PERFORMANCE EVALUATION OF INDUSTRIAL THERMAL AND ELECTRICAL SYSTEMS

A Project Report

Submitted by

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DECLARATION

I hereby declare that this submission is my own and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other Degree or Diploma of the University or other Institute of Higher learning, except where due acknowledgement has been made in the text.

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ABSTRACT

Energy Audit is an essential task to assess the performance of the continuously operating thermal and electrical utilities. In this work both electrical and thermal utilities are assessed and the documentation of the results are produced. Trials of the utilities such as Chillers, Transformers, Compressors, Air handling utilities, Thermopac, Boiler, etc.., are conducted to acquire the data required for computation. In addition, billing analysis to validate the opportunity to increase the Power Factor and reduce the Sanction Load is carried out.

Improving the efficiency of the Utility in the industries is a highly recommendable way to mitigate carbon emissions in the environment without compromising the quality of production. This in turn helps a country to retain its pace of GDP growth at reduce emission rates. Efficient utilities gives maximum output for the energy consumed, which reduces the load on the network. Furthermore, this contributes to reduce the overall load on the network. In addition, the number units of energy generated at the generating side also decreases which leads to reduction in fuel as well as carbon emissions.

Microsoft Excel is used as a tool for computation. Standard prescribed equations from Bureau of Energy Efficiency to assess utilities are used to create tools in MS Excel for individual Utilities. Onsite measurement of the different parameters required for the assessment of the utility was taken. The measured parameters were used in MS Excel tool to compute the performance levels. Post assessment the results are compared with the standards to understand the % deviation in the performance and the root cause of it. Based on the observation and the mathematical conclusions changes are recommended to improve the performance with feasible monetary investments. Next, simple payback period is projected with respect to savings achieved after assessment.

The assessment showed that the Energy Management in both the industries were significantly poor and energy saving opportunity is very high. After computation it is observed that the proposed monetary savings for the proposed investment needed to improve the utilities performance is feasible. In addition, it was found out that by implementing the recommendation given for these industries will mitigate Co_2 emissions nearly 655 tonnes annually.

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INTRODUCTION

Energy scarcity and environmental pollution are two of the biggest challenges that our society is facing (1). From the survey data of energy and pollution, it is observed that energy and environmental pollution has made their ways towards sky because of the raising energy demand (2&3). This has alarmed the human race about the upcoming devastating events due to ecological imbalance (4). Previously it has been admitted that energy is more important for the development of any society, but now the wind of development has changed its motto from “ONLY ENERGY” to “ECO FRIENDLY ENERGY”

Power plants operating on fossil fuels are abundantly contributing to air pollution by emitting Co_2 rich flue gases. Which by considering on current status of our energy demand, it is difficult to shut these power plants even though they are highly inefficient in their operation (5). It is also true that, these power plants will be shut down once we reduce the load on them. In order to shift load from these power plants (6), promotion of the emission free energy source in this case renewable energy, has to be done on priority.

New goals and projects are set from the Indian Ministry of power to address these two issues, inefficient utilities and Co_2 emissions (7). Although shift from conventional energy to renewable sources of energy address majorly on the environmental related issues, it won’t completely suffice the increasing energy demand. Hence demand side management is more important to reduce the increasing energy consumption (6).

Inefficient electrical and thermal systems both in industrial as well as commercial sectors are the major contributors for the increasing energy demand. Converting these inefficient systems in to efficient ones will lead to the better results in terms of energy conservation as well as financial savings. To achieve the above targets, performance assessment and retrofitting of electrical and thermal utilities, should be considered at first place (8). Hence energy audit plays a very important role in energy conservation and pollution reduction.

LITERATURE REVIEW

This literature review focuses mainly on energy efficiency and Co_2 mitigation in industries.

Air Pollution takes number of years to reduce in the atmosphere. It increases global warming which leads to major calamities like climate change and loss of biodiversity (1).

Indian government has taken initiatives to achieve low carbon emissions and increase renewable sources of energy, but on the other side problems are still persisting such as inefficient electrical utilities and poor electricity network. Best available technologies can be implemented to convert inefficient utilities in industries to efficient one, which help to reduce specific energy consumption (2).

Coal stand first being primary energy source in India. It contributes up to 55% for the total energy requirement. Furthermore, power sector alone consumes 75% of the coal available in India (3).

Use of energy efficient devices such as CFL and LED lights for lighting will reduce energy demand and its counterparts such as global warming, emissions, etc. (4)

Transformer losses accounts for the majority of the loss in the electrical network because of its continuous operation. Majority of the loads in the industries are inductive in nature. When these loads shows losses it accounts for the majority of losses in the network. Hence retrofitting and replacement if necessary has to be taken care for these loads time to time (12).

MATERIALS AND METHODOLOGY

The major audit instruments used in energy auditing are as follows:

1. Power Analyzer
   It is used to collect real time data of energy consumed, harmonics, power factor and other associated electrical parameters in electrical network. This measures and stores current, voltage, active power, apparent power, reactive power, power factor, harmonics, etc from line to line as well as line to neutral in an electrical network. Normally it is used to assess all electrical utilities, but majorly used to assess power line, transformer, distribution panel & motor loads higher than 10kW.

   The data collection in this instrument is done by connecting potential transformers and current transformers to all the cables.

2. Clamp Meter
   Principle working of this instrument is same as of the power analyzer but doesn't all store the data. Also, it measures data of each line separately.

3. Lux meter
   Measures light intensity i.e. lux levels

4. Distance Meter
   Measures the distance. Used to measure the dimensions of the spaces.

5. Anemometer
   Measures the velocity of the air

6. Flow meter
   Measures the flow of liquid using Doppler Effect.

7. Flue Gas Analyzer
   Measures the quality of combustion of fuel and the composition of flue gases.

8. Digital Hygrometer
   Measures the temperature and relative humidity

9. Waveling Thermometer
   Measures dry bulb and wet bulb temperature

10. TDS meter
    Measures total dissolved salts in the water and additional features like PH and temperature can also be measured

In addition to these instruments materials like plier, LT gloves, safety shoes measuring tape, grease and pressure gauge, are used on the field to assist during measurements.

METHODOLOGY

The first and foremost things that has to be considered during measurement is where to measure?

Measurement of the parameters at the specified place gives better results. A brief procedure followed during the measurement of different parameters in most used instruments are as follows:

1. Power analyzer
    - Turn on power
    - Connect potential transformer wires to the power analyzer
    - Connect current transformer wires to the power analyzer
    - Wear LT Gloves and safety Shoes
    - Based on color coding, connect potential transformer to the bare cables/ exposed surface of the bar in distribution box for which voltage has to be measured.
    - Similarly connect current transformer to the cables/ bars.
    - Verify all the parameters, to know whether the connection proper, if yes
    - Turn on the recording. If no, then it will be a connection problem. So change it and verify it again

2. Clamp meter
    - Turn on power
    - Connect clamp to the cable that has to be measured, this gives majority of the electrical parameters. By operating the knob provided parameters required can be observed
    - To measure voltage, connect the probes provided in the clamp meter to the bear surface of the cables.

3. Flow meter
    - Select the area where laminar flow in the pipe is available, suitably long section of the pipe.
    - Measure the Outer diameter and collect the information of the thickness of the pipe.
    - Turn on the power source
    - Select the type of material available in the database, if the material is not available then insert new material and its required data.
    - Insert OD and thickness details.
    - Consider the output given by the instruments for transducer spacing
    - Transducers are used here to create ultrasonic signals to measure flow
    - Based on the spacing needed to mount transducer, file the surface of the pipe
    - Connect transducer to the flow meter through wires
    - Apply grease to both filed surface of the pipe and to the transducer surface, to arrest vibration, which may lead to errors during measurement
    - Wait till the flow attains stable value and note it down
    - Conduct 2 to 3 trails and consider the average value of them for calculation.

4. Flue gas analysis
    - Select the area where flue gas has to be measured, in this case studies, measurements are carried out right after the boiler, after Thermopac, after air pre heater & before chimney

- Connect the probe to the digital flue gas analyzer
- Turn on the device
- Wait until the device gets calibrated.
- Insert the probe in the hole provided for measurement of temperature. If hole is not provided ask the concerned person to drill a hole.
- During measurement wait until the value attains saturation for better accuracy.
- Conduct 2 to 3 trails and consider the average value.

CASE STUDY 1: INDUSTRY NO. 1

INTRODUCTION

The Industry No. 1 is new and latest one. The major products are: Hair oil, Gulabari, Kewara water, and Hajmola. The products manufactured by Industry No. 1 are valuable, useful and well accepted in the domestic as well as in international market.

ENERGY SOURCE

Electricity is the major source used in this Industry No. 1. They are having HT connection at 11 KV provided by the Govt. of J & K Power Development Department Electric Maint. & R.E. Wing, Jammu. In addition of the above supply, they have installed 100% power back-up by Diesel Generators i.e. 500 KVA x 2 Nos. + 250 KVA x 3 Nos. At few places, they have installed solar system also.

ELECTRICITY SUPPLY

This Industry No. 1 receives the supply at 11 KV from the J & K Power development department. They are having 4 Nos. of transformer i.e. 1 x 1000 KVA, 1x 630 KVA and 2 x 250 KVA each. The voltage ratio of transformation is 11kV/440V.

MAJOR ENERGY USE AND AREA

Major energy consumption is for compressor, HVAC, Thermal utilities, process machines, lighting, Split & Window A.C., computer system, UPS and for miscellaneous load like geysers, blowers, etc.

AREAS COVER DURING AUDIT

We have covered entire area of the Plant and found out the scope of savings. Such as HVAC system, compressors, DG sets, process machines, electrical system, Lighting electricity bills analysis, load distribution system, power factor and MDI analysis etc., boilers, and other equipment, transformers and DG are covered in the energy audit.

HVAC SYSTEM

The Industry No. 1 has installed 4 Nos. of chillers i.e. 1x100 TR, 1x 62 TR, 1x 40 TR and 1 x 17 TR. The first 3 chillers are being used for unit-3 and one is used for unit-2. In addition of the above, around 26 Nos. of split and window A.C. are being used at different locations. They have also installed some fresh air AHU

PERFORMANCE ANALYSIS OF TRANSFORMERS

The Industry No. 1 is receiving HT supply at 11 KV from SEB of J & K Govt. and this 11 KV supply is reduced to 415 volts with the help of 4 Nos. of stepped down transformers i.e.

- 1 No. X 1000 KVA for unit-3,
- 2 Nos. X 250 KVA each for unit 1 & 4. (only one functional)
- 1No. X 630 KVA for unit-2.

During audit, all the working transformers recording is done for 24 hrs. To see the overall load profile as well as analyze the power quality data. All important power quality and electrical parameters are recorded i.e. frequency, voltage, current, power in watts, power factor, % total harmonic distortion in current and voltage and % unbalance in voltage and current. The summary of recording is as follows:

630 KVA TRANSFORMER NO. 1

24 hours recording of 630 KVA Transformer No. 1 (unit-2) (03.02.16, 11:30 AM to 04.02.16, 11:00 AM)				
Data	**Minimum**	**Maximum**	**Average**	**Remarks**
Frequency	49.96	50.13	50	Current unbalance is slightly on higher side
Voltage V	414	426.5	422	
% THDv	2.1	5.0	3.6	
Current(Amps)	75	175	138	
% THDi	3.7	13.0	7.3	
KW	55.34	129	101.97	
Power Factor	0.84	0.99	0.986	
% Voltage unbalanced	0.1	0.6	0.3	
% Current unbalanced	0.8	11.5	6.96	
% loading	10.5	20.7	16.4	

Table 1: 630kVA Transformer performance data

250KVA TRANSFORMER NO. 2

24 hours recording of 250KVA Transformer No. 2 (Unit-1 & 4) (02.02.16, 11:15 AM to 03.02.16, 11:15 AM)				
Data	**Minimum**	**Maximum**	**Average**	**Remarks**
Frequency	49.89	50.12	50	Current unbalance and harmonic distortion is very high Avg.PF is low
Voltage V	381	435	413	
% THDv	2.4	6.2	4.2	
Current(Amps)	46	100	70	
% THDi	9.0	30	17.98	
KW	28.35	61.84	44.15	
Power Factor	0.85	0.99	0.94	
% Voltage unbalanced	0.1	1	0.90	
% Current unbalanced	7.2	26.3	18.17	
% Loading	13.34	24.98	18.79	

Table 2: 250kVA Transformer performance data

1000 KVA TRANSFORMER NO. 3

24 hours recording of 1000 KVA Transformer No. 3 (Unit-3) (02.02.16, 11:30 AM to 03.02.16, 10.45 AM)				
Data	**Minimum**	**Maximum**	**Average**	**Remarks**
Frequency	49.89	50.12	50	Current unbalance and harmonics distortion is high
Voltage V	413.3	424.5	415	
% THDv	2.0	5.9	4.20	
Current(Amps)	302	440	388	
% THDi	8.4	18	13	
KW	212.13	315	279.46	
Power Factor	0.965	0.99	0.98	
% Voltage unbalanced	0.2	0.6	0.37	
% Current unbalanced	6.6	13.7	9.67	
% Loading	21.98	31.8	28.5	

Table 3: 1000kVA Transformer performance data

TRANSFORMER LOSS ANALYSIS

FORMULA

$$\textbf{Power loss in Transformer} = \textbf{No load Loss} + \left(\frac{kVA\ load}{Rated\ kVA}\right)^2 \times Full\ Load\ Loss$$

Existing Transformer losses: (As per Indo Tech Transformers Technical Data Sheet)

TRANSFORMATION LOSSES					
Sl. No.	**Parameters**	**Units**	**Values**		
1	**Transformer Capacity**	kVA	**1000**	**630**	**250**
2	**No Load Loss**	W	1500	1200	600
3	**Full Load Loss**	W	10800	6650	3600
4	**Power Factor**		0.98	0.986	0.94
5	**Average Load**	kW	279.46	101.97	44.15
		kVA	285.163	103.418	46.9681
6	**Actual Load Loss**	W	878.235	179.197	127.066
7	**Existing Loss**	kW	2.378	1.379	0.727
8	**Total Transformers Loss**	kW	**4.484**		

Table 4: Transformer Losses

Total Existing losses/hr. = 4.484 kW

RECOMMENDATION AND SAVINGS CALCULATION

Shift entire load to 1000 KVA transformer to reduce transformation losses.

ENERGY SAVINGS CALCULATION					
Sl. No.	**Parameters**	**units**	**Values**		
1	**Transformer Capacity**	kVA	1000	630	250
2	**Average Load**	kW	279.46	101.97	44.15
		kVA	285.163	103.418	46.9681
3	**Total Average load**	kVA	436		
4	**Proposed Transformer Capacity**	kVA	1000		
5	**No Load Loss**	W	1500		
6	**Full Load Loss**	W	10800		
7	**Total Transformation Loss**	kW	3.55		
8	**Current Transformer Loses**	kW	4.484		
9	**Saving**	kWh	0.936		
10	**Annual Savings**	kWh	8197		
11	**Monetary Savings @ 2.945/kWh**	INR	24139		

Table 5: Energy Savings calculations for Transformers

Annual Savings by shifting load to 1000 kVA Transformer = **24139** INR/-

OTHER OPTIONAL RECOMMENDATIONS

- Unit 1, 2 & 4 can be fed by only 630 KVA transformer. It depends on the load profile of the plant time to time and the concerned person has to see the techno-economics for the same and best option should be chosen to minimize the transformer losses and should have all the load transfer option all the time.
- For reducing the impact of harmonics on system, the concerned person should go for de-tuned filters along with the capacitors.
- The capacitors should be checked on regular basis and record must be maintained and signed by competent authority. The details of capacitor performance is as follows:

CAPACITORS PERFORMANCE ASSESMENT

The plant has installed three capacitor banks of the capacity 200 kVAr, 200 kVAr and 75 kVAr.

During the study the performance of different capacitor bank has been checked.

FORMULA

$$\% \textbf{ Deration} = \left(\mathbf{100} - \left(\frac{\textbf{Average Current}}{\textbf{Rated current}}\right) \times \mathbf{100}\right)$$

The results are as follows:-

UNIT-1

Bank no.	Rated Capacity (kVAr)	Rated Current (amp.)	Actual Current, R/Y/B			Average Current	% De-Ration
1	25	33	32.2	33	32.7	32.63	1.11
2	25	33	0	0	0	0.00	100.00
3	25	33	0	0	0	0.00	100.00

Table 6: Unit 1 Capacitor test data

UNIT-2

Bank no.	Rated Capacity (kVAr)	Rated Current (amp.)	Actual Current, R/Y/B			Average Current	% De-Ration
1	20	26.4	26	26	26.2	26.07	1.26
2	20	26.4	13.6	14.9	24	17.50	33.71
3	20	26.4	26	26	25	25.67	2.78
4	10	13.2	0	0	0	0.00	100.00
5	10	13.2	14.5	0	12.9	9.13	30.81
6	40	52.8	0.4	0.4	0	0.27	99.49
7	5	6.6	0	0	2.6	0.87	86.87
8	5	6.6	3.3	5.5	6	4.93	25.25
9	10	13.2	11.8	11.7	11	11.50	12.88
10	20	27.456	9.6	0	9.7	6.43	76.57
11	20	27.456	14.4	14.2	0	9.53	65.28
12	20	27.456	13.1	0	0	4.37	84.10

Table 7: Unit 2 Capacitor test data

UNIT-3

Bank no.	Rated Capacity (kVAr)	Rated Current (amp.)	Actual Current, R/Y/B			Average Current	% De-Ration
1	25	33	22	34	22	26.00	21.21
2	25	33	25.5	26.1	33.8	28.47	13.74

3	25	33	33	32	33	32.67	1.01
4	25	33	0	0	1.5	0.50	98.48
5	25	33	33	32	33	32.67	1.01
6	25	33	0	26.7	30	18.90	42.73
7	5	6.6	6.5	6.6	6.3	6.47	2.02
8	10	13.2	12.5	12	13	12.50	5.30
9	10	13.2	12.8	12.9	13	12.90	2.27
10	25	33	33	32.9	33	32.97	0.10

Table 8: Unit 3 Capacitor test data

OBSERVATIONS & SUGGESTIONS

- Most of the capacitors are de-rated and damaged. Hence replace those capacitors.
- Capacitors de rated more than 25-30% should be replaced to maintain power factor at optimum level.
- Check capacitors regularly

ELECTRICITY BILL ANALYSIS

- The Industry No. 1 is receiving supply from J & K Govt. at 11 KV with three HT connections.
- The 11 KV supply is then reduced to 433 volts with the help of 4 Nos. of step-down transformers of different capacities i.e. 1000 KVA, 630 KVA and 2 Nos. x 250 KVA each.
- LT supply goes to feeders of the sub-stations and then goes to departmental DBs and then to individual machine.
- During energy audit, electricity bills of last 21 months were collected and assessed i.e. April 2014 to Dec.2015 for each connection.
- The tariff structure is as follows:
- The company has two part tariff i.e. fixed charges towards demand and energy charges and the details are as follows:

Demand charges : Rs. 153 per kW or Rs.114 per HP

If no demand is recorded then 100% charge is payable as per Sanctioned demand

Unit charges : Rs. 2.68 per unit

Electricity duty : 22% of unit charges.

Revised electricity duty : 10% from Oct.2015 onward

Billing on : kVAh

Per unit average cost was coming around Rs.4.70 in unit 1 & 2 and Rs. 3.73 in unit -3.

DETAILED BILL ANALYSIS UNIT 1

Location : Unit 1		Period: 2014-15 & 2015-16					
Month	**Sanctioned load**	**Total unit cons.**	**Demand charges**	**Unit charges**	**Electricity Duty**	**Total bill amount**	**Per unit cost**
14-Apr	298.4 kW	31800	45760	85224	18749	149733	4.709
14-May	298.4 kW	37800	45760	101304	22287	169351	4.480
14-Jun	298.4 kW	41400	45760	110952	24409	181121	4.375
14-Jul	298.4 kW	39006	45760	104536	22998	173294	4.443
14-Aug	298.4 kW	32616	45760	87411	19230	152401	4.673
14-Sep	298.4 kW	26808	45760	71845	15806	133411	4.977
14-Oct	298.4 kW	24990	45760	66973	14734	127467	5.101
14-Nov	298.4 kW	23562	45760	63146	13892	122798	5.212
14-Dec	298.4 kW	25428	45760	68147	14992	128899	5.069
15-Jan	298.4 kW	30024	45760	80464	17702	143926	4.794
15-Feb	298.4 kW	27072	45760	72553	15962	134275	4.960
15-Mar	298.4 kW	19470	45760	52179.6	11480	109419	5.620
15-Apr	298.4 kW	29394	45760	78775.92	17330.7	141866.62	4.826
15-May	298.4 kW	38742	45760	103828.6	22842.28	172430.84	4.451
15-Jun	298.4 kW	41544	45760	111337.9	24494.34	181592.26	4.371
15-Jul	298.4 kW	41274	45760	110614.3	24335.15	180709.47	4.378
15-Aug	298.4 kW	36066	45760	96656.88	21264.51	163681.39	4.538
15-Sep	298.4 kW	38700	45760	103716	22817.52	172293.52	4.452
15-Oct	298.4 kW	36702	45760	98361.36	21639.5	165760.85	4.516
15-Nov	298.4 kW	31410	45760	84178.8	8417.88	138356.68	4.405
15-Dec	298.4 kW	34344	45760	92041.92	9204.192	147006.11	4.280
Total		**688152**	**960960**	**1844246**	**384587.1**	**3189792.74**	**4.697**

Table 9: Unit 1 Bill Analysis.

Total energy consumption (21 months)	:	688152 units
Annual Avg. power consumption	:	393230 units
Total demand charges for 21 months	:	Rs.960960 (30% of total)
Total energy charges for 21 months	:	Rs.1844246
Electricity duty	:	Rs. 384587
Total charges for 21 months	:	Rs. 3189793
Avg. per unit cost	:	Rs. 4.70 per unit
Per unit fixed charges	:	Rs.1.40

DETAILED BILL ANALYSIS UNIT 2

Location : Unit 2		Period : 2014-15 & 2015-16					
Month	**Sanctioned load**	**Total unit cons.**	**Demand charges**	**Unit charges**	**Electricity Duty**	**Total bill amount**	**per unit cost**
14-Apr	373 kW	24198	57070	64850.64	14267	136188	5.63
14-May	373 kW	37404	55753	100242.7	22053	178049	4.76
14-Jun	373 kW	36240	57070	97123.2	21367	175560	4.84
14-Jul	373 kW	68142	57070	182620.6	40177	279867	4.11
14-Aug	373 kW	47268	57070	126678.2	27869	211617	4.48
14-Sep	373 kW	36672	57070	98280.96	21622	176973	4.83
14-Oct	373 kW	21972	57070	58884.96	12955	128910	5.87
14-Nov	373 kW	23940	57070	64159.2	14115	135344	5.65
14-Dec	373 kW	26508	57070	71041.44	15629	143741	5.42
15-Jan	373 kW	30270	57070	81123.6	17847	156041	5.15
15-Feb	373 kW	45960	57070	123172.8	27098	207341	4.51
15-Mar	373 kW	44718	57070	119844.2	26366	203280	4.55
15-Apr	373 kW	36066	57070	96657	21265	174991	4.85
15-May	373 kW	43176	57070	115712	25457	198238	4.59
15-Jun	373 kW	54444	57070	145910	32100	235080	4.32
15-Jul	373 kW	54936	57070	147228	32390	236689	4.31
15-Aug	373 kW	48192	57070	129155	28414	214639	4.45
15-Sep	373 kW	50328	57070	134879	29673	221622	4.40
15-Oct	373 kW	61950	57070	166026	36526	259622	4.19
15-Nov	373 kW	58854	57070	157729	15773	230572	3.92
15-Dec	373 kW	50094	57070	134252	13425	204747	4.09
Total		**901332**	**1197153**	**2415571**	**496388**	**4109111**	**4.71**

Table 10: Unit 2 Bill Analysis

Total energy consumption (21 months)	:	901332 units
Annual Avg. power consumption	:	515047 units
Total demand charges for 21 months	:	Rs. 1197153 (29% of Total)
Total energy charges for 21 months	:	Rs. 2415571
Electricity duty	:	Rs. 496388
Total charges for 21 months	:	Rs. 4109111
Avg. per unit cost	:	Rs. 4.71 per unit
Per unit fixed charges	:	Rs. 1.33

DETAILED BILL ANALYSIS UNIT 3

Location : Unit 3		Period : 2014-15 & 2015-16					
Month	**Sanctioned load**	**Total unit cons.**	**Demand charges**	**Unit charges**	**Electricity Duty**	**Total bill amount**	**Per unit cost**
14-Apr	559.5 kW	150152	85670	402407	88530	576607	3.84
14-May	559.5 kW	187736	85670	503132	110689	699492	3.73
14-Jun	559.5 kW	152728	85670	409311	90048	585029	3.83
14-Jul	559.5 kW	210760	85670	564837	124264	774771	3.68
14-Aug	559.5 kW	210216	85670	563379	123943	772992	3.68
14-Sep	559.5 kW	183120	85670	490762	107968	684399	3.74
14-Oct	559.5 kW	188744	85670	505834	111283	702787	3.72
14-Nov	559.5 kW	166912	85670	447324	98411	631405	3.78
14-Dec	559.5 kW	152920	85670	409826	90162	585657	3.83
15-Jan	559.5 kW	148784	85670	398741	87723	572134	3.85
15-Feb	559.5 kW	125152	85670	335407	73790	494867	3.95
15-Mar	559.5 kW	103432	85670	277198	60984	423851	4.10
15-Apr	559.5 kW	162312	85670	434996	95699	616365	3.80
15-May	559.5 kW	188784	85670	505941	111307	702918	3.72
15-Jun	559.5 kW	214536	85670	574956	126490	787117	3.67
15-Jul	559.5 kW	220312	85670	590436	129896	806002	3.66
15-Aug	559.5 kW	207808	85670	556925	122524	765119	3.68
15-Sep	559.5 kW	197712	85670	529868	116571	732109	3.70
15-Oct	559.5 kW	226256	85670	606366	133401	825437	3.65
15-Nov	559.5 kW	188168	85670	504290	50429	640389	3.40
15-Dec	559.5 kW	190000	85670	509200	50920	645790	3.40
Total		**3776544**	**1799070**	**10121136**	**2105032**	**14025237**	**3.73**

Table 11: Unit 3 Bill Analysis

Total energy consumption (21 months)	:	3776544 units
Annual Avg. power consumption	:	2158025 units
Total demand charges for 21 months	:	Rs. 1799070 (12.8% of total)
Total energy charges for 21 months	:	Rs. 10121136
Electricity duty	:	Rs. 2105032
Total charges for 21 months	:	Rs. 14025237
Avg. per unit cost	:	Rs. 3.73 per unit
Per unit fixed charges	:	Rs. 0.48

ANALYSIS AND COMMENTS

- It is seen from the analysis that in unit-1, the average per unit cost is coming around Rs. 4.70 and ranging between Rs.4.28 to 5.62. The major reason for higher per unit cost is the lower utilization and higher fixed charges. Per unit fixed charges is coming around Rs. 1.40 per unit against Rs. 0.48 in unit-3. The same trend is also observed in unit-2.
- In unit-3, the average per unit cost is coming around Rs.3.73 and ranging between Rs.3.65 to 4.10 and the fixed charges per unit is coming around Rs. 0.48 per unit.
- For reducing, overall cost, the company has to reduced his demand by partial surrendering of the excess demand as follows:

Existing System

Actual load unit-1	:	48 kW (assumed 60 kW max.)
Sanctioned load unit-1	:	298 kW
Actual load of unit-2	:	125 kW (assumed 150 kW)
Sanctioned load unit-2	:	373 kW
Actual load of unit-3	:	325 kW (assumed 500 kW)
Sanctioned load of unit-3	:	560 kW

So the total sanctioned load is 1230 kW and existing running load is 500 kW and peak expected load is assumed 710 kW. So as on safer side, the company can consider 800 kW peak running load and safely surrender 430 kW or say 400 kW. The expected saving is as follows:

Existing sanctioned load	:	1230 kW
Existing running load	:	500 kW
Peak load assumed	:	830 kW
Scope of surrendering demand	:	400 kW
Fixed Rate per kW	:	Rs. 153 per kW
Annual expected saving	:	400 x 153 x 12
	:	Rs.7, 34,400/-
Investment	:	Nil

D.G. SET PERFORMANCE ANALYSIS

- The Industry No. 1 has installed 5 Nos. of DG sets at different locations.
- Out of the 5 DG sets, 2Nos. are of 500 KVA of Cummins make and 3Nos. of 250 KVA each of Cummins make.
- They operate the DG set during power failure to meet the emergency requirement of the plant.
- During audit, we have taken trial of all the working DG sets and the trial data are as follows:

<table>
<tr><th>SL. NO.</th><th colspan="10">NAME PLATE DETAILS</th></tr>
<tr><td>1</td><td>Designated Unit No.</td><td colspan="3">3</td><td colspan="3">1</td><td colspan="3">2</td></tr>
<tr><td>2</td><td>Capacity (kVA)</td><td colspan="3">500</td><td colspan="3">250</td><td colspan="3">250</td></tr>
<tr><td>3</td><td>No.</td><td colspan="3">2</td><td colspan="3">2</td><td colspan="3">1</td></tr>
<tr><td>4</td><td>Make</td><td colspan="3">Cummins</td><td colspan="3">Cummins</td><td colspan="3">Cummins</td></tr>
<tr><td>5</td><td>Rated Current(Amp)</td><td colspan="3">695</td><td colspan="3">348 A</td><td colspan="3">348 A</td></tr>
<tr><td>6</td><td>Rated voltage(Volts)</td><td colspan="3">415</td><td colspan="3">415</td><td colspan="3">415</td></tr>
<tr><td>7</td><td>Year of commissioning</td><td colspan="3">Nov.2013</td><td colspan="3">2002</td><td colspan="3">2006</td></tr>
<tr><td>8</td><td>Fuel Tank capacity</td><td colspan="3">800 Ltrs</td><td colspan="3">425 Ltrs.</td><td colspan="3">1000 Ltrs.</td></tr>
<tr><td colspan="11">TRIAL RUN DATA</td></tr>
<tr><td>9</td><td>Trial Run Date</td><td colspan="3">03.02.2016</td><td colspan="3">03.02.2016</td><td colspan="3">04.02.2016</td></tr>
<tr><td>10</td><td>Trial start time</td><td colspan="3">4:50 PM</td><td colspan="3">3:30 PM</td><td colspan="3">11:26 AM</td></tr>
<tr><td>11</td><td>Trial finish time</td><td colspan="3">5:50 PM</td><td colspan="3">4:30 PM</td><td colspan="3">12:26 PM</td></tr>
<tr><td>12</td><td>Frequency(Hz.)</td><td colspan="3">50.57</td><td colspan="3">51.4</td><td colspan="3">50.38</td></tr>
<tr><td>13</td><td>Voltage(Volts)</td><td colspan="3">410.8</td><td colspan="3">411</td><td colspan="3">408 (avg.)</td></tr>
<tr><td rowspan="2">14</td><td rowspan="2">Current(Amps)</td><td>Min</td><td>Max</td><td>Avg.</td><td>Min</td><td>Max</td><td>Avg.</td><td>Min</td><td>Max</td><td>Avg.</td></tr>
<tr><td>217</td><td>467</td><td>403.2</td><td>54</td><td>89.5</td><td>69.3</td><td>106.6</td><td>166</td><td>149</td></tr>
<tr><td>15</td><td>KW (avg.)</td><td colspan="3">259.3</td><td colspan="3">48.6</td><td colspan="3">91.78</td></tr>
<tr><td>16</td><td>Power Factor</td><td colspan="3">0.9</td><td colspan="3">0.98</td><td colspan="3">0.86</td></tr>
<tr><td>17</td><td>THD_i (%)</td><td colspan="3">2.2 -5.67</td><td colspan="3">8.0 – 19</td><td colspan="3">2.0-3.3</td></tr>
<tr><td>18</td><td>THD_v (%)</td><td colspan="3">1.33 – 3.2</td><td colspan="3">1.5 – 3.3</td><td colspan="3">0.7 - 0.2</td></tr>
<tr><td>19</td><td>Units Generated (kWh)</td><td colspan="3">260.86</td><td colspan="3">48.112</td><td colspan="3">91.83</td></tr>
<tr><td>20</td><td>Fuel consumed (Ltrs)</td><td colspan="3">78.65</td><td colspan="3">26.78</td><td colspan="3">32</td></tr>
<tr><td>21</td><td>Specific fuel Consumption (units/Liter)</td><td colspan="3">3.32</td><td colspan="3">1.8</td><td colspan="3">2.87</td></tr>
<tr><td>22</td><td>Lubricating oil pressure (Kg/Cm^2)</td><td colspan="3">4.0 -5.5</td><td colspan="3">3.1 – 3.3</td><td colspan="3">4.7 - 5.36</td></tr>
<tr><td>23</td><td>Water Temp.(Degree Centigrade)</td><td colspan="3">72</td><td colspan="3">67</td><td colspan="3">67-73</td></tr>
<tr><td>24</td><td>Average Loading %</td><td colspan="3">65%</td><td colspan="3">24.30%</td><td colspan="3">45.90%</td></tr>
</table>

Table 12: DG Set Test Data

ANALYSIS AND COMMENTS

Details of specific fuel consumption (ltrs/Unit)

S.No.	DG capacity	% loading	Units generation/hr.	Fuel consumption/hr.	SFC
1	250 KVA, Unit No1	24.3	48.112	26.78	.56
2	250 KVA, Unit-No.2	45.91	91.83	32.0	.34
3	500 KVA, Unit- No.3	65.0	260.86	78.65	.30

Table 13: Details of specific fuel consumption

MECHANICAL EFFICIENCY OF DG SETS

S.No.	DG capacity	% loading	Energy Input *(kcal)*	Energy Output *(kcal)*	% Efficiency
1	250 KVA, No1	24.3	317075.2	41376.3	13.05
2	250 KVA,No.2	45.91	378880	78973.8	20.84
3	500 KVA, unit-3	65.0	931216	219122.4	23.53

Table 14: Mechanical Efficiency of DG Sets

- The operation and maintenance of DG sets is good.
- Approximately 15-17% power of the total power is generated from DG sets.
- The DG sets normally run on low load condition and at low load operation, the specific fuel consumption (ltrs/unit) becomes high and per unit cost increases.
- During power cuts, they operate all 3 DG sets i.e. 500 KVA for unit-3, 250 each for unit 1 & 2. The total load of DG sets are 1000 KVA or 800 KW while the running load is around 400-425 kW.
- Load sharing using 500kVA DG reduces the fuel consumption and in turn the operating cost i.e. Unit-1 and Unit-3 loaded on 500kVA DG set. Existing fuel consumption of the DG sets connected to Unit-1 and Unit-2 are cumulatively 105 ltrs/hr.
- If the entire load is shifted to 500 KVA then total fuel consumption will be around 90 ltrs and saving is around 15 ltrs /hr. the detailed savings are as follows:

Existing operation for unit 1 & 3	=	500 + 250 KVA
Existing load on both sets	=	260 + 48 kW
Existing fuel consumption	=	78.65 + 26.78ltrs
The existing SFC is	=	0.3 and .56 ltrs/unit
If total load run on 500 KVA, the SFC will be	=	.3 ltrs/unit
The expected fuel consumption will be	=	90 ltrs*

Expected fuel saving	=	15 ltrs
Annual fuel saving @ 800 hrs/yr. operation	=	12000 ltrs
Annual monetary saving @ Rs.50/-per liter	=	Rs. 6.0 lakhs
Investment towards changeover	=	NIL

* Approximate values.

- Other options also may be considered i.e. when two 500 KVA DG sets are operated, then entire plant load can be shifted on both the DG sets then no need to run other small DG sets. But monitoring is important.
- The concerned operator should operate the sets according to KW load not the amperes.
- In case load slightly increases, instead of starting another DG set, try to cut non-critical load for some time and again start when avg. load comes down.
- Hence always operate the sets according to total load and apply load management system, that how the total load can be managed with operating minimum DG sets and try to achieve 70-85% load on DG sets for efficient operation and achieving good SFC.
- The oil tanks should be calibrated and their capacity should be marked on DG sets body.
- The unit-2 cables are also laid up to unit-3 sub-station few years ago so the concerned persons should check the cable conditions and arrange suitable changeover system. So that load of unit-2 can be switchover to any unit as per load management.
- The weekly statement should be prepared and SFC should be calculated and compare with the standards and analyse the losses and plan to reduce losses in future

PERFORMANCE ANALYSIS OF AIR COMPRESSORS

The compressed air system is not only an energy intensive utility but also one of the least energy efficient. Industry No. 1 has 5 compressors. Details of compressors are as follows:-

S.No.	***Make***	***Model***	***Installed Capacity in cfm***	***Motor Power in KW***
1	Atlas CopCo	***GA11***	55	11
2	Atlas CopCo	***GA15***	80	15
3	Atlas CopCo	***GA30***	180	30
4	Atlas CopCo	***GA18***	95	18
5	Kaeser		173	25

Table 15: List of Air Compressors

COMPRESSED AIR SYSTEM LEAKS

- Leaks can be a significant source of wasted energy in an industrial compressed air system, sometimes wasting 20-30% of a compressor's output.
- A typical plant that has not been well maintained will likely have a leak rate equal to 20% of total compressed air production capacity.
- On the other hand, proactive leak detection and repair can reduce leaks to less than 10% of compressor output.

While leakage can come from any part of the system, the most common problem areas are:

✓ Couplings, hoses, tubes, and fittings,
✓ Pressure regulators,
✓ Open condensate traps and shut-off valves, and
✓ Pipe joints, disconnects, and thread sealants.

FORMULA

1. $\% \, Leakage = \frac{T}{(T+t)} \times 100$, where T : loading time in minutes,
   t : Unloading time in minutes
2. $Q = \frac{P_2 - P_1}{P_0} \times \frac{V}{T} \, m^3/min$, where P_1 : Initial pressure after bleeding in kg/cm^2.
   P_2 : Final pressure after filling in kg/cm^2, P_0 : Atmospheric pressure in kg/cm^2.
   V : Storage Volume in m^3, T: Time taken to build pressure up to P_2 in kg/cm^2 in minutes.

OBSERVATIONS & RECOMMENDATIONS

During the audit it was observed that air leakage in few compressors is significant and performance testing & calculations are as follows:

PERFORMANCE TEST OF COMPRESSORS : GULABARI AND HAIROIL SECTION				
Sl.No.	**Parameters**	**Units**	**Measured Values**	**Measured Values**
1	Location		***Unit 1&4***	***Unit 1&4***
2	Compressor Identity		***GA11***	***GA15***
3	Rated Delivery	cfm	55	80
4	Atmospheric Pressure	Kg/cm2	1.027	1.027
5	Initial Pressure	Kg/cm2	0.00	0.0000
6	Final Pressure	Kg/cm2	6.20	6.50
7	Pump up time	min	3.00	2.00
8	Total volume	m3	0.80	0.5600
9	Free Air delivery	m3/min	1.61	1.7722
10	FAD	cfm	56.80	62.5215
11	Actual power Consumed	KW	11.00	16.00
12	Specific Power Consumption	cfm/KW	5.16	3.9076
13	Performance		Satisfactory	Satisfactory

Table 16: Performance Test of Compressors- Gulabari and Hairoil Section

PERFORMANCE TEST OF COMPRESSORS : HAJMOLA AND CREAM SECTION					
Sl.No.	**Parameters**	**Units**	**Measured Values**		
1	Location		***Unit 2 &3***	***Unit 2 &3***	***Unit 2 &3***
2	Compressor Identity		***GA30***	***GA18***	***Kaeser***
3	Rated Delivery	cfm	180	95	173
4	Atmospheric Pressure	Kg/cm2	1.027	1.027	1.027
5	Initial Pressure	Kg/cm2	0	0	0
6	Final Pressure	Kg/cm2	7	7	7
7	Pump up time	min	2.000	4.000	2.580
8	Total volume	m3	1.500	1.500	1.500
9	Free Air delivery	m3/min	5.112	2.556	3.963
10	FAD	cfm	180.351	90.175	139.807
11	Actual power Consumed	KW	32	20	26
12	Specific Power Consumption	cfm/KW	5.636	4.509	5.377
13	Performance		Satisfactory	Satisfactory	Satisfactory

Table 17: Performance test of compressors: Hajmola and Cream Section

LEAKAGE TEST AND MONETARY SAVINGS			
Sl. No.	**Parameters**	**Units**	**Measured Values**
1	Location		Unit 1&4
2	Compressor Identity		GA11
3	Rated Delivery	cfm	55
4	Loading Time	Min	0.83
5	Unloading Time	Min	4.17
6	Leakage	%	16.66
7	Permissible Leakage	%	5
8	Net leakage	%	11.66
9	FAD	cfm	56.80
10	System Air Leakage loss	cfm	6.62
11	No of working hours @ 18hrs/day	Hrs.	6570
12	Annual compressed air Loss	cfm	43509.34
13	Actual power consumption	kW	12.5
14	Specific energy consumption	cfm/KW	4.5
15	Annual units loss	kWh	9575.775
16	Cost per Unit	INR	2.95
17	Potential Monetary savings	INR	**28249**

Table 18: Leakage Test and Monetary Savings

In addition to the above calculations, it is observed that the compressors GA18 and GA30 have never achieved the required pressure due to continuous loss in the line. Considering the loss of 200cfm for both GA18 and GA30 Potential Monetary savings are computed as follows:

MONETARY SAVINGS CALCULATIONS				
Sl.No.	***Parameters***	***Units***	***Measured Values***	
1	Location		***Unit 2 &3***	***Unit 2 &3***
2	Compressor Identity		***GA18***	***GA30***
3	Actual Power	kW	16.5	32
4	Total power	kW	48.5	
5	Loss due to leakage	cfm	200	
6	FAD	cfm	90.2	180.4
7	Total FAD	cfm	270.5	
8	Specific Power consumption	kW/cfm	0.179280495	
9	Total No. of working hours @ 24hrs/day	Hrs.	8760	
10	Annual Energy Loss	kWh	314099.4277	
11	Cost per unit	INR	2.95	
12	Annual monetary loss	INR	**926593**	

Table 19: Monetary savings Calculations

MONETARY SAVINGS SUMMARY			
Sl. No.	***Compressor No***	***Savings***	***Units***
1	GA11	28249	INR
2	GA 18& GA30	926593	INR
	Total	**954842**	**INR**

Table 20: Savings Summary

CAUSES FOR PERFORMANCE DEGRADTION

1. Condensed water vapors in the receiver leads to the decreased capacity of the receiver hence the flow reduces.
2. Leakages in the line is also one of the major contributor to the elevated power consumption. Due to the leaks, the receiver always losses pressure hence the compressor works continuously.

CHILLER'S PERFORMANCE ANALYSIS

The chiller load in the different sections of plant is as follows:

CHILLERS			
Sl. No.	Area	Unit No.	Load in TR
1	Hairoil	1	Nil
2	Cream Section	2	17
3	Hajmola	3	62+100+40
4	Gulabari	4	Nil

Table 21: Chiller Loads

During the audit only 1 chiller was continuously working i.e., 62TR and the rest i.e., 40TR and 17TR were made to work to conduct trials.

SPECIFIC POWER CONSUMPTION					
Sl. No.	Parameters	Units	Computed values	Computed values	Computed values
1	Capacity	TR	62	40	17
2	Compressors	KW/TR	0.90	0.80	0.59
3	Pumps	KW/TR	0.46	0.51	0.60
4	Cooling Tower	KW/TR	0.10	0.12	0.13
5	Overall	KW/TR	1.46	1.42	1.32

Table 22: Overall Specific Power Consumptions

EVALUATION

PERFORMANCE ASSESSMENT OF CHILLERS					
Sl. No.	Parameters	Units	Measured values	Measured values	Measured values
1	Capacity	TR	62	40	17
2	Evaporator Liquid flow	m3/h	70.00	35.00	12.00
3	Liquid density	kg/ m3	996.00	996.00	996.00
4	Specific heat of liquid	kJ/kg/K	4.19	4.19	4.19
5	Liquid temperature at evaporator outlet	°C	2.40	3.50	7.60
6	Liquid temperature at evaporator inlet	°C	4.10	4.90	10.50
7	Net Refrigeration Effect	kJ/hr	496259.99	204488.76	145228.75
8	Net Refrigeration Effect	kcal/hr	118556.51	48852.36	34695.15

9	**Net Refrigeration Capacity**	TR	39.21	16.15	11.47
10	**Power drawn by Compressor**	kW	41.82	30.51	9.45
11	**Compressor shaft power**	kW	41.82	30.51	9.45
12	KW Refrigerant effect	kW	137.86	56.81	40.34
13	**Coefficient of Performance, COP**	%	3.30	1.86	4.27
14	**Energy Efficiency Ratio, EER**	W/W	3.30	1.86	4.27
15	**Power drawn by Pumps (Condenser + Chilled water)**	kW	21.49	19.5	9.54
16	**Power drawn by Cooling Tower**	kW	4.49	4.49	2.1
17	**Specific Power consumption, SPC**	kW/TR	1.07	1.89	0.82

Table 23: Performance analysis of Chillers

PERFORMANCE ANALYSIS OF AIR HANDLING UNITS

The plant has 6 AHUs and their descriptions are as follows:

AIR HANDLING UNITS		
Sl. No	***Area***	***Rated CFM***
1	Grinding	6000
2	FBE	1200
3	CAD Milling & FBE	5500
4	Cad Press	10000
5	Bottle Line	5000
6	AHU Near to Boiler	2400

Table 24: Air Handling Units Inventory

EVALUATION

AIR HANDLING UNIT PERFORMANCE ANALYSIS								
Sl. No.	***Parameters***	***Units***	***Measured values***					
1	AHU Area	-	Grinding	FBE	CAD Milling & FBE	Cad Press	Bottle Line	Near to Boiler
2	Average Velocity	m/s	2.13	1.20	1.61	2.40	1.73	1.32
3	Length	M	1.36	0.60	1.40	1.75	1.80	0.90
4	Breadth	M	0.94	0.60	1.00	1.20	0.60	0.60
5	Area	m2	1.28	0.36	1.40	2.10	1.08	0.54
6	Flow	m3/s	2.72	0.43	2.25	5.04	1.86	0.71
7	Actual flow	Cfm	5750.50	914.46	4771.27	10668.67	3943.60	1508.86
8	Rated Flow	Cfm	6000.00	1200.00	5500.00	10000.00	5000.00	2400.00
9	Rated power	KW	3.72	1.50	3.73	7.46	5.50	2.20
10	Power Measured	KW	2.58	0.90	2.28	3.96	1.89	0.66
11	% Loading	%	0.69	0.60	0.61	0.53	0.34	0.30
12	Enthalpy of inlet air	KJ/Kg	33.53	39.72	40.11	32.38	38.81	53.98
13	Enthalpy of outlet air	KJ/Kg	23.93	37.18	32.61	26.07	30.22	34.46
14	Change in Enthalpy	KJ/Kg	9.60	2.54	7.50	6.31	8.59	19.52
15	Change in Enthalpy	Kcal/kg	2.28	0.60	1.79	1.50	2.04	4.65
16	KW Refrigerant effect	KW	32.08	1.35	20.79	39.12	19.68	17.11
17	Net Refrigeration Effect	TR	9.09	0.38	5.89	11.08	5.58	4.85
18	Specific Power Consumption	KW/TR	0.28	2.35	0.39	0.36	0.34	0.14
19	COP	%	12.43	1.50	9.12	9.88	10.41	25.93

Table 25: Air Handling Unit Performance Analysis

***Remarks: All Air Handling Units are working satisfactorily**

PERFORMANCE ANALYSIS OF COOLING TOWERS

The plant has total 4 Cooling towers of capacity 125 TR, 100 TR, 80 TR and a smaller capacity one. During audit 100 TR and 80 TR cooling towers were working and the trials were done on them.

EVALUATION

PERFORMANCE ASSESSMENT OF COOLING TOWERS					
Sl. No.	***Parameters***		***Units***	***Measured Values***	***Measured Values***
1	Type of Blades		-	Metallic	Metallic
2	Capacity	TR	-	100	80
3	Average running Hours		Hours	24	24
4	Ambient	DBT	˚C	15	18
		WBT	˚C	11.1	12.7
5	Cooling Water Tower	Inlet	˚C	20.5	18.5
		Outlet	˚C	17	16.1
6	CT	Range	˚C	3.5	2.4
		Approach	˚C	5.9	3.4
		Effectiveness	%	37.23	41.38
7	Power consumed By CT Fan		KW	4.49	2.1

Table 26: Performance Assessment of Cooling Towers

OBSERVATION & RECOMMENDATIONS

It is observed that the cooling tower fan blades were made of Aluminum. Replacing the current CT fan blades with FRP blades reduces the consumption of the power.

In addition, incorporating temperature sensor control systems will provide the flexibility for the CT fans to shut down when the required temperature is achieved, specifically in night and winter.

SAVINGS CALCULATIONS

SAVINGS FROM FRP BLADES				
Sl. No.	***Description***	***Units***	***Measured Values***	***Measured Values***
1	Cooling Tower	TR	100	80
2	Current Power Consumption	KW	4.49	2.1
3	No. of working Hours per year	Hrs.	8760	8760
4	Total units consumption	kWh	39332.4	18396
5	Expected savings	%	15	15
6	Annual units Savings	kWh	5899.86	2759.4
7	Cost Per Unit	INR	2.95	
8	Total Annual Saving	INR	**25545**	

Table 27: Savings from FRP Blades

SAVINGS FROM TEMPERATURE CONTROL SYSTEMS				
Sl. No.	***Description***	***Units***	***Measured Values***	***Measured Values***
1	Cooling Tower	TR	100	80
2	Current Power Consumption	KW	4.49	2.1
3	No. of working hours saved per day	Hrs.	10	10
4	Total saved working hours per year	Hrs.	3650	3650
4	Total units consumption	kWh	16388.5	7665
5	Expected savings	%	15	15
6	Annual units Savings	kWh	2458.275	1149.75
7	Cost Per Unit	INR	2.95	
8	Total Annual Saving	INR	**10644**	

Table 28: Savings from Temperature Control Systems

SAVINGS SUMMARY			
Sl. No.	**Description**	**Units**	**Computed Values**
1	Cooling Towers	TR	100 & 80
2	Energy Savings	kWh	**12267.2**
3	Monetary Savings	INR	**36188**
4	Investment	INR	**100000**
5	Payback	Years	**2.76**

Table 29: Savings Summary

PERFORMANCE ANALYSIS OF PUMPS

During the audit pumps connected to 62TR, 40 TR & 17TR has been assessed for their performance. The detailed assessment is as follows for different Pumps.

EVALUATION

PUMP EFFICIENCY : 62TR PUMPS					
SL.No.	**PARAMETERS**	**UNITS**	**MEASURED VALUES**	**MEASURED VALUES**	**MEASURED VALUES**
1	Pump Location		62TR chiller	62TR chiller	62TR chiller
2	Pump Type		Chilled water Pump	Chilled water Pump	Condenser Pump
3	Rating	Hp	7.5	7.5	10
4	Flow Rate	m3/s	0.005	0.005	0.020
5	Differential Head	m	26	26	19
6	Density	kg/m3	996	996	996
7	Gravity	m/s2	9.81	9.81	9.81
8	Hydraulic Power	KW	1.27	1.27	3.71
9	Input power or Measured power	KW	5.61	7.08	8.8
10	Motor efficiency η	%	0.58	0.58	0.648
11	Shaft Power	KW	3.25	4.11	5.70
12	Pump η	%	39.04	30.93	65.11

Table 30: PUMP EFFICIENCY: 62TR PUMPS

PUMP EFFICIENCY: 40TR PUMPS					
Sl.No.	**Parameters**	**Units**	**Measured Values**	**Measured Values**	**Measured Values**
1	Pump Location		40TR chiller	40TR chiller	40TR chiller
2	Pump Type		Chilled Water Pump	Chilled Water Pump	Condenser Pump
3	Rating	Hp	7.5	5	7.5
4	Flow Rate	m3/s	0.01	0.01	0.0115
5	Differential Head	m	17	6	18
6	Density	kg/m3	996	996	996
7	Gravity	m/s2	9.81	9.81	9.81
8	Hydraulic Power	KW	1.66	0.59	2.02
9	Input power or Measured power	KW	7.08	3.72	8.7
10	Motor efficiency η	%	0.58	0.5	0.648
11	Shaft Power	KW	4.11	1.86	5.64
12	Pump η	%	40.45	31.52	35.88

Table 31: PUMP EFFICIENCY: 40TR PUMPS

PUMP EFFICIENCY: 17TR PUMPS					
Sl.No.	Parameters	Units	Measured Values	Measured Values	Measured Values
1	Pump Location		17TR chiller	17TR chiller	17TR chiller
2	Pump Type		Chilled Water Pump	Chilled Water Pump	Condenser Pump
3	Rating	Hp	3	3	7.5
4	Flow Rate	m3/s	0.008	0.008	0.011
5	Differential Head	m	8	8	16
6	Density	kg/m3	996	996	996
7	Gravity	m/s2	9.81	9.81	9.81
8	Hydraulic Power	KW	0.63	0.63	1.72
9	Input power or Measured power	KW	1.98	2.16	5.4
10	Motor efficiency η	%	0.648	0.648	0.648
11	Shaft Power	KW	1.28	1.40	3.50
12	Pump η	%	48.74	44.68	49.14

Table 32: PUMP EFFICIENCY: 17TR PUMPS

OBSERVATIONS & RECOMMENDATIONS

The pump efficiencies are significantly low. In case of the failure of the pumps, replace pumps with energy efficient pumps.

SAVINGS AND PAYBACK CALCULATIONS			
Sl.No.	Parameters	Units	Computed Values
1	Total Power consumption from pumps	KW	50.530
2	Average no. of working hours per year @ 20hrs/day	Hrs.	7300
3	Annual energy consumption	kWh	368869
4	Expected energy savings	%	10
5	Annual energy savings	kWh	36886.9
6	Cost Per Unit	INR	2.95
7	Annual Monetary savings	INR	**108816**
8	Investment per pump	INR	20000
9	No of Pumps	No.	9
10	Total Investment	INR	**180000**
11	Payback period	Years	**1.65**

Table 33: Savings and Payback Calculations

CAUSES FOR THE DROP IN PUMP EFFICIENCY

1. Eroded impellor blades
2. Back pressure in the line due to more number of bends leads to draw more power to overcome the back pressure. Hence Hydraulic power for the electric power drawn remains low

PERFORMANCE ANALYSIS OF THERMOPAC

The Thermopac in the plant is used for heating load in the Hajmola unit. The details of the Thermopac is as follows:

THERMOPAC SPECIFICATIONS			
Sl. No.	***Description***	***Units***	***Values***
1	Make	-	Thermax
2	Model No.	-	VTB-06 126
3	Fuel Type	-	Pet Coke
4	Output	kcal/hr.	600000
5	Output	MW	0.697
6	Max temperature	˚C	280
7	Connected Load	KW	22

Table 34: Thermopac Specifications

EVALUATION

THERMOPAC EFFICIENCY			
Sl. No.	***Parameters***	***Units***	***Measured Values***
1	Mass flow rate of thermic fluid	Kg/hr	22406.4
2	Specific heat of thermic Fluid	KJ/Kg/˚C	2.59
3	Outlet Temp	˚C	197
4	Inlet Temp	˚C	183
5	Heat Output	KJ/hr	812456.06
6	Mass flowrate of Pet coke	Kg/hr	35
7	GCV of Pet coke	KJ/Kg	33440
8	Heat Input	KJ/hr	1170400
9	Thermopac η	%	69.42

Table 35: Thermopac Efficiency

It is observed that convective coil section in the Thermopac is not insulated. Hence it has a significant energy loss. The details of the analysis and potential savings with payback is as follows:

FUEL LOSS DUE TO RADIATION AND SAVINGS CALCULATIONS			
Sl. No.	***Parameters***	***Units***	***Measured Values***
1	Material		Iron Polished
2	GCV of Fuel	Kcal/kg	8000
3	Area	m2	5.72
4	Ambient Temperature	˚C	31
5	Ambient Temperature	K	304
6	Surface Temperature	˚C	170
7	Surface Temperature	K	443
8	Emissivity coefficient	-	0.38
9	Stefan's constant	W/m2 K4	5.6703×10^{-8}
10	Energy lost	W	3695.97
11	Heat lost	Kcal /Hr	3166.70
12	Fuel Lost per hour	Kg/hr	0.40

13	Annual Fuel Loss	Tonnes	3.47
14	Monetary savings @ 11.5 INR/kg of Pet coke	INR	**39877**
15	Investment on Insulation	INR	10000
16	Payback	Months	3.0

Table 36: Fuel loss due to radiation and Savings Calculations

FLUE GAS ANALYSIS AFTER COMBUSTION CHAMBER			
Sl. No.	***Parameters***	***Units***	***Measured Values***
1	Fuel gas temperature	˚C	239
2	Ambient temperature	˚C	25.5
3	O2 level	%	17.1
4	CO2	%	2.9
5	CO	mg/m3	130
6	GCV of fuel	Kcal/kg	8000
7	Excess air	%	480
8	Mass of dry flue gases	kg/kg of fuel	40.6
9	Specific heat of air	kcal/kg ˚C	0.24
10	Net temperature difference	˚C	213.5
11	Dry flue Gas loss	%	26.0043

Table 37: Flue gas analysis after combustion chamber

FLUE GAS ANALYSIS AFTER AIR PREHEATER			
Sl. No.	***Parameters***	***Units***	***Measured Values***
1	Fuel gas temperature	˚C	117
2	Ambient temperature	˚C	26.1
3	O2 level	%	19.3
4	CO2	%	1.4
5	CO	mg/m3	35
6	GCV of fuel	Kcal/kg	8000
7	Excess air	%	1293

Table 38: Flue gas analysis after Air Preheater

The average acceptable level of oxygen in the flue gas is 6%. Maintaining acceptable level of oxygen yield the savings in terms of monetary wise as well as energy wise. The calculations are as follows:

SAVINGS THROUGH DRY FLUE GASES			
Sl. No.	***Parameters***	***Units***	***Measured Values***
1	Fuel gas temperature	˚C	239
2	Ambient temperature	˚C	25.5
3	O2 level	%	6
4	GCV of fuel	Kcal/kg	8000
5	Excess air to be maintained	%	40
6	Mass of dry flue gases	kg/kg of fuel	9.8
7	Specific heat of air	kcal/kg ˚C	0.24
8	Net temperature difference	˚C	213.5
9	Dry flue Gas loss	%	6.28
10	Savings from Dry flue gas	%	19.7274
11	Annual fuel consumption	Tonnes	272.04

12	Annual Fuel Savings	Tonnes	54
13	Monetary Savings @ 11.5 INR/kg of Pet coke	INR	**617164**

Table 39: Savings through Dry Flue Gases

OBSERVATIONS & RECOMMENDATIONS

- It is observed that the quality of the fuel is poor, which contained more moisture content. More moisture in the fuel is also a contributor for increasing oxygen level in the flue gas
- Hence it is recommended to conduct the fuel test and to use the specified quality fuel. In addition, Equipment review from the manufacturer should also be carried out.
- The connected ID fan, FD fan and a circulation pump doesn't have VFD. Installing VFD results in 15% reduction in power consumption, hence it is recommended to install VFD.

SAVINGS THROUGH VARIABLE FREQUENCY DRIVES			
Sl. No.	***Parameters***	***Units***	***Measured Values***
1	ID fan measured power	KW	9.57
2	FD fan measured power	KW	3.1
3	Total Power	KW	12.67
4	Savings	%	15
5	Total working hours per year @ 20hrs/day	Hrs.	7300
6	No of units Saved	kWh	13873.65
7	Cost per unit	INR	2.95
8	Monetary Savings	INR	**40927**
9	Investment	INR	80000
10	Payback	years	2.0

Table 40: Savings through Variable Frequency Drives

SAVINGS SUMMARY			
Sl. No.	***Parameters***	***Units***	***Measured Values***
1	Savings from arresting radiation loss	INR	39877
2	Savings from optimizing excess air	INR	617164
3	Savings from VFD	INR	40927
4	**Total Savings**	**INR**	**697968**

Table 41: Savings Summary

CAUSES FOR THE PERFORMANCE DEGRADATION

1. Poor fuel quality, this misleads operator while maintaining air fuel ratio. Finally results in incomplete combustion
2. Moisture in fuel results in endothermic reaction i.e. conversion of moisture in to steam. This reduces the net heat available to transfer from furnace to thermic fluid

PERFORMANCE ANALYSIS OF BOILER

The plant has 2 boilers and the details are as follows:

BOILER SPECIFICATIONS			
Sl. No.	Parameters	Units	Values
1	Capacity	Ton	1
2	Make	-	Thermax
3	Max Pressure	Kg/cm2	10
4	Fuel	-	Bio- Briquette
5	Type	-	Fire tube

Table 42: Boiler Specifications

The second boiler is of 200kg capacity and fuel type is HSD.

OBSERVATIONS AND CALCULATIONS

- 1 ton Bio-briquette boiler is mainly used to provide steam for the process in unit -2 i.e., cream section based on the requirement.
- The boiler was repeatedly shut down and started due to lack of the continuous requirement of steam in the process. Hence the efficiency is significantly low.

EVALUATION

BOILER EFFICIENCY : DIRECT METHOD			
Sl. No.	Parameters	Computed Values	Units
1	Mass flow rate of Steam	381.5	Kg/hr
2	Specific heat of water	4.18	KJ/Kg/˚C
3	Feed Water Temperature	25	˚C
4	Feed Water enthalpy	104.5	KJ/Kg
5	Specific heat of Steam	4.24	KJ/Kg/˚C
6	Steam Temperature	152	˚C
7	Steam enthalpy	644.48	KJ/Kg
8	Heat output	206002.37	KJ/hr
9	Mass flow rate of Fuel	108.99	Kg/hr
10	GCV of Fuel	3928	KJ/Kg
11	Heat Input	428112.72	KJ/hr
12	Boiler η	**48.1**	%

Table 43: Boiler Efficiency: Direct Method

SL. NO.	EVAPORATION RATIO		UNITS
1	Quantity of Steam generation	381.5	Kg/hr
2	Quantity of Fuel consumption	109	Kg/hr
3	Evaporation Ratio	**3.5**	-

Table 44: Evaporation Ratio

FLUE GAS ANALYSIS AFTER BOILER			
Sl. No.	**Parameters**	**Units**	**Measured Values**
1	Fuel gas temperature	˚C	223
2	Ambient temperature	˚C	25.2
3	O2 level	%	9.9
4	CO2	%	5.4
5	CO	mg/m3	310
6	GCV of fuel	Kcal/kg	3278
7	Excess air	%	93
8	Mass of dry flue gases	kg/kg of fuel	13.51
9	Specific heat of air	kcal/kg ˚C	0.24
10	Net temperature difference	˚C	197.8
11	Dry flue Gas loss	%	19.57

Table 45: Flue gas analysis after Boiler

FLUE GAS ANALYSIS AFTER AIR PREHEATER			
Sl. No.	**Parameters**	**Units**	**Measured Values**
1	Fuel gas temperature	˚C	151
2	Ambient temperature	˚C	25.6
3	O2 level	%	12.8
4	CO2	%	3.8
5	CO	mg/m3	490
6	GCV of fuel	Kcal/kg	3278
7	Excess air	%	167.9

Table 46: Flue gas analysis after Air Preheater

FLUE GAS ANALYSIS AT CHIMNEY			
Sl. No.	**Parameters**	**Units**	**Measured Values**
1	Fuel gas temperature	˚C	99
2	Ambient temperature	˚C	25.6
3	O2 level	%	19.7
4	CO2	%	0.6
5	CO	mg/m3	1553
6	GCV of fuel	Kcal/kg	3278
7	Excess air	%	1642

Table 47: Flue gas analysis at chimney

Reducing the Excess air reduces the dry flue gas losses. Hence it is recommended to maintain the O_2 level at 5% (acceptable level) and the savings with respect to 5% O_2 level is as follows:

SAVINGS THROUGH DRY FLUE GASES			
Sl. No.	***Parameters***	***Units***	***Measured Values***
1	Fuel gas temperature	˚C	223
2	Ambient temperature	˚C	25.2
3	O2 level	%	5
4	GCV of fuel	Kcal/kg	3278
5	Excess air	%	43.75
6	Mass of dry flue gases	kg/kg of fuel	10.0625
7	Specific heat of air	kcal/kg ˚C	0.24
8	Net temperature difference	˚C	197.8
9	Dry flue Gas loss	%	14.57
10	Savings from Dry flue gas	%	4.99
11	Annual fuel consumption	Tonnes	328.5
12	Annual Fuel Savings	Tonnes	16
13	Monetary Savings @ 4 INR/kg of Bio Briquette	INR	**65604**

Table 48: Savings through Dry Flue Gases

The 200kg Boiler requires on an average of 800-1000ltrs hot water per day. Hence it is recommended to replace the boiler with solar water heater. The payback analysis for replacing HSD with SWH is as follows:

PAYBACK BY REPLACING HSD BOILER WITH SOLAR WATER HEATER			
Sl. No.	***Parameters***	***Units***	***Measured Values***
1	Boiler Fuel	-	HSD
2	Fuel consumed per month	Ltrs	370
3	Cost of fuel per liter	INR	52
4	Expense on fuel per year	INR	230880
5	Cost of solar water heater per liter	INR	150
6	Investment for 1000LPD Solar water Heater	INR	150000
7	Payback*	Months	8

Table 49: Payback by replacing HSD Boiler with Solar Water heater

*Note: The Payback 8 months is only for solar water heater, which may extend up to 12months if electric heater is incorporated in the system to compensate the seasonal variation

LIGTHING SYSYTEM ANALYSIS

- Tubes are the most common lights installed in the entire factory.
- Lux level is measured in the different units of the factory.
- Average lux level is computed and the suitable LED Lights to meet the Avg. Lux level computed are recommended.
- LED lights recommended for various section is as follows:

UNIT No.	Location/ Name	Recorded Average Lux Level		Type of Light fitting	No. of light fitting	Total watt
		Range	Average			
1	KEORA	220-250	210	3*36W CFL	14	1512
	-	-	-	36W GG	9	324
	DISPATCH STORE	250-260	240	36W FTL	204	7344
	DISPATCH STORE	190-220	200	36W GG	38	1368
	ASHOK KUMAR	230-240	220	2 * 36 FTL	1	72
	LAB	240-250	230	2*36W FTL	1	72
	AMLA MFG	250-280	250	36W GG	6	216
2	CREAM SECTION	132-466	200	8W LED DL	22	176
	CREAM SECTION	132-467	200	3*36W CFL	6	648
	CREAM STORE	200-410	281	36W GG	12	432
	FILLING AREA	124-220	152	3*36W CFL	10	1080
	-	-	-	36W GG	18	1296
3	FINISH AREA	210-230	195	36W GG	9	324
	AJAY SINGH	230-210	220	36W GG	1	36
	-	-	-	36W GG	8	288
	GEL SECTION	195-240	215	36W GG	12	432
	CANTEEN	210-220	200	36W FTL	15	540
	DORMATERY	180-250	200	36W FTL	36	1296
	KITCHEN	200-280	250	2* 36W	1	72
	-	-	-	3*36W CFL	12	1296
	-	-	-	2*36W FTL	4	288
	-	-	-	36W GG	44	1584

Table 50: Lighting load & Lux levels

LIGHTING: INVESTMENT AND PAYBACK CALCULATION

Sl. No	Title Recommendation	Replace all the 2 *36 FTL with 2* 18W LED Tube light	Replace all the 2*36W street light with 35w LED street light	Replace all the 3 *36 CFL with 45W LED panel	Replace all the 36w electronic ballast with 18W LED tube	Replace all the 150W HPSV street light with 50W LED	Replace all the 70W Globe light with 35W LED
1	Description of Existing system	At present they are using 2 * 36 FTL	At present they are using 2*36W street light	At present they are using 3 * 36 CFL	At present they are using 40 W electronic tube	At present they are using 150W HPSV	At present they are using 70W Globe Light
2	Recommendation	It should be replace with 2* 36W LED Tube light	It should be replace with 35W LED street light	It should be replace with 45W LED panel	It should be replace with 18W LED tube light	It should be replace with 50W LED	It should be replace with 35W LED
	Energy Saving Calculation						
3	Average power consumption of 40W tube light in Watts	80	80	108	40	170	70
4	Average power consumption of 18W LED tube in Watts	36	35	45	18	50	35
5	Average power saving after replacement in Watts	44	45	63	22	120	35
6	Average working hour per day in hrs	20	20	20	20	20	20
7	Average No. of working days	360	360	360	360	360	360
8	Approximate No. of fixture	47	5	127	255	24	36
	Cost Benefit Calculation						
9	Annual Energy Saving potential (kwh)	14889.60	1620.00	57607.20	40392.00	20736.00	9072.00
10	Power tariff per unit in (Rs.)	2.95	2.95	2.95	2.95	2.95	2.95
11	Annual Cost Saving (Rs.)	43924.32	4779	169941.24	119156.4	61171.2	26762.4
12	Cost of fixture (Rs.)	1200	3500	4500	650	5000	3500
13	Total investment cost (Rs.)	56400	17500	571500	165750	120000	126000
14	Maintenance Cost @ 5 %(Rs.)	2820	875	28575	8287.5	6000	6300
15	Net Saving (Rs.)	**41104.32**	**3904**	**141366.24**	**110868.9**	**55171.2**	**20462.4**
16	Payback Period in Years	**1.37**	**4.48**	**4.04**	**1.50**	**2.18**	**6.16**

Table 51: Lighting: Investment and Payback Calculation

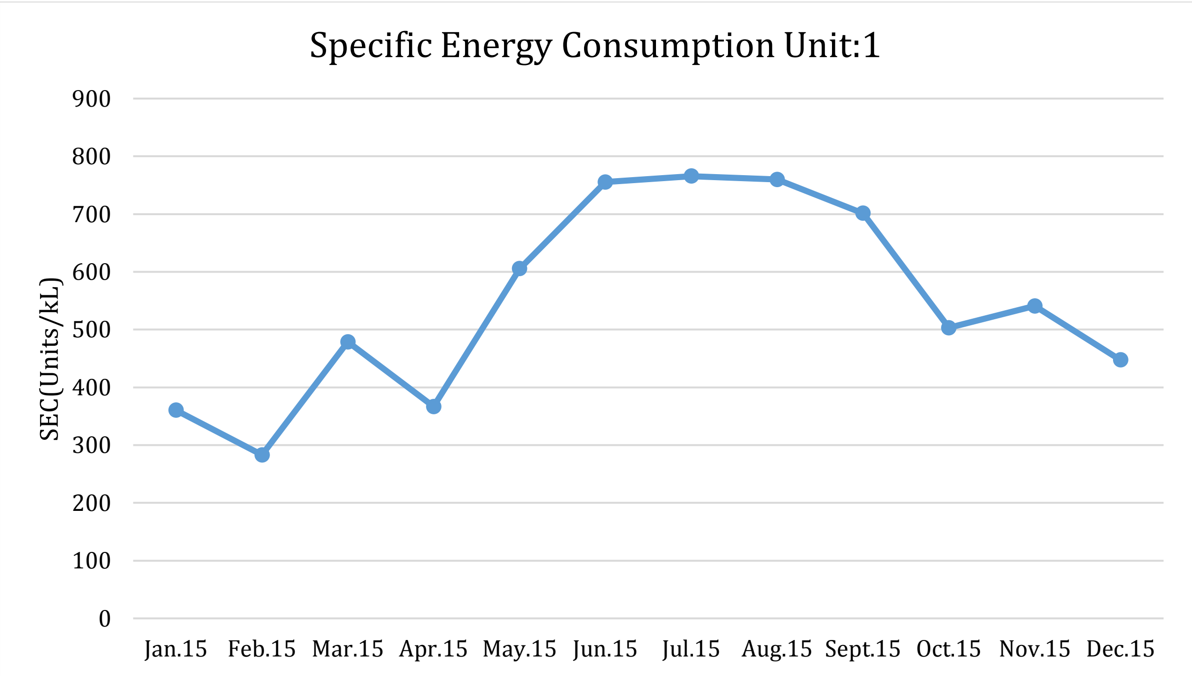
SPECIFIC ENERGY CONSUMPTION OF DIFFERENT UNITS (UNITS/KL OR MT)

- During energy audit, the production and power data is collected from Jan.2015 to Dec. 2015 for calculating specific energy consumption and the details are given below.
- In the below calculation, the captive generated units are not added since the units generated are not documented month wise, instead total units generated till date are documented.

SPECIFIC ENERGY CONSUMPTION (UNITS/KL) UNIT-1

Month	Hair oil (KL)	Kewara water (KL)	Gulabari Zaika (KL)	Total	Power Purchased	SEC (Units/KL)
Jan.15	12.52	67.21	3.58	83.31	30024	360.389
Feb.15	16.95	75.14	3.59	95.68	27072	282.943
Mar.15	0	36.18	4.5	40.68	19470	478.614
Apr.15	15.46	61.448	3.285	80.19	29394	366.541
May.15	9.88	49.61	4.49	63.98	38742	605.533
Jun.15	13.13	33.8	8.07	55.00	41544	755.345
Jul.15	14.12	36.23	3.56	53.91	41274	765.609
Aug.15	13.4	27.81	6.26	47.47	36066	759.764
Sept.15	13.5132	35.25	6.405	55.17	38700	701.491
Oct.15	11.81	54.95	6.21	72.97	36702	502.974
Nov.15	7.19	44.59	6.29	58.07	31410	540.899
Dec.15	11.8	55.1	9.87	76.77	34344	447.362

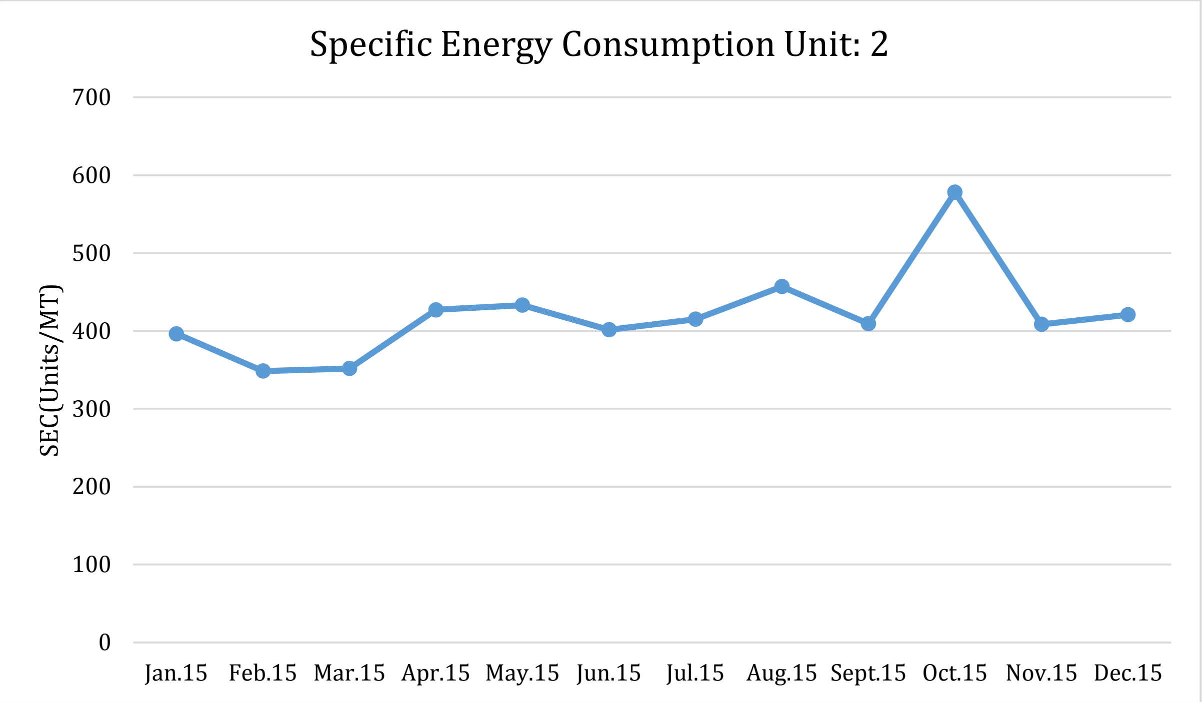
Table 52: Specific Energy Consumption Unit 1



SPECIFIC ENERGY CONSUMPTION (UNITS/MT) UNIT-2

Month	Odomos /Odonil (MT)	Power Purchased	SEC(Units/MT)
Jan.15	76.39	30270	396.256
Feb.15	131.92	45960	348.393
Mar.15	127.14	44718	351.723
Apr.15	84.45	36066	427.069
May.15	99.68	43176	433.146
Jun.15	135.6	54444	401.504
Jul.15	132.35	54936	415.081
Aug.15	105.48	48192	456.883
Sept.15	122.96	50328	409.304
Oct.15	107.18	61950	578.000
Nov.15	144.11	58854	408.396
Dec.15	119.08	50094	420.675

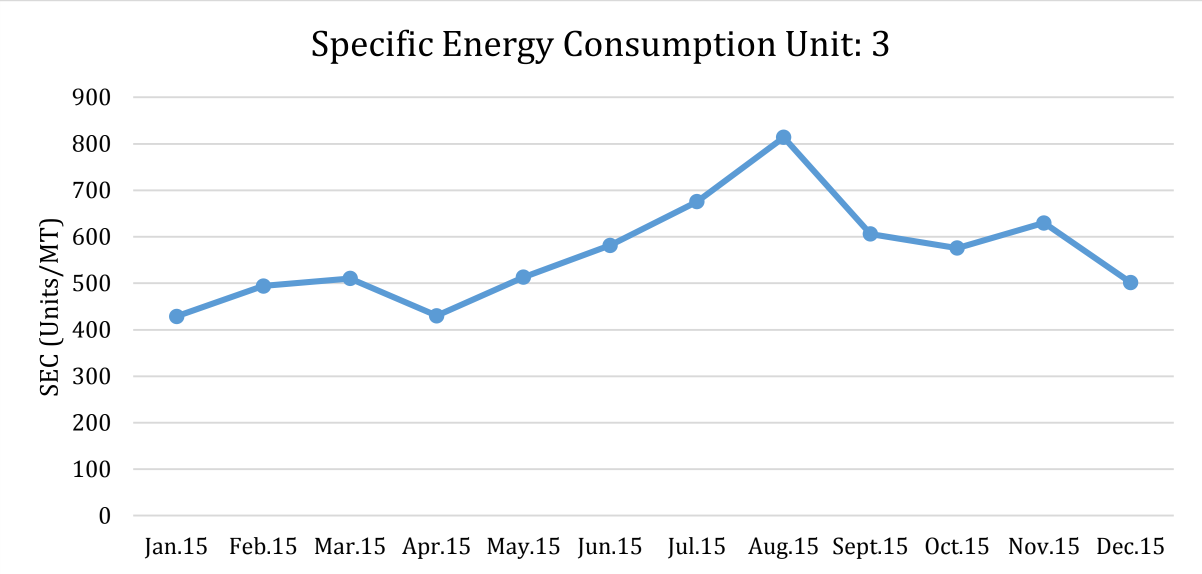
Table 53: Specific Energy Consumption Unit 2



SPECIFIC POWER CONSUMPTION (UNITS/MT) UNIT-3

Month	Hajmola (MT)	Power Purchased	SEC(Units/MT)
Jan.15	347.04	148784	428.723
Feb.15	253.26	125152	494.164
Mar.15	202.59	103432	510.548
Apr.15	377.4	162312	430.079
May.15	367.97	188784	513.042
Jun.15	368.81	214536	581.698
Jul.15	326.06	220312	675.679
Aug.15	255.26	207808	814.103
Sept.15	326.19	197712	606.125
Oct.15	393.01	226256	575.700
Nov.15	298.74	188168	629.872
Dec.15	378.68	190000	501.743

Table 54: Specific Energy Consumption Unit 3



ANALYSIS AND COMMENTS:

- In unit-1, the overall SEC (Units/kL) is around 547.29 from Jan2015 – Dec.2015 and it is ranging from 282.9 to 765.6. The variation is very high. The SEC is lowest achieved in the month of Feb. 2015 i.e. 282.9 because the productivity is maximum and power consumption is minimum. SEC is maximum i.e. around 700 units/kL in the month of June 2015 to Sep 2015 due to higher power consumption and lower utilization. So preventive measures has to be taken by the management to record minimum SEC as per internal baseline data.

- In unit-2, cream section, the overall SEC (units/MT) is around 420.5 and ranging from 348 to 578. It is noticed that the maximum SEC has achieved in the month of Oct. 2015 i.e. 578. The major reason for higher SEC is higher power consumption w.r.t. to production achieved. The SEC is achieved minimum in the month of Feb. 2015 i.e. 348.4 because the production is higher and power consumption is low. So it should be maintained throughout the year to reduce the overall power consumption of the plant.

- In unit-3, Hajmola section is the highest power consuming section in the plant. The overall SEC (units/MT) is coming around 563.5 and ranging from 428 to 814. The maximum SEC is achieved in the month of Aug. 2015 i.e. 814.1 due to higher power consumption w.r.t to production achieved.

GENERAL OBSERVATION & RECOMMENDATIONS:

- It is observed in cream section, there are 3 Nos. of filling and packing machines are there and sometimes machines are not working i.e. Wimco M/C but the idle power is wasted i.e. around 15 amps. Current is drawn by idle machine. So it is recommended that when there is no use, the machine main switch should be closed so that idle power consumption could be avoided.
- In Gel section, the production loss is there due to improper cooling system. Some modification is required i.e. for increasing the retaining time, the conveyor speed should be reduced. Conveyor length has to be modified so that material should have enough time to attain room temperature. Due to this insufficient cooling system, the extra manpower is being used. Hence necessary action has to be taken immediately.
- Cooling tunnel fan grills should be cleaned for proper air circulation in Odonil section.
- In Hajmola section, taping machines run idle. To avoid idle running time sensors should be used. When package is ready on conveyor then only taping machine should start otherwise it should be off.
- In Jeera roasting machine, the surface temperature is high i.e. 80-90 degree C. the proper insulation should be provided to avoid heat loss.

- In sachet packing machines compressed air is used to force sachet cutting after sealing. Because the cutting tool is blunt. Use of compressed air for this process is leading to nearly 7-8 lakhs per annum monetary loss.
- The misuse of live compressed air for human cloth cleaning should be strictly prohibited.
- Canteen has a solar geyser but still electrical heater/geyser is being used. Instructions to use solar energy first on priority has to be given to the concerned person.
- For dormitory, 100 ltrs of solar water heating system is installed which is inadequate as it is only sufficient for 5-6 people. But for 100 people, Hot water required is around 1500-2000 ltrs. Hence suitable solar water heating system has be installed to meet the requirements.
- There is no graduations for HSD tank in DG sets. Due to this actual quantity of oil consumed is not being measured.
- There is no marking for reservoir capacity on compressor reservoir. It should be measured and marked on the tank.
- Where day light is available, the artificial lights should be stopped in day time to save power.
- In alleys and lobbies, where much lights are not required, the concerned person should reduce the no. of light fixtures and in day time if sufficient light is available then it should be switched off.
- All the valves and flanges are not insulated and they are exposed to open air. This should be properly insulated i.e. box type system.
- The fuel should be tested for its property time to time in boiler and in the Thermo-pac.
- Compressed air system, the unit 1 & 4 supply should be given from unit-3 compressor as its requirement in unit-1 & 4 is very less and power is wasted during its operation.
- In FCB machines, 50 HP blowers are being is used and as per the measurement it is found that its load remained in the range of 20-21 kW for long time and in starting it takes 25-26 kW for 5-6 minutes. So 50 HP blower seems to be on higher capacity. The concerned person should try in one of the machine with 35 HP motor and analyses the energy saving and see the techno-economics and extend to other machines also.

CASE STUDY 2: ENERGY LOST DUE TO LACK OF INSULATION AT INDUSTRY No. 2

Indian Coal is used as a fuel in Industry No. 2. To compute the energy lost due to radiation in the steam line due to lack of insulation the below parameters are considered as constants and the calculation are carried out.

GENERAL PARAMETERS FOR HEAT LOSS CALCULATION

Sl. No.	Parameters	Values
1	Material	Mild Steel
2	GCV of Fuel (kcal/Kg)	3499
3	Ambient Temperature in K	306.70
4	Emissivity coefficient	0.32
5	Stefan's constant (W/m2 K4)	5.67E-08
6	Co2 emitted per kg of Indian coal (kg)	1.101

Table 55: General Parameters for Heat loss calculation

FORMULAS USED:

1. $Area\ (A) = \pi \times r \times l.\ \ m^2$
2. $Energy\ Lost\ (q) = \varepsilon \times \sigma \times \left({T_S}^4 - {T_a}^4\right) \times A.$ Watts
3. $Heat\ Lost\ (\dot{q}) = q \times .238 \times 3600/1000.\quad kcal/hr$
4. $Fuel\ Lost\ (\dot{m}) = \dot{q}/GCV\ of\ fuel.\quad kg/hr$

Indian coal consists of maximum 30% of fixed carbon. 1 Kg carbon stoichiometrically produces 3.67 kg Co_2. Hence 1 kg of Indian coal produces 1.101 kg Co_2.

THERMAL ENERGY LOSS IN DIFFERENT SECTION OF THE PLANT:

Sl. No.	Location	Radius	Length	Surface Area	Surface Temperature		Energy lost	Heat lost	Fuel Lost per hour	Annual Fuel Loss
		mtrs	mtrs	m2	˚C	K	W	kcal/hr	kg/hr	Tonnes
1	Near RO Plant	0.20	2.0	2.6	201.00	474.00	1927.91	1651.84	0.47	4.1
2	Near RO Plant	0.05	0.6	0.2	201.00	474.00	146.91	125.87	0.04	0.3
3	Near RO Plant	0.10	1.5	1.0	204.00	477.00	745.37	638.63	0.18	1.6
4	Near RO Plant	0.51	0.5	1.6	204.00	477.00	1242.29	1064.39	0.30	2.7
5	Water Drain Plant	0.03	2.5	0.4	158.50	431.50	186.82	160.07	0.05	0.4
6	Water Drain Plant	0.03	2.5	0.4	145.00	418.00	156.88	134.41	0.04	0.3
7	Water Drain Plant	0.03	25.0	4.0	150.00	423.00	1676.36	1436.30	0.41	3.6
8	Condensate Recovery	0.10	1.0	0.6	111.00	384.00	149.29	127.91	0.04	0.3
9	In Front Of Hot Water Pump	0.05	1.5	0.5	158.50	431.50	224.19	192.09	0.05	0.5
10	Back Header Dying Machine	0.05	0.5	0.1	163.70	436.70	72.84	62.41	0.02	0.2
								Total Annual Fuel loss		**14.0**

Table 56: Thermal Energy Loss in Different Section of the Plant

If the heat loss is arrested through proper insulation then the amount of Co_2 mitigated annually is calculated as follows:

1kg Indian coal yields 1.101 kg Co_2.

14000kg Indian Coal yields 15414 kg Co_2. Which is equivalent to 15.414 tonnes Co_2 mitigation per annum.

RESULTS AND DISCUSSION

ANNUAL CO_2 MITIGATING POTENTIAL AT INDUSTRY NO. 1 & 2.

Sl. No.	Energy Sources	Values	Units	Co_2 Generation from Different Sources	Units	Total Co_2 in tonnes
1	Electrical Units	452361	kWh	0.909	kg of Co2/kWh	411.19
2	Pet coke	57470	Kgs	3.3	kg of Co2/kg of PC	189.66
3	Bio Briquettes	16000	Kgs	1.658	kg of Co2/kg of BB	26.52
4	HSD	4440	Ltrs	2.712	kg of Co2/Ltrs of HSD	12.04
5	INDIAN Coal	14000	Kgs	1.101	Kg of Co2/kg of Indian Coal	15.42
Total						**654.83**

Table 57: Annual CO2 Mitigating Potential at Industry No. 1 & 2.

From the case studies it is found out that the potential energy savings in the industries are significantly high. It has also provided the overview of the energy utilization in the industries.

This study has revealed that most of the industries in India has similar problems if they are addressed, then energy scarcity will reduce drastically. Also life of the utilities increases.

As per trends in global Co_2 emissions 2015, it is observed that India stands in fourth position by emitting 2.3 GT of Co_2 in to atmosphere (11). The main contributors for the emission is power plants and cement industry. But generally we can say it is due electricity generation.

CHAPTER 5

CONCLUSIONS

1. Annual Co_2 emissions can be reduced by implementing suggestive measures nearly 655 tonnes
2. Loading transformer to its optimal capacity saves energy. Because it operates 24*7 minor deviation in performance in this utility accounts for major losses.
3. Quality of fuel determines how good combustion can take place. If the fuel contain moisture it absorbing the heat and leads to improper burning of fuel due to reduced temperature and increases oxygen content in the flue gas.
4. Receiver in the compressed air systems has to drain from time to time to remove moisture. Otherwise net effective volume available for operation reduces
5. In HVAC system heat load in the shop floor determines the Co efficient of performance. So when there are multiple TR ratings of HVAC systems available then operate the less TR HVAC system to give better COP.
6. Incorporating variable frequency drives for motor loads more than 10kW will reduces the starting current

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