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DETAILED ENERGY AUDIT REPORT

M/ Jorethang Dairy Plant – Sikkim Dairy Cluster



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



Bureau of Energy Efficiency

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Bureau of Energy Efficiency, 2019

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

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Disclaimer

This Detailed Energy Audit Report is an output of an exercise undertaken by Confederation of Indian Industry under the GEF-UNIDO-BEE project's initiative for the benefit of MSME units and is primarily intended to assist and build the capability of decision making by the management of MSME units for implementation of EE & RE technologies, BOP etc. While every effort has been made to avoid any mistakes or omissions. However, GEF, UNIDO, BEE or Confederation of Indian Industry would not be in any way liable to any person or unit or other entity by reason of any mistake/omission in the document or any decision made upon relying on this document.

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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
DEA	Detailed Energy Audit
EE	Energy Efficiency
FCU	Fan Coil Unit
FI	Financial Institution
GEF	Global Environmental Facility
HSD	High Speed Diesel
kW	Kilo Watt
LSP	Local Service Provider
MSME	Micro and Medium Scale Industries
OEM	Original Equipment Manufacturer
RE	Renewable Energy
TOE	Tonnes of Oil Equivalent
UNIDO	United Nations Industrial Development Organisation
VFD	Variable Frequency Drive

ACKNOWLEDGEMENT

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".

CII is grateful to Mr. Milind Deore, Director, Bureau of Energy Efficiency, Mr. Sanjay Shrestha, Industrial Development Officer, Industrial Energy Efficiency Unit, Energy and Climate Branch, UNIDO, Mr. Suresh Kennit, National Project Manager UNIDO and Mr. Niranjana Rao Devela, National Technology Coordinator, Energy Efficiency & Renewable Energy in MSMEs, UNIDO for their support and guidance during the project.

CII would like to give special gratitude to Sikkim Cooperative Milk Producers Union Ltd for supporting CII for carrying out this project at Sikkim Dairy Cluster and for their constant support and coordination throughout the activity. CII team is also grateful to the M/s Jorethang Dairy Plant especially Mr. T B Subba, General Manager, Mr. Ramesh Chettri, Assistant Plant Officer 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 Sikkim 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	Jorethang Dairy Plant
Name(s) of the Plant Head	Mr. T B Subba, DGM
Contact person	Mr. T B Subba
Constitution	Cooperative Society
MSME Classification	Medium Scale
Address:	Sikkim Co-operative Milk Producers Union Ltd, Karfertar, Jorethang South Sikkim, 737121
Industry-sector	Dairy

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

Some of the important energy conservation measures implemented are as below.

- Use of LED Lighting
- Installation of Evaporative Condenser
- High Efficiency Chilled Water Pump
- Optimized voltage at Main Incomer

CII – Godrej GBC Energy Audit Team conducted Detailed Energy Audit at Jorethang Dairy RO Plant from 21st May 2018 to 23rd May 2018 and final presentation to plant team was given on 23rd May 2018.

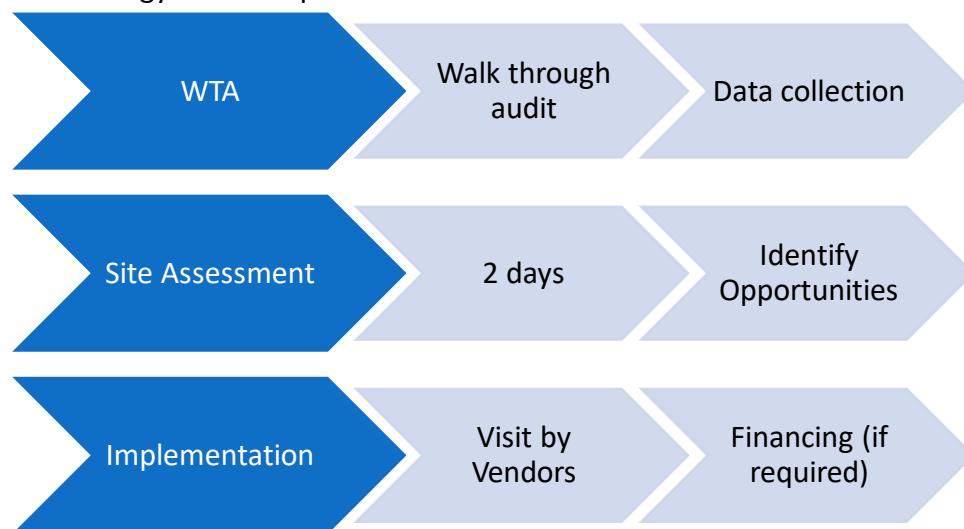
The energy audit included detailed data collection, power measurements of Major electrical energy consumers, process measurements, analysis of data, and performance analysis of the equipment and identification of specific energy saving proposals.

The major form of energy used in the plant is electricity which is from Energy and Power Department Govt. of Sikkim. For thermal energy, plant is using HSD as the main fuel.

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

Jorethang Dairy plant team and CII energy team have together identified an annual energy saving potential of Rs. 6.90 Lakhs with an investment of Rs. 23.99 Lakhs based on energy cost.

Table 2: Summary of savings

Details	No. of Proposals	Annual savings
Total Annual savings	05	6.90
Investment Required (Rs. Lakhs)	05	23.99
Pay Back	Years	3.5

Table 3: Summary of fuel savings

Details	UOM	Annual savings
Total Electricity Savings	kWh	57642
Total Fuel Savings (HSD)	Litres	7813
Annual TOE Savings	TOE	12.04
Annual TCO₂	TCO ₂	68.20

Table 4: Summary of Energy Saving Proposals

Sl. No.	Energy Saving Proposals	Annual savings (lakhs)	Investment (lakhs)	Payback (Years)	Electricity Savings (kWh)	Fuel Savings (HSD)	TOE savings	TCO ₂ savings
1	Waste heat recovery from chiller compressor	2.04	5.19	2.5		3051	2.77	8.2
2	Installation of VFD for chiller compressor	0.81	2.71	3.3	20160		1.73	16.5
3	Installation of Heat Pump for preheating boiler feed water	2.55	3.54	1.4		4762	4.32	12.8
4	Installation of 20 kWp Solar Roof Top	1.23	11.55	9.4	30660		2.64	25.1
5	Replacement of existing compressor with Screw Compressor	0.27	1	3.7	6822		0.59	5.6
	Total	6.9	23.99	3.5	57642	7813	12.0	68.2

2. INTRODUCTION ABOUT JORETHANG DAIRY PLANT

2.1 Unit Profile

Sikkim is among the lowest milk producing states in India, with a total production of 0.067 Million Tonnes of milk in 2015-16. There are mainly 2 dairies in Sikkim which are located in southern and eastern part of Sikkim. Jorethang Dairy Plant is located in the Karfetar in Jorethang with daily milk processing of 20,000 to 25,000 litres per day.

Table 5: Unit Profile

Particulars	Details
Name of Plant	Jorethang Dairy Plant
Name(s) of the Plant Head	Mr. T B Subba DGM
Contact person	Mr. Ramesh Chettri
Contact Mail Id	chettriramesh91@gmail.com
Contact No	+91 9002525435
Constitution	Cooperative Society
MSME Classification	Medium Scale
No. of years in operation	36
No of operating hrs/day	8
No of operating days/year	365
Address:	Sikkim Co-operative Milk Producers Union Ltd, Karfetar, Jorethang South Sikkim, 737121
Industry-sector	Dairy
Type of Products manufactured	Milk ,Paneer, Dahi, Butter and Chhurpi

2.2 Production Details

The various products manufactured in Jorethang Dairy Plant are liquid milk, butter, curd, paneer, churpi. The graph below shows the milk processed during last one year:

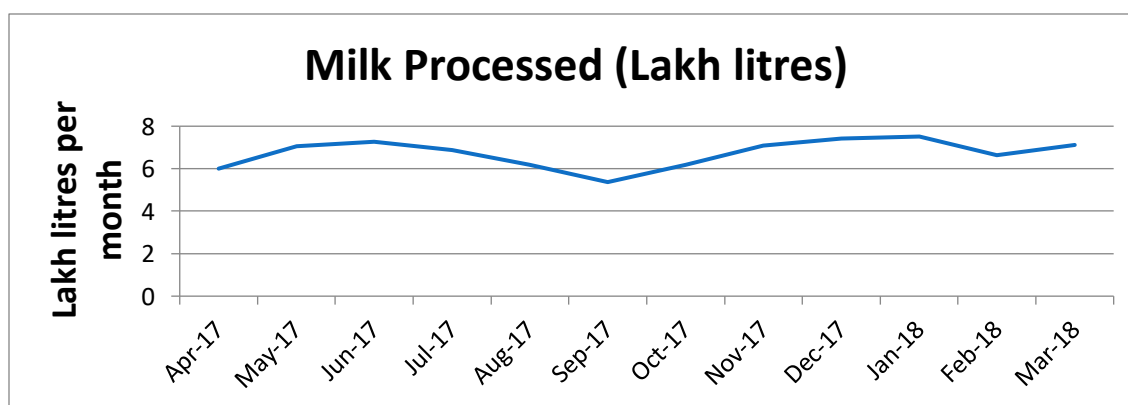


Figure 1: Milk Processed

2.3 Dairy Process Flow Diagram

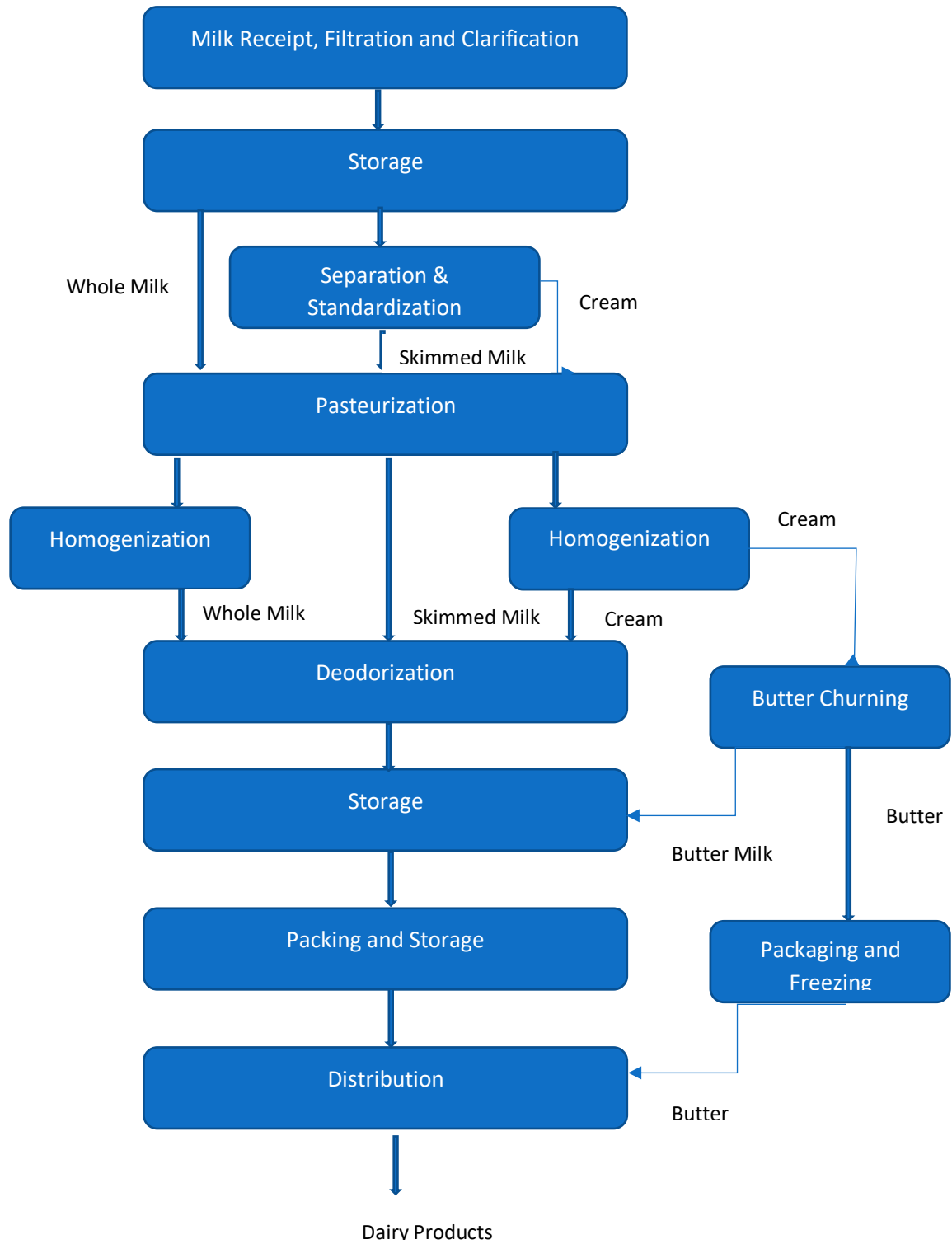


Figure 2: Typical process flow of Milk manufacturing

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 72°C for 16 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	0.23
2	Milk Packaging in Poly Pouches	Lakh Litres per Day	0.06
3	Curd Manufacturing	Kg/day	360
4	Butter Manufacturing	Kg/day	80
5	Paneer Manufacturing ¹	Kg/day	160
6	Churpi Manufacturing	Kg/day	13

¹ Based on demand from market

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	4.00	-
2	High Speed Diesel	Rs/L	67	10800

The table below shows the monthly consumption of various fuel used in the plant during the last one year and the contract demand of the plant is 130 kVA.

Table 8: Fuel Consumption Details

Month	Electricity Consumption (kWh)	Fuel Consumption (Boiler) – HSD (L)	Fuel Consumption (DG set) – HSD (L)
Apr-17	7,600	3,750	678
May-17	5,600	3,970	1,166
Jun-17	7,760	3,010	734
Jul-17	4,040	3,390	833
Aug-17	7,560	3,120	230
Sep-17	6,000	2,750	1,429
Oct-17	6,920	2,560	300
Nov-17	6,800	3,105	400
Dec-17	3,120	3,620	367
Jan-18	3,120	3,550	16
Feb-18	3,720	3,110	200
Mar-18	3,720	4,325	550
Total	65,960	40,260	6,903

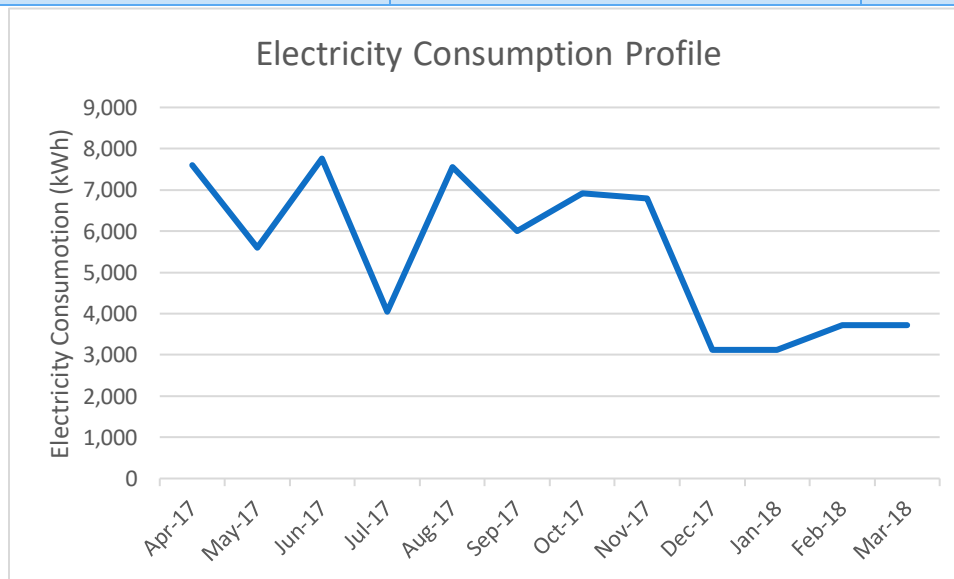


Figure 3: Electricity consumption profile

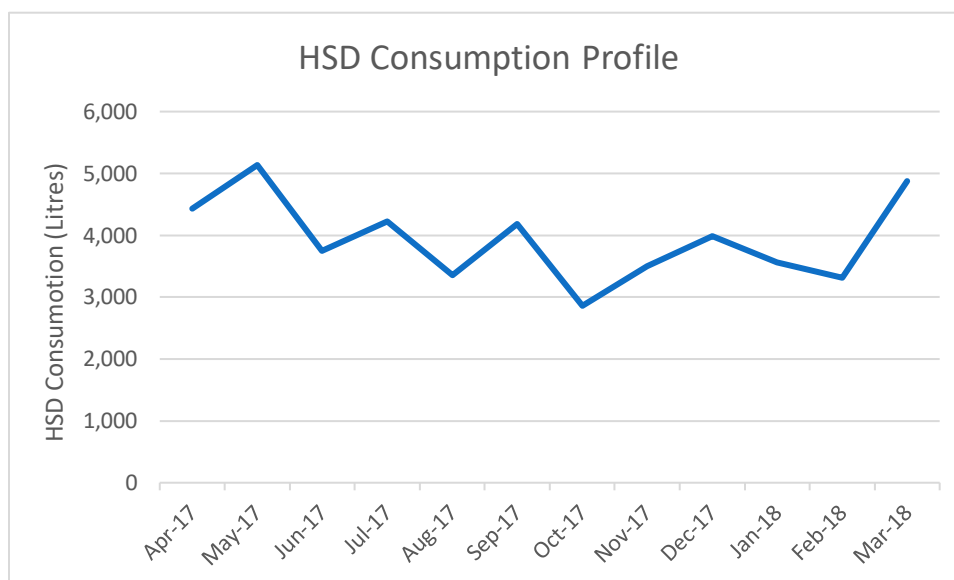


Figure 4: HSD consumption profile

The energy consumption breakup of the plant both thermal and electrical is shown in the below table. Total energy consumption of the plant is 48 MTOE out of which 88% of the total energy is contributed by thermal and rest only 12% is contributed by electricity.

Table 9: Energy consumption breakup of plant

SI No	Particulars	UOM	
1	Annual Electricity Consumption	kWh	65,960
2	Annual Electricity Consumption	kCal	56725600
3	Annual Electricity Consumption	MTOE	5.67
4	Annual Diesel Consumption	Litres	47163
5	Annual Diesel Consumption	kCal	423901044
6	Annual Diesel Consumption	MTOE	42.39
7	Total Energy Consumption	kCal	480626644
8	Total Energy Consumption	MTOE	43.05

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 0.21 Lakhs/month whereas the average thermal energy cost is Rs 2.6 – 3.0 Lakhs/month.

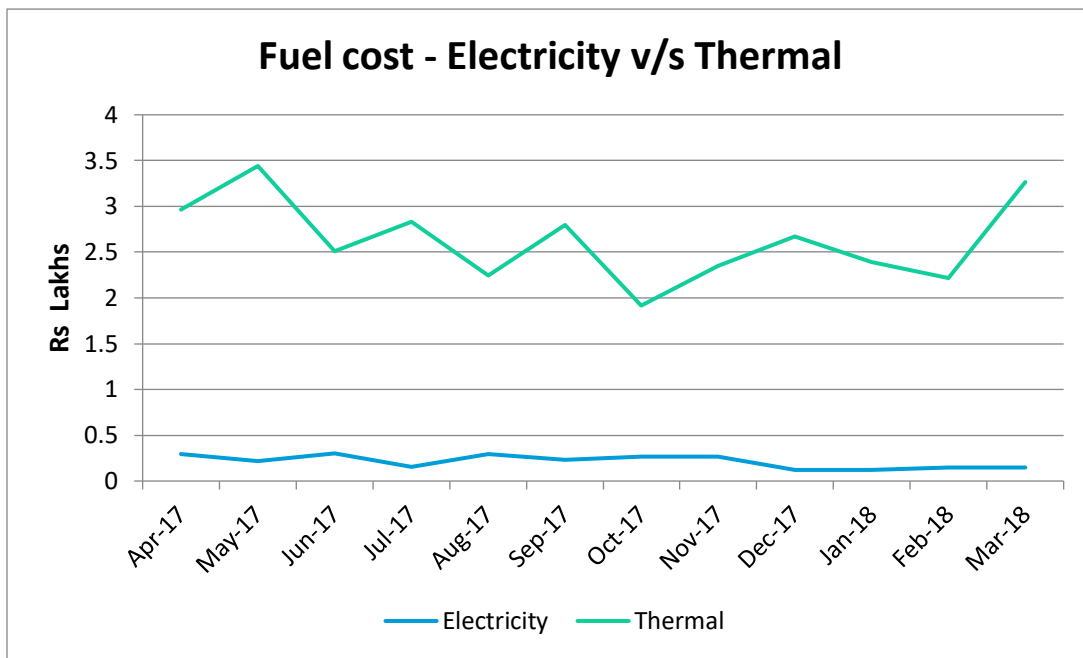


Figure 5: Share of fuel cost

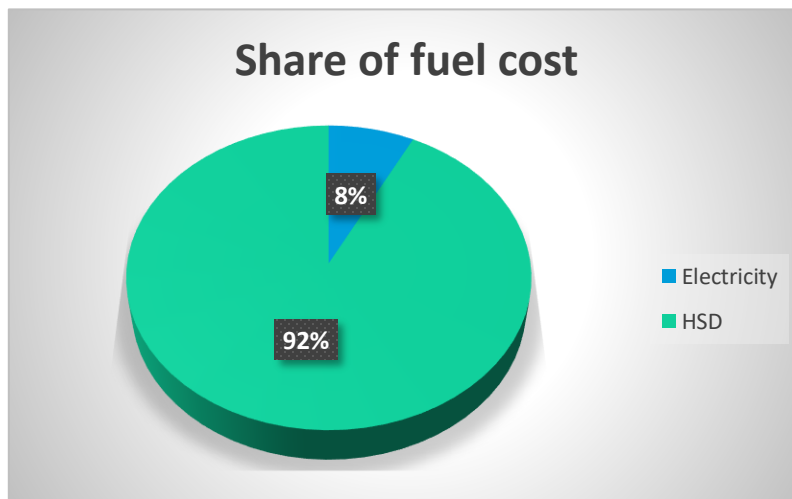


Figure 6: Fuel Cost Electrical vs Thermal

3. PERFORMANCE EVALUATION OF EQUIPMENT/PROCESS

3.1 List of equipment and process where performance testing done

CIII during the detailed energy audit at Jorethang Dairy plant carried out measurements and performance testing in the following equipment and process.

Refrigeration System

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

Boiler and Steam System

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

Compressor

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

Pumps

- Efficiency estimation

Electrical

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

3.2 Result of Performance Testing

The table below shows electrical measurements done in the plant.

Table 10: Electrical Measurements

Sl No	Equipment/Feeder	Voltage	Current	Power	PF
1	Chiller Compressor	410	44	28	0.85
2	Chilled Water Pump	415	6.2	3.5	0.85
3	Boiler Feed Pump	422	0.9	0.5	0.8
4	Packing Machine 1 (2 header in line)	415	2.1	1.3	0.84
5	Packing Machine 02	410	2.2	1.2	0.84
7	Evapco Pump 1	415	1.9	1.4	0.81
8	Boiler Blower	413	2.3	1.3	0.83
9	Cold Storage FCU 1	422	2.8	1.5	0.82
10	Butter Churning	414	4.3	2.4	0.79
11	Crate Washing	414	14.3	8.1	0.81
12	ETP Load	413	8.3	4.5	0.83
13	Curd Making	414	5.8	3.2	0.81
14	Pastuerizing Section (Milk Pumps, Homogenizer, Hot water Pump)	413	58.5	34	0.8
15	Air Compressor	414	10.8	6.5	0.83
16	Condenser Fan	415	2.3	1.4	0.82

Table 11: Transformer Measurements

Rating	Phases	Voltage	Current	Power	PF	VTGD	ITGD
200	R	235	116	22	0.82	1.2	3.1
	Y	234	108	21	0.82	1.1	3.3
	B	236	122	24	0.84	1.1	3

- Harmonics are within the limits as per standard IEEE 519 -2014 (VTGD < 8% and ITGD < 15%)
- Currently there is no penalty or rebate for Power factor improvement as the plant is coming under domestic category but still the PF can be improved and can be maintained close to unity by putting capacitor banks.

Table 12: Boiler Efficiency

Boiler Efficiency Calculation		
Feed Water Temperature	30	°C
Calorific value of fuel	10800	kCal/kg
Density of HSD	0.84	kg/l
O ₂ in flue gas	%	12.5
Feed Water Flow	320	lph
Feed Water Flow	320	kg/hr
HSD Flow	23.1	kg/hr

Enthalpy of steam at 6.5 kg/cm ²	660	kCal/kg
Feed Water Enthalpy at 30 deg C	30	kCal/kg
Boiler Efficiency	80.0	%

Table 13: Pump Measurements

Description		UOM	Chilled Water Pump
Design Parameters			
	Rated Motor Power	kW	3.70
	Rated Flow	m ³ /hr	36.00
	Rated Head	m	23.50
	Design Efficiency	%	59.00
Measured Parameters			
	Power Measured	kW	3.4
	Flow	m ³ /hr	26
	Head	m	22
Calculations			
	Hydraulic Power	kW	1.56
	Pump shaft Power	kW	3.05
	Efficiency of the pump	%	51.00
			Estimated head

Table 14: Air Compressor performance

Parameters	UOM	
Rated capacity of compressor	CFM	35
Rated power of compressor	kW	7.5
Free air delivery of compressor(FAD)	CFM	17
Operating power consumption of compressor	kW	6
Specific power consumption of compressor	kW/CFM	0.352941
Volumetric Efficiency of compressor	%	45

Table 15: Performance of Chiller Compressor

Parameters	UOM	
Rated size of compressor	kW	30
	TR	20
Voltage	Volts	410
Current	Amperes	46
Power Consumption of Compressor	kW	28
Power Factor	PF	0.85
Suction Pressure	bar	2
Discharge Pressure	bar	200
Discharge Temperature	°C	105

Evaporator Temperature	°C	-3
Condensing Temperature	°C	37
Operating Power	kW	28
Operating TR	TR	17.5
SEC	kW/TR	1.60

3.3 Energy Balance of Jorethang Dairy

During the detailed energy audit at Jorethang Dairy the total load on the plant measured at transformer level was 67 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.

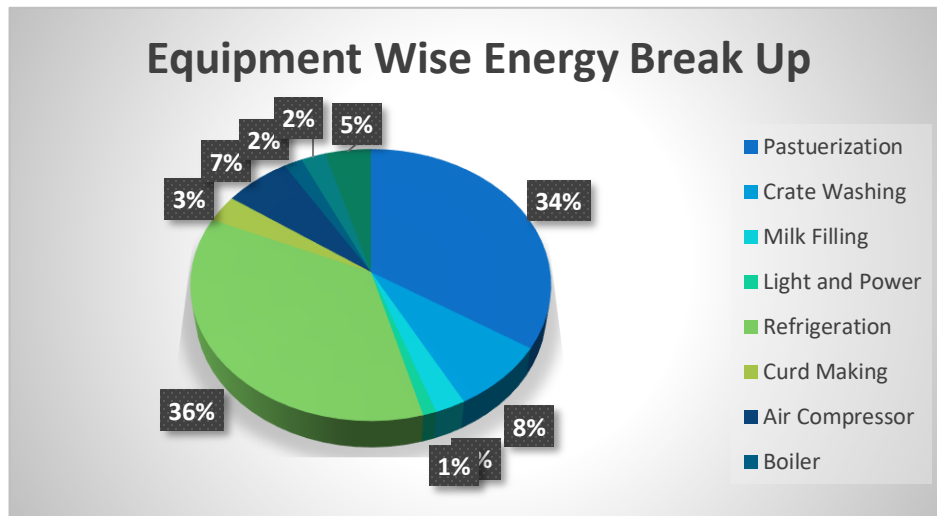


Figure 7: Equipment/Process wise energy breakup

3.4 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 16: Specific Energy Consumption

Sl No	Particulars	UOM	
1	Annual Electricity Consumption	kWh	65960
2	Annual Electricity Consumption	MTOE	5.67
3	Annual Diesel Consumption	Litres	47163
4	Annual Diesel Consumption	MTOE	43.05
5	Total Energy Consumption	MTOE	49
6	Annual Production	Kilo Litres	8069
7	Overall Electrical SEC	kWh/KL	8
8	Overall Thermal SEC	MkCal/KL	0.053
9	Overall SEC	MkCal/KL	0.06

4. ENERGY SAVING PROPOSALS

Energy Saving Proposal 1 – Waste heat recovery from chiller compressor

Present System

Jorethang Dairy Plant has installed reciprocating chiller compressor of 20 TR capacity for the chilled water requirement in the plant. For the refrigeration purpose, vapor compression based ammonia cycle is used.

In a refrigeration cycle, when the compressor is run, the refrigerant starts flowing through the system i.e., the system starts its 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 :

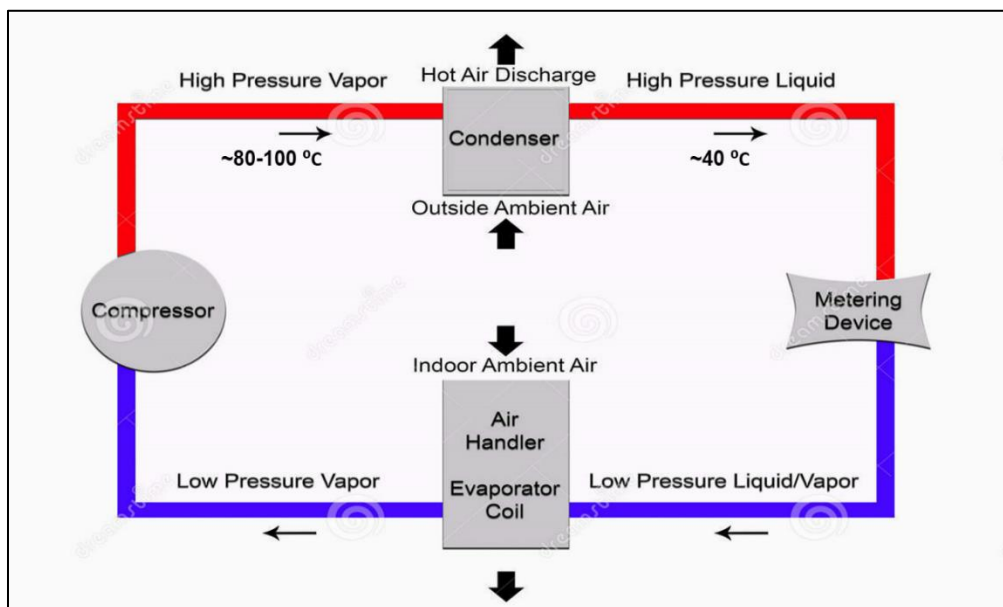


Figure 8: Vapor Compression Cycle

Refrigeration plants with air-cooled and water-cooled condensers produce a lot of waste energy by dumping the condensation energy to the ambient air. By installing a de superheater, a large

proportion of this waste energy can be turned into hot water that may be used for many purposes such as:

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

Recommendation

De-super heater is proposed to be installed on chiller compressors to harness waste heat of ammonia gas. De-superheater is installed on discharge side of NH₃ compressor. The temperature of NH₃ gas observed to be 105°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 60°C. This hot water is proposed to be used in the boiler feed water. 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.

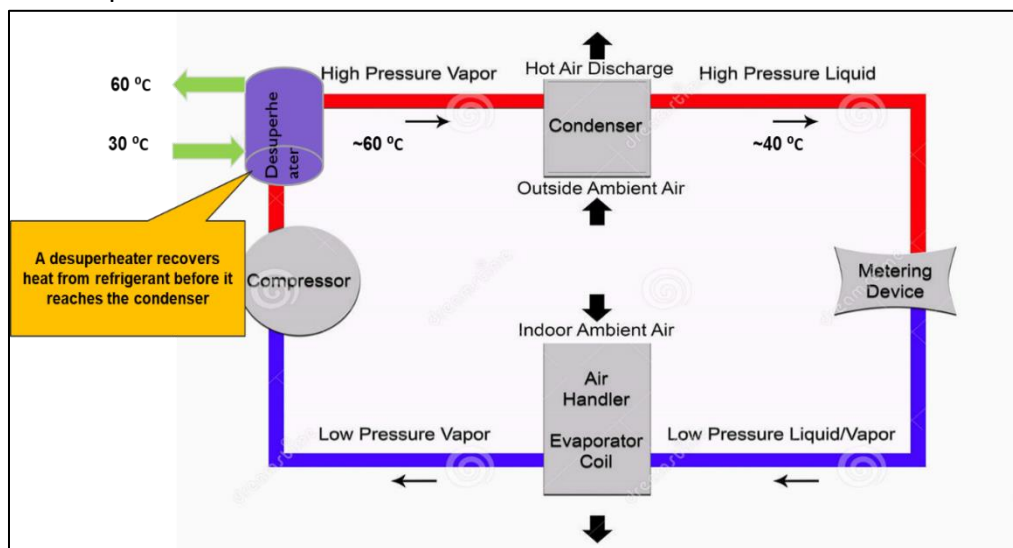


Figure 9: Refrigeration system with desuperheater

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

Table 17: Technical parameters of desuperheater

Item	Value
Temperature of ammonia gas in/out	110 °C/60 °C
Temperature of water in/out	30 °C /70 °C
Amount of water that can be heated	256 litre/hr
Heat load recovered	11.92 kW

Savings

The expected savings by installation of de super heater is 3,051 litres of HSD annually. The annual monetary saving for this project is ***Rs 2.04 Lakhs with an investment of Rs 5.19 lakhs and payback for the project is 2.5 years***

Detailed savings calculations is given in below table

Table 18: Savings Calculation

Parameters	UOM	
Size of compressor	kW	29.8
Heat Recovery possible	kW	11.92
Heat Recovery possible	kCal/hr	10251
Amount of hot water available for process (from 30 to 70°C)	litre per hour of water at 70°C	256
Hours of operation	hours per day	6
Days of operation	days per year	360
Total heat recovery possible	kCal/year	22142592
Cost of diesel	INR/liter	67
Calorific value	kCal/kg	10800
Boiler efficiency	%	80%
Fuel Savings	kg/year	2563
Density of HSD	kg/litre	0.84
Annual Fuel Savings	Litres/year	3051
Cost of HSD	Rs/Litre	67
Annual Cost Savings	Rs Lakhs	2.04
Investment	Rs Lakhs	5.19
Pay Back	Years	2.5
NPV AT 70% Debt	Rs Lakhs	7.96
IRR (%)	%	57.56
TOE Savings	TOE	2.77
TCO ₂	TCO₂	8.20

Energy Saving Proposal 2 – Installation of VFD for chiller compressor

Present System

Jorethang Dairy Plant has installed reciprocating chiller compressor of 20 TR capacity for the chilled water requirement in the plant. For the refrigeration purpose, vapor compression based ammonia cycle is used. The compressor is used for maintaining the temperature in the IBT and for the fan coil units installed in cold storage. The details of existing compressor in the plant is shown below:



Figure 10: Chiller Compressor

Table 19: Performance of compressor

Parameters	UOM	
Rated size of compressor	kW	30
	TR	20
Voltage	Volts	410
Current	Amperes	46
Power Consumption of Compressor	kW	28
Power Factor	PF	0.85
Suction Pressure	bar	2
Discharge Pressure	bar	200
Discharge Temperature	°C	105
Evaporator Temperature	°C	-3
Condensing Temperature	°C	37
Operating Power	kW	28
Operating TR	TR	17.5
SEC	kW/TR	1.60

In a refrigeration cycle, when the compressor is run, the refrigerant starts flowing through the system i.e., the system starts its 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 0°C) and also for the Fan Coil units to maintain the temperature at cold storage. During the morning time when all the processes (mainly pasteurization and pre chilling of raw milk) are in operation the compressor is 80% to 100% loaded and consumes more power. 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 30 kW 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 20,160 units annually. The annual monetary saving for this project is **Rs 0.81 Lakhs with an investment of Rs 2.70 lakhs and payback for the project is 3.3 years**

Detailed savings calculations is given in below table:

Table 20: Savings Calculation for VFD for chiller compressor

Parameters	UOM	
Size of compressor	kW	30
	TR	20
Power Consumption of Compressor	kW	28
Power Savings	%	20

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Power Consumption after installing VFD	kW	22
Power Savings	kW	5.60
Hours of operation	hours per day	10
Days of operation	days per year	360
Annual Energy Savings	kWh	20,160
Electricity Cost	Rs/kWh	4
Savings per year	Rs Lakhs	0.81
Investment	Rs Lakhs	2.70
Pay Back	Years	3.3
NPV AT 70% Debt	Rs Lakhs	2.86
IRR (%)	%	45.17
TOE Savings	TOE	1.73
TCO₂	TCO₂	16.5

Energy Saving Proposal 3 – Installation of Heat Pump for preheating boiler feed water

Present System

Jorethang Dairy Plant has installed one HSD boiler for producing steam at 6 kg/cm² which is used in the process application like pasteurization, curd making, CIP, crate washing etc. One boiler is running and one is standby. All the heating process in dairy is through indirect heating.

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

Table 21: Boiler Details

Boiler	Fuel Type	Design Capacity (TPH)	Make of the company	Operating Pressure (bar)	Operating Condition	Operating hrs
Boiler 1	HSD Fired	0.6	Energy Solutions	6	Running	6

Table 22: Efficiency calculation of 0.7 TPH boiler

Boiler Efficiency Calculation		
Feed Water Temperature	30	°C
Calorific value of fuel	10800	kCal/kg
Density of HSD	0.84	kg/l
Feed Water Flow	320	lph
Feed Water Flow	320	kg/hr
HSD Flow	23.1	kg/hr
Enthalpy of steam at 6.5 kg/cm ²	660	kCal/kg
Feed Water Enthalpy at 30 deg C	30	kCal/kg
Boiler Efficiency	80.0	%

Currently the feed water for the boiler is taken from a 1000 litre tank using a 0.75 kW feed water pump. During the study it was observed that the feed water temperature is 30°C and feed water required for the boiler is 320 litres per hour. Since the boiler feed water is going at ambient condition to the boiler more fuel is to be burned inside the boiler to generate steam at higher temperature. Also lower temperature of feed water can result in the formation of dissolved oxygen which can lead to corrosion.



Figure 11: 600 kg Boiler

Recommendation

It is recommended to install a 28 kW electrical heat pump for boiler feed water heating from 22°C to 80°C. An EHP system works on the principle of the 'heat pump'. This is the cyclic process in which heat is taken up from an area of cold temperature and discarded into an area of high temperature.

A heat pump cannot operate by itself; it requires an external energy source. In an electric heat pump (EHP) system, electrical energy is used to drive the heat pump.

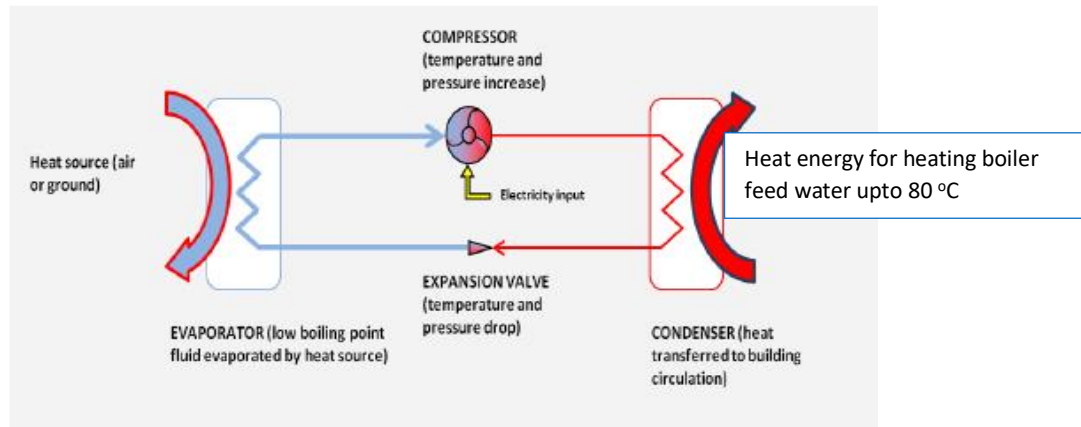


Figure 12 : Heat Pump working

The heat pump is similar to a chiller unit where the utilization point is from condenser part for heating application. It has four basic components compressor, condenser, expansion valve and an evaporator. When electrical energy is given to unit, compressor compresses the R134a refrigerant to high temperature high pressure vapor. From compressor the vapor goes to the condenser which is basically a heat exchanger where on one side boiler feed water is circulated and other side refrigerant flows. The heat from the refrigerant is dissipated to the boiler feed water which is coming at 22°C. The heat is used to heat the boiler feed water to 80°C² and fed to the boiler. The refrigerant is then expanded using an expansion valve to low temperature low pressure vapor and given to the evaporator. In the evaporator using small fans installed on the top of heat pump the ambient air is used to evaporate the refrigerant due to its low boiling point. The low temperature low pressure vapor is sucked in by the compressor and cycle is repeated. The COP of heat pump is 2.5 i.e. if 1 kW of energy can generate 2.5 kW of heat energy.

The heat pump is supplied on a rental model for initial period of one year at an amount of Rs 25,000 + 18% GST per month. The rental model will be automatically renewed every year.

Savings

The expected savings by installation of electrical heat pump is 4,762 litres of HSD annually. The annual monetary saving for this project is **Rs 2.55 Lakhs with an investment of Rs 3.54 lakhs and payback for the project is 1.41 years.**

Detailed savings calculations are given in the table below

Table 23: Savings Calculation for heat pump

Parameters	UOM	
Feed Water Temperature	°C	30
GCV of fuel	kCal/kg	10800
Boiler Efficiency	%	80

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Feed Water Requirement	kg/hr	320
Feed Water Requirement for 6 hour boiler operation	kg/day	1920
Max temperature delivered by heat pump	°C	80
Heat Energy required to raise temp to 80 °C	kCal/day	96000
Pipe line losses	%	10
Heat Energy required to raise temp to 80 °C after losses	kWh/day	124.03
Operating hrs of heat pump	hrs/day	8
Electrical heat energy of pump	kW	15.50
COP of Heat Pump		2.5
Fuel required for equivalent energy of 108000 kCal/day	litre/day	13.23
Auxiliary Power Consumption of Heat Pump	kW	6
Energy Consumption of heat pump	kWh/day	44.7
Operating days	days	360
Fuel Cost	Rs/litre	67
Electricity Cost	Rs/kWh	4
Annual Fuel Savings	Rs Lakhs	3.19
Electricity cost for running heat pump	Rs Lakhs	0.64
Net Annual Savings	Rs Lakhs	2.55
Size of Heat Pump available for producing 17.44 kW Electrical Heat Energy	kW	28
Investment for 28 kW Heat Pump	Rs Lakhs	3.54
Pay Back	Years	1.41
NPV AT 70% Debt	Rs Lakhs	11.30
IRR (%)	%	96.09
TOE Savings	TOE	4.32
TCO₂	TCO₂	12.8

Energy Saving Proposal 4 – Installation of 20 kWp Solar Roof Top

Present System

Jorethang Dairy Plant is purchasing electricity from grid for the operation of various equipment's in the plant. The contract demand of the plant is 130 kVA with electricity price of Rs 4/kWh with an average load of 40 kW – 60 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.

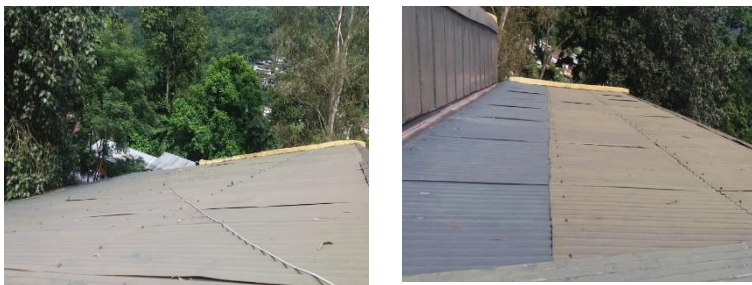


Figure 13: Rooftop area for solar

Table 24: Site Specifications

Parameters	
Effective Rooftop available ,sq ft	2000
Location	Latitude: - 27.1317°N, Longitude: - 88.2796°E
Altitude above sea level, m	322
Annual in plane irradiation	1533 kWh/m ²

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 20 kWp solar roof top is 30,660 units of electricity annually. The annual monetary saving for this project is **Rs 1.23 Lakhs with an investment of Rs 11.55 lakhs and payback for the project is 9.4 years.**

Detailed savings calculations is given in below table

Table 25: Savings calculation for solar roof top

Parameters	UOM	
Proposed Roof top Solar installation	kW	20
Area Available at Roof	Sq.ft	2000
Annual units generation per kW of Solar PV	kWh per kW/year	1533
Total Energy Generation Per Annum	kWh/year	30,660
Electricity Cost	Rs/kWh	4
Cost Savings	Rs Lakhs	1.20
Investment	Rs Lakhs	11.55
Payback period	Months	113
NPV AT 70% Debt	Rs Lakhs	0.95
IRR (%)	%	13.91
TOE Savings	TOE	2.64
TCO ₂	TCO ₂	25.1

Energy Saving Proposal 5 – Replacement of existing compressor with Screw Compressor

Present System

Jorethang Dairy Plant has installed reciprocating compressor of rated capacity 35 CFM to cater the compressed air requirement of the plant.

Over a period of time the reciprocating compressor operating efficiency comes down and the quantity of free air delivered reduces due to reasons such as poor maintenance, wear and tear etc.



Figure 14: Old reciprocating compressor

If the operating efficiency of the compressor is low the specific power consumption (kW/cfm) increases and hence the cost of compressed air goes up. The quantity of free air delivered, operating efficiency and the specific power consumption of the compressor can be determined by carrying out a performance test. If the specific power consumption increases by 25 - 30 % as compared to a new efficient compressor, it makes economic sense to replace the compressor with new efficient.

Compressor free air delivery test (FAD) was conducted for the reciprocating compressor to evaluate the volumetric efficiency and specific power consumption.

The parameters of the FAD test conducted is shown below:

Table 26: Performance of compressor

Parameters	UOM	
Rated capacity of compressor	CFM	35
Rated power of compressor	KW	7.5
Free air delivery of compressor(FAD)	CFM	17
Operating power consumption of compressor	KW	6.0
Specific power consumption of compressor	kW/CFM	0.35
Volumetric Efficiency of compressor	%	48

It can be seen clearly from the above parameters that the volumetric efficiency of the compressor is on lower side and have high operating specific energy consumption (SEC) figure 0.35kW/CFM. Typically for reciprocating compressor the specific power consumption should be 0.13 kW/CFM at an operating pressure of 6.5 kg/cm²

Recommendation

It is recommended to replace the existing 35 CFM/7.5 kW reciprocating compressor with a new screw compressor and the keep the old one as standby.

- Rated Power: 5.5 kW
- Rated Capacity: 25 CFM

- Overall specific power consumption: 0.17kW/CFM @7 Kg/cm²

Savings

The expected electricity savings by replacement of the old compressor with new screw one is 6,822 units annually. The annual monetary saving for this project is **Rs 0.27 Lakhs with an investment of Rs 1.00 lakh and payback for the project is 3.60 years.**

Detailed savings calculations is given in below table:

Table 27: Savings Calculation for air compressor

Parameters	UOM	
Power consumption of the existing compressor	kW	6
Rated capacity of the new compressor	CFM	25
Specific power consumption of the new compressor@ 6 kg/cm ²	kW/CFM	0.13
Power consumption of new compressor	kW	2.21
Power Savings	kW	3.79
Hours of operation	hours per day	5
Days of operation	days per year	360
Annual Energy Savings	kWh	6822
Electricity Cost	Rs/kWh	4
Savings per year	Rs Lakhs	0.27
Investment	Rs Lakhs	1
Pay Back	Years	3.60
NPV AT 70% Debt	Rs Lakhs	0.91
IRR (%)	%	41.13
TOE Savings	TOE	0.59
TCO ₂	TCO ₂	5.6

5. MANAGEMENT ASPECTS AND CONCLUSIONS

THE OBJECTIVES OF JORETHANG DAIRY RO 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

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

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

The immediate task of Jorethang Dairy RO Plant should be to implement the identified proposals and get the savings.

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

5.3 Assign Specific Responsibility

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

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 – 6.3.

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, Jorethang Dairy RO Plant should carry out the following motivational aspects to sustain energy conservation activities.

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

5.6 Conclusions

- ❖ Jorethang Dairy RO Plant and CII – Godrej GBC teams have jointly identified **05** energy saving proposals worth an annual saving potential of **Rs. 6.90 Lakhs**. The investment required for implementation of energy saving proposals is **Rs. 23.99 Lakhs**. The total investment will have a simple payback period of **3.5 Years**

Table 28: Summary of savings

Details	No. of Proposals	Annual savings
Total Annual savings	05	6.90
Investment Required (Rs. Lakhs)	05	23.99
Pay Back	Years	3.5

Table 29: Summary of fuel savings

Details	UOM	Annual savings
Total Electricity Savings	kWh	57642
Total Fuel Savings (HSD)	Litres	7813
Annual TOE Savings	TOE	12.04
Annual TCO₂	TCO ₂	68.20

Table 30: Summary of Energy Saving Proposals

Sl. No.	Energy Saving Proposals	Annual savings (lakhs)	Investment (lakhs)	Payback (Years)	Electricity Savings (kWh)	Fuel Savings (HSD)	TOE savings	TCO ₂ savings
1	Waste heat recovery from chiller compressor	2.04	5.19	2.5		3051	2.77	8.2
2	Installation of VFD for chiller compressor	0.81	2.71	3.3	20160		1.73	16.5
3	Installation of Heat Pump for preheating boiler feed water	2.55	3.54	1.4		4762	4.32	12.8
4	Installation of 20 kWp Solar Roof Top	1.23	11.55	9.4	30660		2.64	25.1
5	Replacement of existing compressor with Screw Compressor	0.27	1	3.7	6822		0.59	5.6
	Total	6.9	23.99	3.5	57642	7813	12.0	68.2

5.7 Jorethang Dairy, RO Plant should

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

6. ANNEXURE

6.1 Common Monitorable Parameters in Dairy

SI 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/cm ² 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 O ₂ analyzer	%	Weekly	FO/NG fired – 2.5% – 3% O ₂ and Briquette/Wood fired – 4% O ₂		
			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	

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		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 supply & 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/cm ² g	Hourly	As per capacity of compressor		
Discharge Pressure	For compressor performance		Pressure Guage	Kg/cm ² g	Hourly	As per capacity of compressor				

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			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/cm ² g	Hourly	Closest possible to user requirement	
			Loading %	For proper planning of usage	From Panel / By manually noting time	%	Per Shift	70 - 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	

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			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	

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		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 PF close to unity Transformer loading - 50% -60% VTHD < 8% at 415 V side 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@cglobal.com
7	APFC	In phase Power	Mr Kamalakannan Elangovan	9901599953	kamal.elangovan@inphase.in
8	APFC	Process Technique Electronic Pvt Ltd	Mr.Venkatesh	9448077736	support@processtechnique.com
9	ATCS	Shaw Energy Saving Solutions	Mr.Dilip Shaw	9396661892	shawenergysavingsolutions@gmail.com
10	ATCS	ECO GREEN SYSTEMS LLP	Mr Sachin Deshpande	8390525050	sachind@ecogreensys.com
11	Auto Drain Valves - Level Based	Summits Hygronics Pvt Ltd	Mr Balakannan S	9600910170	design@airdryer.in
12	Auto Drain Valves - Level Based	Beko Compressed Air Technologies Pvt Ltd	Mr Madhusudan Masur	040-23081106	Madhusudan.Masur@bekoindia.com
13	Automatic voltage controller /Stabiliser	Jindal Electric & Machinery Corp.		0161-2670250	jemc@jindalelectric.com
14	BLDC Ceiling Fans	Atomberg Technologies Pvt Ltd	Ms Roshni Noronha	9987366655	roshninoronha@atomberg.com
15	BLDC Ceiling Fans	Versa Drives	Mr Sathish	94885 94382	sathish@versadrives.com

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

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

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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@cglobal.com
56	Energy Efficient motors	Bharat Bijilee Limited	Mr Saurav Mishra		Saurav.Mishra@bharatbijilee.com
57	Energy Efficient motors	Bharat Bijilee Limited	Mr Anil Naik	9821862782	Anil.Naik@bharatbijilee.com
58	Energy Efficient motors	WEG Electric	Mr. Satyajit Chattopadhyay	080-4128-2007/2008/2005	chatto@weg.net
59	Energy Efficient motors	Baldor Electric India Pvt Ltd	Mr Bhanudas Chaudhari	97663 42483	bchaudhari@baldor.com
60	Energy Saving Coatings	Espee India Pvt Ltd	Mr.pradip Vaidya	8975090551	espee@espeeindia.com
61	Energy Saving Coatings	Innovative Surface Coating Technologies	Mr.Pankaj Patil	9326605194	patilpankaj08@yahoo.com
62	Flat Belts	Elgi Ultra Industries Ltd.		(422) 2304141	info@elgiultra.com
63	Flat Belts	Habasit-Iakoka Pvt. Ltd		422-262 78 79	habasit.iakoka@habasit.com
64	FRP Fans	Encon India	Bhavesh Chauhan	9022144400	bc@encongroup.in
65	Harmonic Filters	Digicon Automation Pvt Ltd	Mr Sandip Shah	9978903949	sandip@digicon.in
66	Heat Exchangers	Alfa Laval	Mr Himanshu Sheth	9552544801	himanshu.sheth@alfalaval.com
67	Heat Exchangers	Alfa Laval	Ms Varsha Tambe	7774097375	varsha.tambe@alfalaval.com
68	Heat Exchangers	Alfa Laval	Mr D.Rama Mohan	9822373561	rammohan.d@alfalaval.com
69	Heat Pump	Mechworld eco	Rohit Singhi	9930301188	rohit.singhi@mechworlddeco.com
70	Heat Pump	Thermax Ltd	Mr.Rohit Prabhakaran	9948076450	rohit.prabhakaran@thermaxglobal.com

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71	Insulation	Permacel	Mr.Venkatesh Kulkarni	9892513453	vkulkarni@prs-permacel.com
72	Insulation	Lithopone insulation paint	Mr Rahman		rahman@choiceorg.com
73	Insulation	U P Twiga Fiberglass Limited	Mr Biswajit Roy	011-26460860	biswajit@twigafiber.com
74	Insulation	Rockwool India Pvt Ltd	Mr Kevin Pereira		kpereira@rockwoolindia.com
75	IOT	ITC Infotech Pvt Ltd	Mr.Uma Shankar	9900765078	Umashankar.SM@itcinfotech.com
76	IOT	E-cube energy	Mr.Umesh	9831012510	umesh@eetpl.in
77	IOT	Vermigold Eco Tech	Mr.Jaideep Saptarshi	9867300840	jd@vermigold.com
78	LED	OSRAM Lighting Pvt. Ltd.	Mr Nitin Saxena	+91 124 626 1300	N.saxena@osram.com
79	LED	Kwality Photonics Pvt. Ltd.	Mr. K. Vijay Kumar Gupta	+ 91 40 2712 3555	kwality@kwalityindia.com
80	LED	Havells India Ltd	Mr. Sunil Sikka	0120-4771000	sunil.sikka@havells.com
81	LED	Surya Roshi Ltd	Mr Sen	011-47108000/25810093-96	v.sen@ho.surya.in
82	LED	Reckon Green Innovations Pvt Ltd	Mr Krishna Ravi	9985333559	krishna@reckongreen.com
83	LED	E view Global PVt Ltd	Mr Rajiv Gupta	9757158328	rajiv@eviewglobal.com
84	LED	SYSKA LED	Mr. Swapnil Shinde	+91 20 40131000	
85	LED	Philips Lighting India Limited (ESCO model available)	Mr. Mohan Narasimhan		Mohan.Narasimhan@philips.com
86	LED	FortuneArt Lighting (ESCO model available)	Mr Prasad	98851 15511	arvlines@gmail.com
87	LED	Avni Energy Solutions Pvt Ltd (ESCO model available)	Mr Sandip Pandey	76762 06777	sales@avnienergy.com
88	LED	Venture Lighting	Mr Karthikeyan	+91 (44) 2262 5567 / 2262 3094 Extn-6200	karthikeyan@vlindia.com

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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@skychade.in
92	Lighting Energy Saver/ Lighting Transformer	BEBLEC (INDIA) PVT. LTD.			mktg@beblec.com
93	Lighting Energy Saver/ Lighting Transformer	Servomax India Limited	Mr Pavan	98484 62496	pavankumar@servomax.net
94	Lighting Energy Saver/ Lighting Transformer	Consul Neowatt Private Limited	NA	+91 44 4000 4200	sri@consulneowatt.com
95	Low Grade WHR	Promethean Energy Pvt. Ltd.	Mr Ashwin KP	+91 9167516848	ashwinkp@prometheanenergy.com
96	Low Grade WHR	Oorja Energy Engg. Services	Mr.Madhusudhan Rao	9000332828	madhu@oorja.in
97	Online Flow Meters	Chandak Instruments Pvt. Ltd.	Mr Rohit Chandak	9371270655 / 9860088074	rohit@chandakinstruments.com
98	PF Boiler Combustion optimizer	Greenbank Group	Mr Vivek Savarianandam	7880710722	v.savarianandam@greenbankgroup.com
99	PID Loop Optimisation	Akxa Tech Pvt Ltd	Mr.Raghu Raj	9243209569	raghuraj.rao@akxatech.com
100	PID Loop Optimisation	Akxa Tech Pvt Ltd	Nagesh Nayak	9320266009	nagesh.nayak@akxatech.com
101	Pumps	Grundfos Pumps India Pvt. Ltd.,	Ms Mahathi Parashuram	44 45966896	mahathi@grundfos.com
102	Pumps	Grundfos Pumps India Pvt. Ltd.,	Mr.Shankar		shankar@grundfos.com
103	Pumps	UT Pumps & Systems Pvt. Ltd	Mr Athul Gupta	0129-4045831	atulgupta@utpsl.in
104	Pumps	KSB India	Mr Arora	0120 2541091 - 93 / 2542872 (D)	rajesh.arora@ksb.com
105	Pumps	Kirloskar Brothers Limited	Ashish Shrivastava	20-2721 4529 Mobile : 7774049493	Ashish.Shrivastava@kbl.co.in

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106	Pumps	CRI Pumps India Pvt. Ltd.	Mr Rajesh Magar	804227 9199	rajeshmagar.v@cripumps.com
107	Pumps	Shakti Pumps	Mr. Alpesh Kharachriya	7600030825	alpesh.kharachariya@shaktipumps.com
108	Pumps	Crompton Greaves	Mr. Vaibhav Jain	9654125359	vaibhav.jain@cgglobal.com
109	Pumps	Sulzer Pumps India Ltd	Mr Arvind singh	9971152020	arvind.singh@sulzer.com
110	Servo voltage Stabiliser	Globe Rectifiers	Mr Manoj Singh	9818222380	gr@globerectifiers.com
111	Servo voltage Stabiliser	Servomax India Pvt Ltd	Mr Pavan	98484 62496	pavankumar@servomax.net
112	Solar	Megawatt Solutions Pvt Ltd	Mr.Arjun Deshwal	9205476722	adeshwal@megawattsolutions.in
113	Solar	Megawatt Solutions Pvt Ltd	Mr.Siddharth Malik		smalik@megawattsolutions.in
114	Solar	Ohms Energy Private Limited	Mr Dhawal Kapoor	9987788335	dhawal.kapoor@ohmsenergy.com
115	Solar	Energy Guru®, SharperSun	Ms. Geetanjali Patil Choori	9970319054	uchoori@energyguru.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

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122	Boiler & Steam Systems	Thermax Ltd	Mr Ashish Vaishnav	8552822277	ashish.vaishnav@thermaxglobal.com
123	Boiler & Steam Systems	Forbes Marshall Pvt. Ltd.	Mr Kuvalekar Datta	9823199619	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	peraiakhch@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
137	Boiler	Energy Solutions	Mr Arnab	9831005354	Arnab231@gmail.com
138	Refrigeration Compressor	Frick India	Mr Rajendar Singh	9331059109	cal@frick.co.in
139	Heat Pump	Aspiration Energy	Mr. Sudharshan	98406 19252	sudharsan.r@aspirationenergy.com

6.3 ESP Implementation Format

FORMAT FOR MONITORING THE IMPLEMENTATION OF ENERGY SAVING PROPOSALS							
Sl. No.	ECM	Annual savings (lakhs)	Investment (lakhs)	Payback	Person Responsible	Target Date	Remarks
1	Waste heat recovery from chiller compressor	2.04	5.19	30.5			
2	Installation of VFD for chiller compressor	0.81	2.71	40.1			
3	Installation of Heat Pump for preheating boiler feed water	2.55	3.54	16.7			
4	Installation of 20 kWp Solar Roof Top	1.23	11.55	112.7			
5	Replacement of existing compressor with Screw Compressor	0.27	1	44.4			
	Total	6.9	23.99	42			

6.4 List of Energy Audit Equipment

SI 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

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