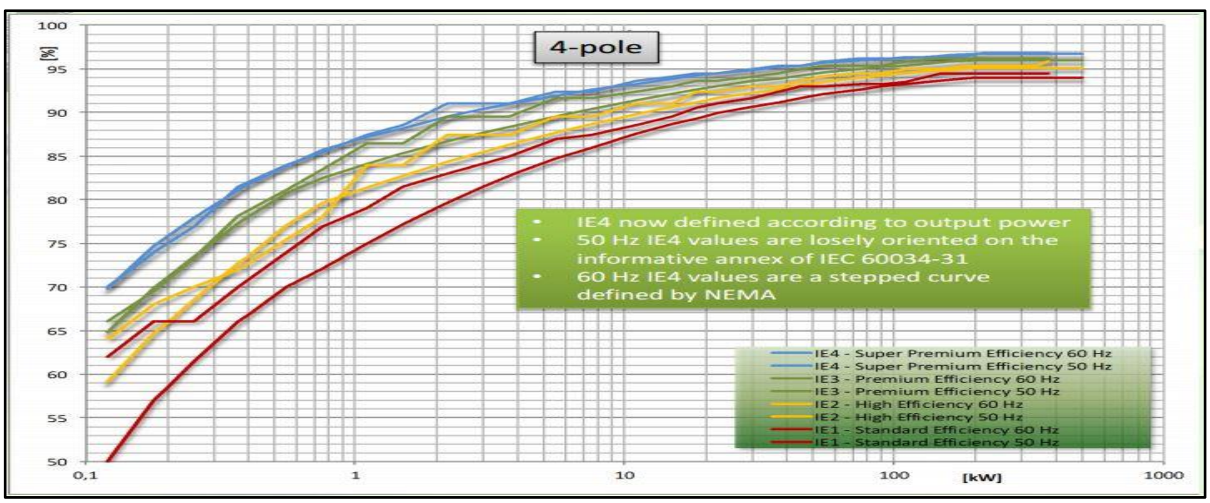
The motors also retain more or less the same efficiencies in the range of 50-100% loading. The figure below shows the features of energy efficient motor.

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




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 |




## Savings

The annual monetary saving for this project is **Rs 2.18 Lakhs** with an investment of **Rs 3.36 Lakhs** and payback for the project is **18 months.**

Table 46: Saving calculation for EE Motors

| Parameters | UOM | Condenser Pump | Aeration Blower | Compressor Ammonia |
|---|---|---|---|---|
| Rating of Motor | kW | 5.5 | 5.5 | 45 |
| Power Consumption | kW | 4.5 | 5.7 | 33.3 |
| Current Efficiency | % | 82 | 82 | 82 |
| Proposed Efficiency | % | 92 | 92 | 90 |
| Total Power Saving based on improved efficiency | kW | 0.60 | 0.76 | 3.61 |
| Annual operating hrs | hours | 8000 | 8000 | 8000 |
| Annual Energy Savings | kWh | 4772 | 6045 | 28904 |
| Electricity Cost | Rs/kWh | 5.5 | 5.5 | 5.5 |
| Savings per year | Rs Lakhs | 0.26 | 0.33 | 1.59 |
| Investment | Rs Lakhs | 0.33 | 0.33 | 2.7 |
| Pay Back | Months | 15 | 12 | 20 |
| **NPV at 70% Debt** | **Rs Lakhs** | **1.17** | **1.52** | **6.82** |
| **IRR (%)** | **%** | **103.59** | **126.64** | **81.15** |
| **TOE Savings** | **TOE** | **0.41** | **0.52** | **2.49** |
| **$TCO_2$ Savings** | **$TCO_2$** | **3.91** | **4.96** | **23.70** |

# Energy Saving Proposal 14 – Install Energy Saver for Split AC's

## Present Status

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

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

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

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

Table 47: List of AC units

| S.No | Capacity of AC units | Power, kW | Nos. |
|---|---|---|---|
| 1 | 1.5 TR | 1.7 | 4 |

## 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.

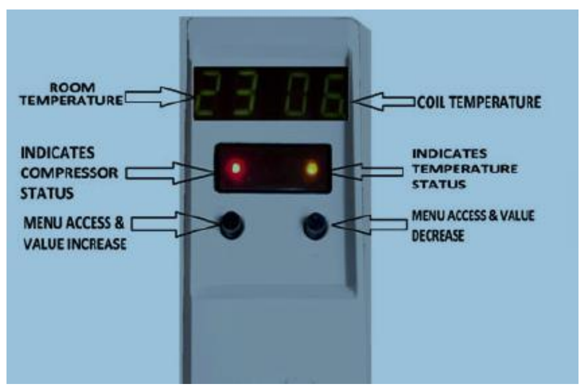



Figure 25: AC Remote controller

## Savings

The expected saving after installation of AC energy saver is 4080 units annually. The annual monetary saving for this project is **Rs 0.22 Lakhs** with an investment of **Rs 0.24 Lakhs** and payback for the project is **13 months.**

Table 48: Saving calculation for AC Energy Saver

| Parameters | UOM | |
|---|---|---|
| Total No of AC Units | Nos | 4 |
| Total AC units power consumption | kW | 6.8 |
| Conservative Power Saving after AC energy saver(15% Saving) | kW | 1.02 |
| Annual operating hrs | hours | 4000 |
| Annual Energy Savings | kWh | 4080 |
| Electricity Cost | Rs/kWh | 5.5 |
| Savings per year | Rs Lakhs | 0.2244 |
| Investment | Rs Lakhs | 0.24 |
| Pay Back | Months | 13 |
| **NPV at 70% Debt** | **Rs Lakhs** | **1.01** |
| **IRR (%)** | **%** | **121.96** |
| **TOE Savings** | **TOE** | **0.34** |
| **$TCO_2$ Savings** | **$TCO_2$** | **3.3** |

# Energy Saving Proposal 15 – Install Energy Efficient BLDC fans in Plant

## Present System

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

Table 49: List of fans

| Sl No. | No of Fans | Power Consumption per fan (Watts) | Total Power (kW) |
|---|---|---|---|
| 1 | 30 | 75 | 2.25 |

## 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.

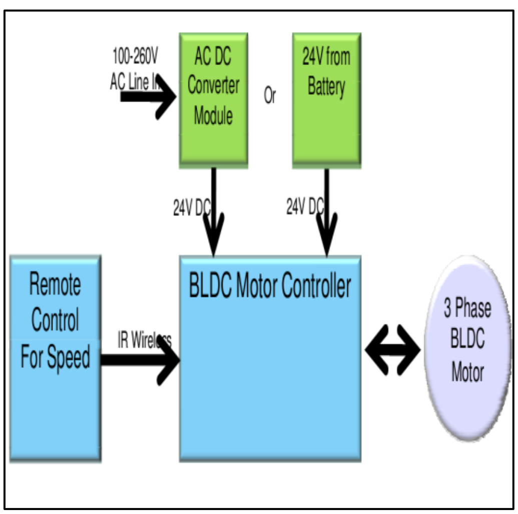



Figure 27: Schematic of BLDC fan

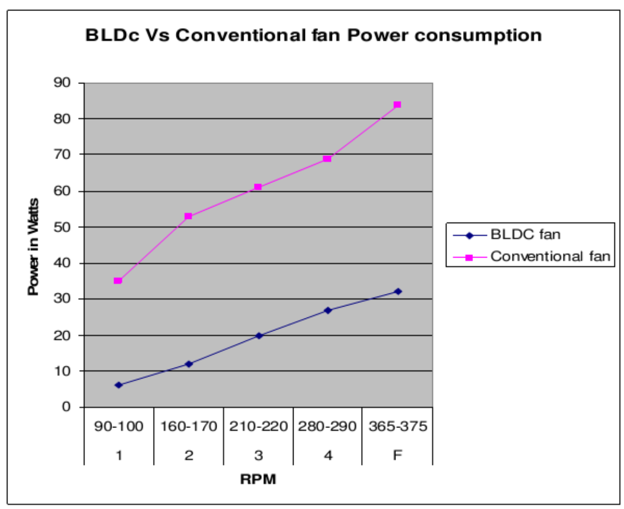



Figure 26: Comparison of normal fan vs BLDC fan

## Savings

The expected savings by installation of BLDC fans is 4909 units annually. The annual monetary saving for this project is **Rs 0.27 Lakhs** with an investment of **Rs 0.75 lakhs** and payback for the project is **33 months**.

Detailed savings calculations are given in below table

**Table 50: Calculations for BLDC Fan**

| Parameters | UOM | |
|---|---|---|
| No of Fans | Nos | 30 |
| Conventional Fan power | Watts | 75 |
| Total Power | kW | 2.25 |
| BLDC Fan Power | Watts | 0.9 |
| BLDC Fan Power | kW | 1.35 |
| Electricity Cost | Rs/kWh | 5.5 |
| Annual Energy Savings | kWh | 4927.5 |
| Annual Cost Savings | Rs Lakhs | 0.27 |
| Investment | Rs Lakhs | 0.75 |
| Pay Back | Months | 33 |
| **NPV at 70% Debt** | **Rs Lakhs** | **1.02** |
| **IRR (%)** | **%** | **53.32** |
| **TOE Savings** | **TOE** | **0.42** |
| **$TCO_2$ Savings** | **$TCO_2$** | **4** |

# Energy Saving Proposal 16 – Install 30 kWp Solar Roof Top

## Present Status

CPD Kottayam is purchasing electricity from grid for the operation of various equipment's in the plant. The contract demand of the plant is 650 kVA with electricity price of Rs 5.5/kWh with an average load of 200 kW to 250 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 51: Site Specifications

| Parameters | |
|---|---|
| Effective Rooftop available ,sq ft | 3000 |
| Location | Latitude: - 09° 55' N<br>Longitude: - 76° 55' E |
| Altitude above sea level, m | 3 |
| Annual in plane irradiation | 4.97 kWh/m²/day |

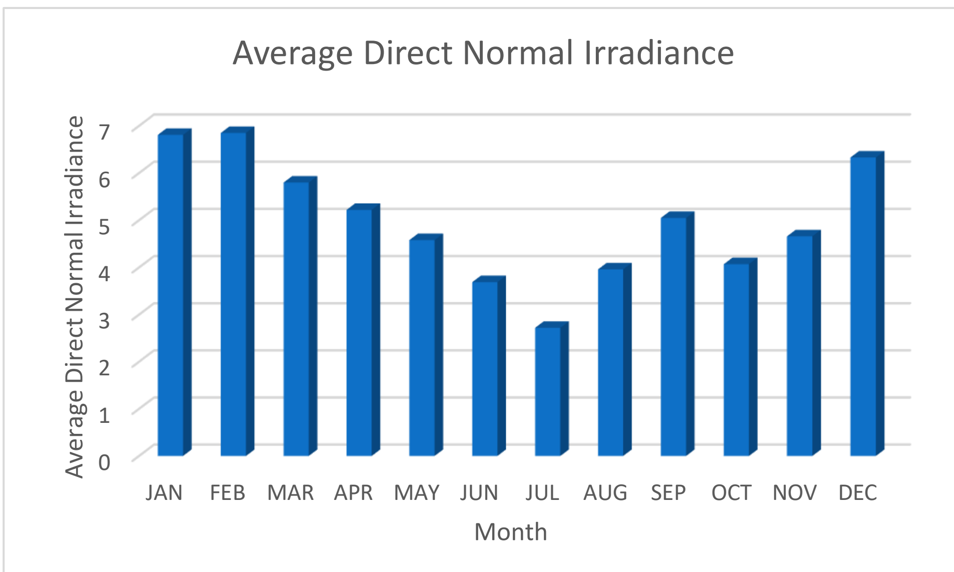



Figure 28 Average Normal Irradiance- Kottayam

### Net Metering Business Model

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

## Recommendation

As per the site feasibility study it was found that plant can install a 30 kWp Solar PV power plant which will generate an average of around 0.45 Lakhs electrical units annually. It is a grid connected net metering based rooftop solar system which is a new concept for MSME industries And in grid connected rooftop or small SPV system, the DC power generated from SPV panel is converted to AC power using power converter and is fed to the grid either of 33 kV/11 kV three phase lines or of 440V/220V three/single phase line depending on the local technical and legal requirements. These systems generate power during the day time which is utilized by powering captive loads and feed excess power to the grid. In case, when power generated is not sufficient, the captive loads are served by drawing power from the grid.

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

## Savings

The expected savings by installation of 30 kWp solar roof top is 43800 units of electricity annually. The annual monetary saving for this project is **Rs 2.4 Lakhs** with an investment of **Rs 15.00 lakhs** and payback for the project is **75 months.**

Detailed savings calculations is given in below table

**Table 52: Savings calculation for solar roof top**

| Parameters | UOM | |
|---|---|---|
| Proposed Roof top Solar installation | kW | 30 |
| Area Available at Roof | Sq.ft | 3000 |
| Annual units generation per kW of Solar PV | kWh per kW/year | 1460 |
| Total Energy Generation Per Annum | kWh/year | 43800 |

| | | |
|---|---|---|
| Electricity Cost | Rs/kWh | 5.5 |
| Cost Savings | Rs Lakhs | 2.4 |
| Investment | Rs Lakhs | 15 |
| Payback period | Months | 75 |
| **NPV at 70% Debt** | **Rs Lakhs** | **5.3** |
| **IRR (%)** | **%** | **24.05** |
| **TOE Savings** | **TOE** | **3.75** |
| **$TCO_2$ Savings** | **$TCO_2$** | **35.8** |

# 5. MANAGEMENT ASPECTS AND CONCLUSIONS

**THE OBJECTIVES OF KOTTAYAM 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

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

We would recommend Kottayam 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, Kottayam 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

- Kottayam Dairy Main Plant and CII – Godrej GBC teams have jointly identified **16** energy saving proposals worth an annual saving potential of **Rs. 20.26 Lakhs**. The investment required for implementation of energy saving proposals is **Rs. 46.66 Lakhs**. The total investment will have a simple payback period of **28 months**

Table 53: Summary of savings

| Details | No. of Proposals | Rs In Lakhs |
|---|---|---|
| Total Annual savings | 16 | 20.26 |
| Annual savings without investment | 2 | 1.56 |
| Annual savings with investment | 14 | 18.70 |
| Investment required | 14 | 46.66 |
| Simple Pay Back | Months | 30 |

Table 54: Summary of fuel savings

| Details | UOM | Annual savings |
|---|---|---|
| Total Electricity Savings | kWh | 196636 |
| Total Fuel Savings (Briquette) | kgs | 105142 |
| Annual TOE Savings | TOE | 61.10 |
| Annual $MTCO_2$ | $MTCO_2$ | 161.20 |

Table 55: Summary of Energy Saving Proposals

| Sl. No. | ECM | Annual savings (lakhs) | Invest ment (lakhs) | Payback | Electricity Savings (kWh) | Fuel Savings (Briquette) | TOE savings | TCO2 saving s |
|---|---|---|---|---|---|---|---|---|
| 1 | Install of Automatic Blow-down System | 0.97 | 3 | 37 | - | 3486 | 1.46 | - |
| 2 | Arrest all leakages in the steam system. | 0.5 | 0.1 | 2 | - | 7200 | 3.02 | - |
| 3 | Install Auto Pumping Trap for 10 KL Pasteuriser Condensate Recovery | 1.83 | 3.5 | 23 | - | 26250 | 11.03 | - |
| 4 | Curd Pasteuriser Pre-heater replacement | 2.60 | 9 | 42 | - | 27300 | 11.47 | - |
| 5 | Install Condensate Recovery System for CIP and pump the condensate to Hot Water Tank of CIP | 1.55 | 3 | 23 | - | 22050 | 9.26 | - |
| 6 | Install VFD Control for Refrigeration Compressor | 1.47 | 2.7 | 22 | 26727 | | 2.30 | 21.9 |
| 7 | Install waste heat recovery from Chiller Compressor | 2.00 | 3.2 | 19 | - | 18856 | 7.92 | 0.0 |
| 8 | Optimize the operation of cooling units of Cold Storage | 1.69 | 1.17 | 8 | 30727 | - | 2.64 | 25.2 |
| 9 | Reduce the Generating Pressure of Main Plant Compressor | 0.105 | 0 | 0 | 1909 | - | 0.16 | 1.6 |
| 10 | Operate the VFD of Main Plant Compressor in Closed Loop | 1.49 | 0 | 0 | 27091 | - | 2.33 | 22.2 |
| 11 | Install VFD for Aeration Blower | 0.51 | 1 | 24 | 9273 | - | 0.80 | 7.6 |
| 12 | Replace low efficiency Chilled Water Pump with high efficiency pump | 0.48 | 0.65 | 16 | 8727 | - | 0.75 | 7.2 |
| 13 | Replace Identified motors with Energy Efficient Motors | 2.18 | 3.36 | 18 | 39636 | - | 3.41 | 32.5 |
| 14 | Install Energy Saver for Split AC's | 0.22 | 0.23 | 13 | 4000 | - | 0.34 | 3.3 |
| 15 | Install Energy Efficient BLDC fans in Plant | 0.27 | 0.75 | 33 | 4909 | - | 0.42 | 4.0 |
| 16 | Install 30 kWp Solar Roof Top | 2.4 | 15 | 75 | 43636 | - | 3.75 | 35.8 |
| | Total | 20.265 | 46.66 | 28 | 196636 | 105142 | 61.1 | 161.2 |

## 5.7 Kottayam 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 | Area | Parameter | Purpose | Monitoring Method | Measurement Unit | Measurement | Reference Range | Actual Operating Value |
|---|---|---|---|---|---|---|---|---|---|
| 1 | BOILER - STEAM & CONDENSATE | STEAM GENERATION | Steam Pressure | For quality of steam produced | By using Pressure Gauge at MSV outlet | Kg/cm2 g | Hourly | Nearer to boiler rated pressure | |
| | | | Steam 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 | For proper fuel combustion | 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 | Kg Steam / Kg Fuel | 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 | |
| | | | | | | | | | |
| | | STEAM DISTRIBUTION | Main Steam line Traps conditions | For any trap leakage / choking | Visual | - | Weekly | Zero Tolerance | |
| | | | Main steam line valves conditions | For any gland / internal leakage | Visual / Using IR Temperature Gun | - | Weekly | Zero Tolerance | |
| | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **STEAM UTILIZATION** | 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 | |
| | | | | | | | | | |
| | | **CONDENSATE RECOVERY** | Process equipment steam traps conditions | For any trap leakage / choking | Visual / Using IR Temperature Gun | - | Weekly | Zero Tolerance | |
| | | | Feed Water temperature | For better boiler operation | By Using Thermocouple | Deg C | Hourly | Above 85 deg C | |
| | | | | | | | | | |
| 2 | **REFRIGERATION SYSTEM** | **CHILLED WATER** | Chilled Water Supply Temperature | For estimating cooling load | Using IR Temperature gun / EMS | Deg C | Hourly | As per plant operations | |
| | | | Chilled Water Return Temperature | For estimating cooling load | Using IR Temperature gun / EMS | Deg C | Hourly | As per plant operations | |
| | | | Difference in Chilled Water supply & return | For estimating cooling load | Using IR Temperature gun / EMS | Deg C | Hourly | As per plant operations | |
| | | | | | | | | | |
| | | **CONDENSER WATER** | Condenser Water supply Temperature | For estimating heat rejection | Using IR Temperature gun / EMS | Deg C | Hourly | As per plant operations | |
| | | | Condenser Water return Temperature | For estimating heat rejection | Using IR Temperature gun / EMS | Deg C | Hourly | As per plant operations | |
| | | | Difference in Condenser water suppy & return | For estimating heat rejection | Using IR Temperature gun / EMS | Deg C | Hourly | As per plant operations | |
| | | | | | | | | | |
| | | **COOLING TOWER** | 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 | For comparison of CT performance | Using IR Temperature gun / EMS | Deg C | Bi-weekly | 3 - 4 deg C | |
| | | | | | | | | | |
| | | **REFRIGERATION COMPRESSOR** | Suction Pressure | For compressor performance | Pressure Guage | Kg/cm2 g | Hourly | As per capacity of compressor | |
| | | | Discharge Pressure | For compressor performance | Pressure Guage | Kg/cm2 g | Hourly | As per capacity of compressor | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Discharge Temperature | For compressor performance | Thermocouple | Deg C | Hourly | As per capacity of compressor | |
| | | | SEC Value | For compressor performance | Power Consumption per TR delivered | 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 | |
| | | | | | | | | | |
| | | **ELECTRICAL** | Electrical input to individual Compressors | For power input estimates | Using Power Analyzer / Panel / EMS | kW | Hourly | Dependent on load | |
| | | | Electrical input to individual Condenser pumps | For power input estimates | Using Power Analyzer / Panel / EMS | kW | Hourly | Dependent on load | |
| | | | Electrical input to individual Chilled Water pumps | For power input estimates | Using Power Analyzer / Panel / EMS | kW | Hourly | Dependent on load | |
| | | | Electrical input to Cooling Tower Fans | For power input estimates | Using Power Analyzer / Panel / EMS | kW | Hourly | Dependent on load | |
| 3 | **Compressed Air System** | **GENERATION** | Generation Pressure | For keeping lowest pressure possible | Using Pressure gauge at discharge line / Panel | Kg/cm2 g | Hourly | Closest possible to user requirement | |
| | | | Loading % | For proper planning of usage | From Panel / By manually noting time | % | Per Shift | 7 0 - 90% | |
| | | | Unloading % | For proper planning of usage | From Panel / By manually noting time | % | Per Shift | 10 - 30 % | |
| | | | Air Flow Rate | For compressor performance | From Panel | CFM | Per Shift | Dependent on demand | |
| | | | Electrical Energy input to Compressor | For compressor performance | Using Power Analyzer / Panel | kW | Per Shift | Dependent on compressor performance | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | SEC Value | For compressor performance | Power Consumption per unit Air Flow | kW/CFM | Per Shift | 0.18 KW/CFM for Screw Compressors 0.14 KW/CFM for Reciprocating Compressor | |
| | | | | | | | | | |
| | | **DISTRIBUTION** | Line Leakages | For immediate rectification | Visual | - | Weekly | Zero Tolerance | |
| | | | Leakage at Compressed Air Vessel Condensate line | For immediate rectification | Visual | - | Weekly | Zero Tolerance | |
| | | | | | | | | | |
| | | **UTILIZATION** | Leakage at Valves | For immediate rectification | Visual | - | Weekly | Zero Tolerance | |
| | | | Leakage at AFRs | For immediate rectification | Visual | - | Weekly | Zero Tolerance | |
| | | | Leakage at equipments | For immediate rectification | Visual | - | Weekly | Zero Tolerance | |
| 4 | **Process & Utility** | **PASTEURIZATION** | Raw milk inlet temperature | For Regeneration Efficiency Calculation | Using Thermocouple / Panel | Deg C | Monthly | 4 - 7 deg C | |
| | | | Temperature after pre-heating by Regeneration | | Using Thermocouple / Panel | Deg C | Monthly | 9 - 10 deg lesser than pasteurization T | |
| | | | Pasteurization Temperature | | Using Thermocouple / Panel | Deg C | Monthly | 75 - 79 deg, depending on holding time | |
| | | | Temperature after pre-cooling by Regeneration | | Using Thermocouple / Panel | Deg C | Monthly | 15 - 20 deg C | |
| | | | Chilled Milk Temperature | | Using Thermocouple / Panel | Deg C | Monthly | 3 - 4 deg C | |
| | | | | | | | | | |
| | | **MOTORS** | Electrical Parameters | For Motor performance | Using Power Analyzer | kW,V, I, A, PF | Quarterly | Voltage +/-5% of rated voltage Within +/-5% of rated current Motor Loading > 80% for better efficiency range | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | PUMPS | Pressure | For Pumps performance | Using Pressure Gauges at suction and discharge | Kg/cm2 | Quarterly | As per manufacturers recommendation | |
| | | | Flow Rate | For Pumps performance | Using flow meter | LPH | Quarterly | As per manufacturers recommendation | |
| | | | Power Consumption | For Pumps performance | Using Power Analyzer | kW | Quarterly | As per manufacturers recommendation | |
| 5 | **Raw Energy** | **ELECTRICAL** | 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<br>PF close to unity<br>Transformer loading - 50% -60%<br>VTHD < 8% at 415 V side<br>ITHD < 15% at 415 V side | |
| | | **FUEL** | 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 |

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|---|---|---|---|---|---|
| 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 |

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|---|---|---|---|---|---|
| 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 |

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|---|---|---|---|---|---|
| 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 |

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|---|---|---|---|---|---|
| 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 |

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|---|---|---|---|---|---|
| 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 |

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|---|---|---|---|---|---|
| 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 |

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|---|---|---|---|---|---|
| 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 | **VFD** | Yaskawa | Mr Sree Kumar | 9573770123 | sreekumar_n@yaskawa.in |
| 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** | **Rem arks** |
| **1** | Install of Automatic Blow-down System | 0.97 | 3 | 37 | | | |
| **2** | Arrest all leakages in the steam system. | 0.5 | 0.1 | 2 | | | |
| **3** | Install Auto Pumping Trap for 10 KL Pasteuriser Condensate Recovery | 1.83 | 3.5 | 23 | | | |
| **4** | Curd Pasteuriser Pre-heater replacement | 2.60 | 9 | 42 | | | |
| **5** | Install Condensate Recovery System for CIP and pump the condensate to Hot Water Tank of CIP | 1.55 | 3 | 23 | | | |
| **6** | Install VFD Control for Refrigeration Compressor | 1.47 | 2.7 | 22 | | | |
| **7** | Install waste heat recovery from Chiller Compressor | 2.00 | 3.2 | 19 | | | |
| **8** | Optimize the operation of cooling units of Cold Storage | 1.69 | 1.17 | 8 | | | |
| **9** | Reduce the Generating Pressure of Main Plant Compressor | 0.105 | 0 | 0 | | | |
| **10** | Operate the VFD of Main Plant Compressor in Closed Loop | 1.49 | 0 | 0 | | | |
| **11** | Install VFD for Aeration Blower | 0.51 | 1 | 24 | | | |
| **12** | Replace low efficiency Chilled Water Pump with high efficiency pump | 0.48 | 0.65 | 16 | | | |
| **13** | Replace Identified motors with Energy Efficient Motors | 2.18 | 3.36 | 18 | | | |
| **14** | Install Energy Saver for Split AC's | 0.22 | 0.23 | 13 | | | |
| **15** | Install Energy Efficient BLDC fans in Plant | 0.27 | 0.75 | 33 | | | |
| **16** | Install 30 kWp Solar Roof Top | 2.4 | 15 | 75 | | | |
| | Total | 20.265 | 46.66 | 28 | | | |

## 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 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |