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CASE STUDY ON ENERGY AUDITING OF INDUSTRIAL AND COMMERCIAL UTILIIES

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Abstract:- *Energy audit is a process of checking the way energy is used and identify areas where wastage can be minimize if not totally eradicate. The objective of Energy Management is to achieve and maintain optimum energy procurement and utilization, throughout the organization as to reduce energy expenditure / wastage without affecting quality. Energy audit consists of several stages which can be done depending on the type of audit and the function of audited facility. It starts with reviewing the historical data of energy consumption which can be analyzed from the electricity bills. These data is important in order to understand the patterns of energy used and their trend. After obtaining the information on energy consumption, the next stage is to set up an energy audit program.*

Energy audits helps industrial sector to understand how they use energy and help to identify the areas where wastage occurs and where opportunities for improvement exist. The standards the step-by-step procedure for measurement and assessment of these systems are presented which are key component of any energy audit practice and are highly recommended to energy auditors and mangers.

Key Words: Energy audit

1. INTRODUCTION

Energy audit is a method of checking and identifying areas where wastage can be reduced. The aim of Energy Management is to achieve and maintain optimum energy procurement and utilization, throughout the organization as to minimize energy costs without affecting production and quality This program should start with site inspection in order to get information on present energy consumed.

The energy consumption such as running hours of air- conditioning, fans, lighting levels, locations of unnecessary air-conditioning and lighting due to unoccupied areas ,unwanted openings, rusted and dusted conditions of panels, temperature and humidity, pump scheduling . Efficiencies of equipment's and machine and the areas of high energy consumption and the scope to reduce consumption should be recorded for further analysis.

1.1 Objective

The objectives of an energy audit can vary from one plant to another. However, an energy audit is usually conducted to understand how energy is used within the plant and to find opportunities for improvement and energy saving.

Sometimes, energy audits are conducted to evaluate the effectiveness of an energy efficiency project. There are three main steps. These three main steps are energy audit preparation, execution, and reporting.

1.2 AIM OF THE PROJECT

- To get details on energy consumption and wastage.
- To improve efficiency by applying appropriate energy conservation techniques.

1.3 FLOW CHART OF ENERGY AUDIT:

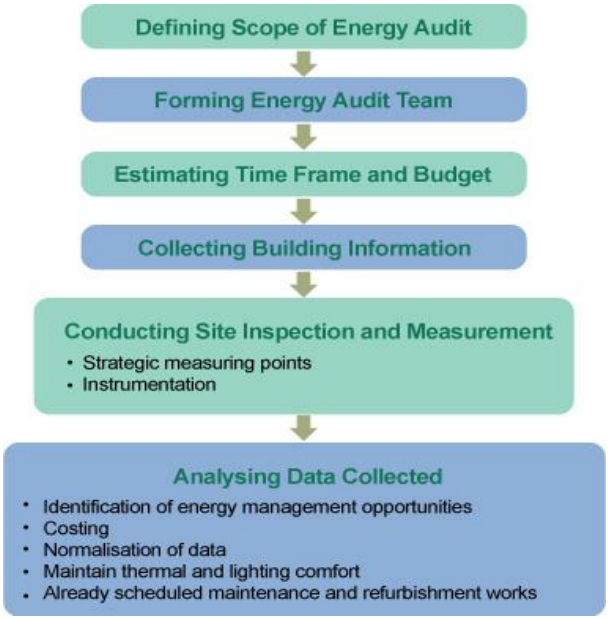


fig1.3 : FLOW CHART OF ENERGY AUDIT.

2. METHODOLOGY

There are two types of energy audit

1. Preliminary audit
2. Detailed audit

3. PROBLEM STATEMENT

The problem statement for our project was electrical energy auditing of government building "Nishtha Bhavan OLD CGO"(churchgate). We completed the site survey of this building and observations are below:

3.1. Check List

Table -3.1: checklist.

Sr.No	Description	Remarks
1	Is there electrical single line diagram available in electrical room?	No SLD should be provided in meter room and LT panel room to identify the distribution system.
2	Is their good adequacy of illumination in electrical rooms/around panels, DBs?	Yes Good Practices
3	Is there proper naming on feeders?	No
4	Is there proper color coding of cables?	Yes
5	size of cables for R, Y, B & neutral and actual current	3.5 Core X 400 sq mm X 4 Alu BEST Main Incomer cable. 3.5 Core X 400 sq mm X 4 Cu for raiser main.
6	Rating of switchgears (Fuse, MCB, MCCB) with respect to actual load	1250Amp ACB 1000Amp ACB
7	Are Insulated mats are provided for LT room, UPS batteries & any electrical installations?	No.

Sr.No	Description	Remarks
8	List of contact person in case of any emergency?	No List of contact persons in Main LT room and meter room shall be provided. It should include Police, Fire, Ambulance, Electrician member contact details
9	Is system and body earthing provided to electrical panels?	Yes
10	Are proper sizes of lugs provided for cables?	Yes
11	Are glands provided for cable entries?	No
12	Was there any blast or cable burning in any electrical panels?	No
13	Is there any work permit system to carry out electrical work in the premises?	No Make the proper work permit system to carry out any electrical work in building premises.
14	Is electrician license copy available?	No
15	Is dry sand bucket is provided in LT panel, DG room, Meter room or not?	No. In addition with the fire extinguisher, sand bucket shall be provided in meter room as a fire extinguisher.
16	Is there any combustible material in LT room, UPS room, DG room?	Yes
17	Is there body earthing for each electrical panel?	Yes
18	Is there indication lamps are provided or not?	Yes, But not working. Make it in working condition earliest
19	Is there any electrical safety training conducted before or not?	No. Conduct the training program on electrical safety for employees to aware them about electrical hazards and prevention to avoid electrical incidents

3.2. Implementation Priority Ranking

The implementation priorities and recommendations are ranked based on the risk levels. The approach followed is a Semi-Quantitative Risk Ranking (SQRR) technique, which is based on the audit team's expertise.

In this report, the implementation priority is ranked based on the experience of the auditor and with a priority towards human safety for the Electrical Risk Assessment and hence is indicative only. This section of the report contains the implementation ranking for individual recommendations.

Table -3.2: Implementation Priority Ranking

Recommendation Priority	Criterion
Very High	Recommendations that require immediate implementation
High	Recommendations that require implementation within two months
Medium	Recommendations that may be implemented within next six months
Low	Recommendations that may be implemented during the next available opportunity

3.3.Load Measurement

Table-3.3: Load Measurement

Sr. No.		**ELECTRICAL ROOM**	1
Location			Common Meter
Voltage	**R-Y**		399
	Y-B		402
	B-R		402
Amp	**R**		911
	Y		968
	B		887
ACB Rating			1250 Amp
Cable size			3.5C X 400 sq mm X 4 (Cu Unarmored)
Max.Allowable Current (Amps)			1820 Amp
Remark			Cable and switchgear size is adequate for measured load current

3.4.Thermal Audit (NEW CONCEPT)

3.4.1 Introduction

This Thermographic Inspection is designed to assess the performance of all switchgears, cable terminations, bus bar joints on site and to highlight areas which require attention.

Thermography is a term used to describe a type of photography that uses infrared radiated wavelengths to make pictures as opposed to visible lights as in normal photographs it can be also referred to as “THERMAL IMAGING” or “INFRARED”.

Objects that have a temperature above absolute zero emit infrared wavelengths. Thermography is the production of thermal (heat) pictures from these wavelengths, whereby temperature measurements or comparative analysis can be made.

3.4.2 Scope of thermal audit

Infrared thermal scanning of all electrical switchgear and associated areas is taken to identify equipment operating near or above desirable/ safe temperatures. Depending on the basis of recorded temperature, ‘priority’ for remedial action has been given.

Table-3.4.2: Image and Object Parameters

Image and Object Parameters	
Thermal Imaging camera	FLIR_E6
IR Resolution	160 X 120
Emissivity	0.95
Reflected Temperature	20 Deg C
Object distance	1mtr from object

Table-3.4.2.1: Priority Code & Actions

Priority Code & Actions			
Priority Code	**Temperature Level**	**Abnormalities Descriptions**	**Color Code**
0	Up to 50 °C	NO ABNORMALITY : No Action	
1	51°C to 70°C	ALERT : Schedule work during next maintenance	
2	71°C to 90°C	SERVICE : Take corrective action as earliest	
3	91°C to 100°C	CRITICAL : Repair Immediately	
4	Above 100°C	IMMEDIATE : Take shut down and repair immediately	

3.4.3. Executive Summary

Table-3.4.3: Executive Summary

SR. NO.	LOCATION	MAXIMUM TEMPERATURE RECORDED (Deg.C)	RECOMMENDATION	PRIORITY
Basement Main Panel Room				
1	Main ACB - 1 (1000Amp)	39.7	No action required	**0**
2	Main ACB - 2 (1250Amp)	38.9	No action required	**0**
3	APFC Panel Main Incomer	39.3	No action required	**0**
4	APFC MCB	**65**	Schedule work during next maintenance	**1**
5	APFC Contactor coil(Normal)	74.4	No action required	**0**
Main LT Panel 1 Front Side				
6	ISIRN 326 Computer room	33.7	No action required	**0**
7	AG 2nd floor N side	**54.5**	Schedule work during next maintenance	**1**
8	Basement Passage	39.4	No action required	**0**
9	Basement CATAR	44.2	No action required	**0**
10	ITAT 4th floor AC	40.9	No action required	**0**
11	AG 2nd floor cabin no 206	36.7	No action required	**0**
12	3rd floor AC	32.9	No action required	**0**
13	Ground floor No.006	32	No action required	**0**
14	3F6	36.3	No action required	**0**
15	3F8	32.9	No action required	**0**
Main LT Panel 1 Rear Side				
16	C Lift	33.7	No action required	**0**
17	ITAT 3rd floor	47	No action required	**0**
18	AG + Computer Gr floor No.008	39	No action required	**0**
19	Feeder 3.4 R	33.8	No action required	**0**

SR. NO.	LOCATION	MAXIMUM TEMPERATURE RECORDED (Deg.C)	RECOMMENDATION	PRIORITY
20	Feeder 3.7 R	46.3	No action required	0
21	Feeder 3.8 R	34.7	No action required	0
22	AG / Audit 1st floor R No.108	41.9	No action required	0
23	AIR Lift	32.8	No action required	0
24	FCI 3rd floor R No.319	33.4	No action required	0
25	AG Gr floor computer AC	33.4	No action required	0
26	AG computer room gr floor	38.9	No action required	0
27	T Lift	32.9	No action required	0
Main LT Panel 2 Front Side				
28	Feeder 2.1F	34.6	No action required	0
29	1st floor R No.132	35	No action required	0
30	AG Canteen gr floor	**51**	Schedule work during next maintenance	1
31	ITAT 3rd floor	38.4	No action required	0
32	2.5 ITAT 3rd floor	47.9	No action required	0
33	Basement panel (East)	**80.5**	Take corrective action as earliest	2
34	Feeder 3.2F Conferace	37.3	No action required	0
35	ITAT AC 4th floor passage	35.3	No action required	0
36	Feeder 3.6F	34.5	No action required	0
37	Feeder 3.7F	39.5	No action required	0
Main LT Panel 2 Rear Side				
38	Guest 3rd floor	36.5	No action required	0
39	AG gr floor computer	41.9	No action required	0
40	1st floor 216	34.2	No action required	0
41	TM gr floor computer room	33.8	No action required	0
Main Panel 2 (Lift)				
42	Main Incomer Terminal	34.1	No action required	0
43	Main Incomer MCCB	33.4	No action required	0
44	Poli Lift	34.1	No action required	0
45	C Lift	33.1	No action required	0
46	Feeder 4	32.9	No action required	0
47	Feeder 5	32.9	No action required	0
48	Feeder 6	31.9	No action required	0
49	Output cable chamber	32.9	No action required	0
50	Bus bar chamber	32.9	No action required	0
51	Feeder 400A MCCB	36	No action required	0
52	Single Ph meters	**53**	Schedule work during next maintenance	1

SR. NO.	LOCATION	MAXIMUM TEMPERATURE RECORDED (Deg.C)	RECOMMENDATION	PRIORITY
53	Main Meter and fuse	**75.8**	Take corrective action as earliest	**2**
54	AIR Meter	**57.9**	Schedule work during next maintenance	**1**
55	Main Meter ground floor	55.9	No action required	**0**
56	Main Bus bar DB	45.8	No action required	**0**

APFC MCB (Basement)

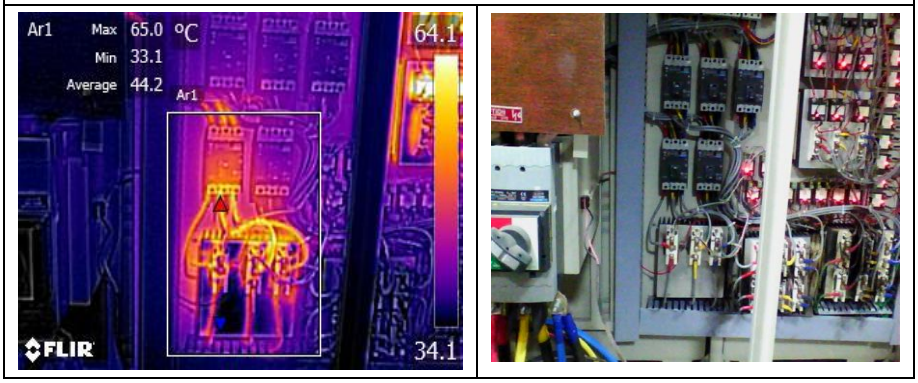


Fig3.5.3: APFC MCB (Basement)

Maximum Temperature Recorded: 65 °C

Observation: Heating observed at MCB Y phase input terminal.

Recommendation: Service the MCB tight the loose connections.

Priority Code: 1

AG 2nd floor N side (Main LT Panel 1 Front)

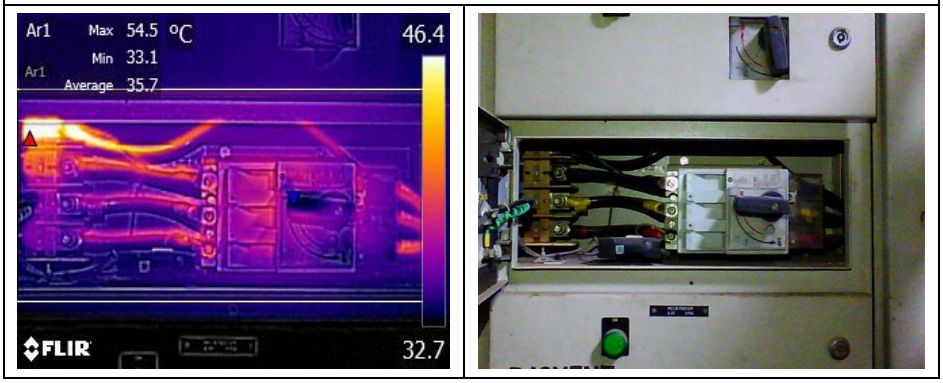


Fig3.5.3.1: AG 2nd floor N side (Main LT Panel 1 Front)

Maximum Temperature Recorded: 54.5°C

Observation: Heating observed at neutral cable terminal.

Recommendation: Service all the terminal tightens the loose connection.

Priority Code: 1

AG Canteen Gr floor (Main LT Panel 2 Front Side)

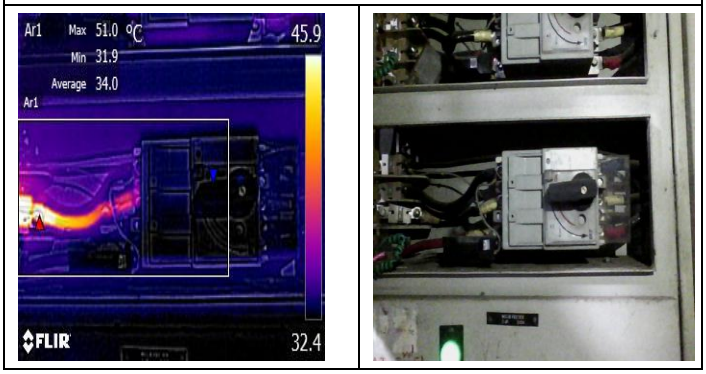


Fig3.5.3.2: AG Canteen Gr floor (Main LT Panel 2 Front Side)

Maximum Temperature Recorded: 51°C

Observation: Heating observed at Y phase cable terminal.

Recommendation: Tight the loose connections and do the servicing

Priority Code: 1

Basement panel (East) Main LT Panel 2 Front Side

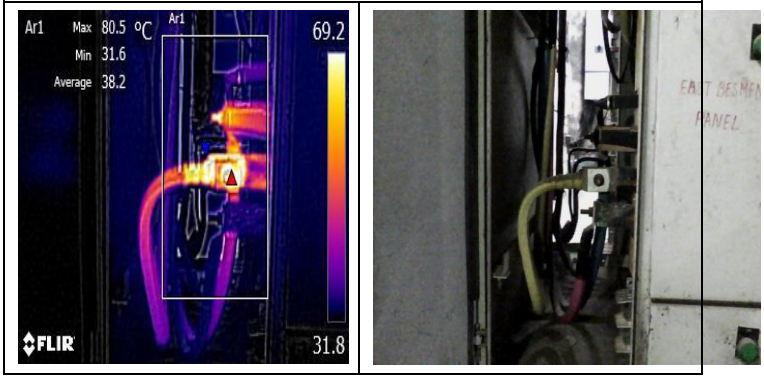


Fig3.5.3.3:Basement panel (East) Main LT Panel 2 Front Side

Maximum Temperature Recorded: 80.5°C

Observation: Heating observed at Y phase cable terminal.

Recommendation: Service the terminal tight the loose connections.

Priority Code: 2

Single Ph meters

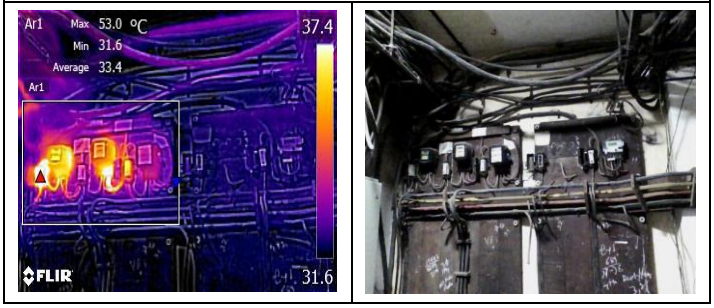


Fig3.5.3.4: Single Ph meters

Maximum Temperature Recorded: 53°C

Observation: Heating observed at meter fuse terminal.

Recommendation: Service the fuse terminal.

Priority Code: 1

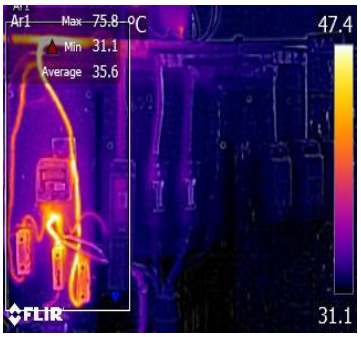
Main Meter and fuse	
	

Fig3.5.3.5: Main Meter and fuse

Maximum Temperature Recorded: 75.8°C

Observation: Heating observed at meter fuse terminal.

Recommendation: Service the fuse terminal.

Priority Code: 2

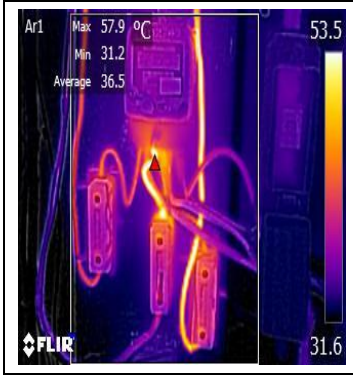
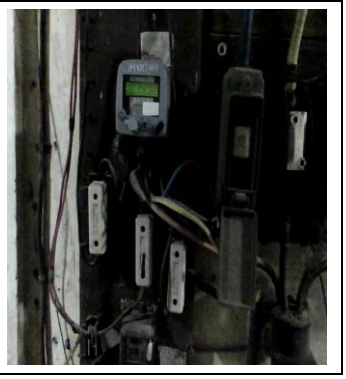
AIR Meter	
	

Fig3.5.3.6: AIR Meter

Maximum Temperature Recorded: 57.9°C

Observation: Heating observed at meter fuse terminal.

Recommendation: Service the fuse terminal.

Priority Code: 1

4. ENERGY AUDIT ASSESSMENT

Energy Audit ensures that all systems are assessed deeply and all possible solutions are on table before management team to make informed decision i.e. **best returns on investments.** Energy Audit is a tool that assesses all systems deeply through use of best modern age tools to bring a list of solutions to management's table with following details –

1. Technical Solution

2. Investment required for each solution

3. Possible Monthly Savings in energy bill

4. Payback Period

5. Annualized return on capital investments

Executive Summary

Table-4.: Executive Summary

Sr No	1	2	**T**
Recommendation	Bill Analysis -PF Improvement	Lighting System	**O**
Proposed Action	Tuning of Capacitor Bank and Health Test for Capacitor Bank	Replace Conventional Fitting with High lumen Led Lighting fitting	**T**
Present Monthly kWh	-	2833.6	**A**
New Monthly kWh	-	2661.3	
Monthly Saving kWh	-	172.27	**L**
Monthly Saving Rs.	114498	1568	116066
Total Inv. Rs.	700000	35880	735880
Payback Period Months	6.11	22.89	6.34

5. Electricity Bill Analysis –

Consumer No. 102557000*9

The facility has a contracted demand of 771kVA, LT IX BT tariff connection, the average rate of electricity is Rs.9.10/Unit (considering last 12 months). The average consumption is 138500 kWh .The PF is on an average 0.975

The salient features of the bill are as under (Yearly Average)

Table-5: Electricity Bill Analysis

SL.	Description	Unit	Value
1	Power Consumption	kWh	138500
2	Power Factor	-	0.975
3	Bill	Rs. /Month	1257619
4	Average rate of power (Year avg)	Rs/kWh	9.10

The month-wise pattern for the last 12 months was studied the same is plotted in the line graph below, the graph points out a seasonal variations in the consumption.

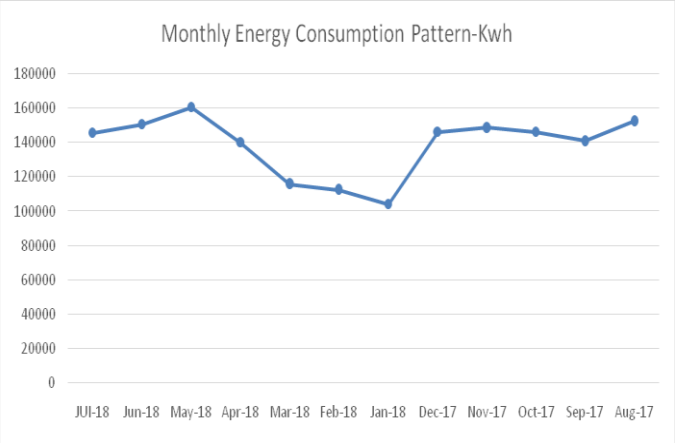


Fig5.1: Graph of month-wise pattern for the last 12 months.

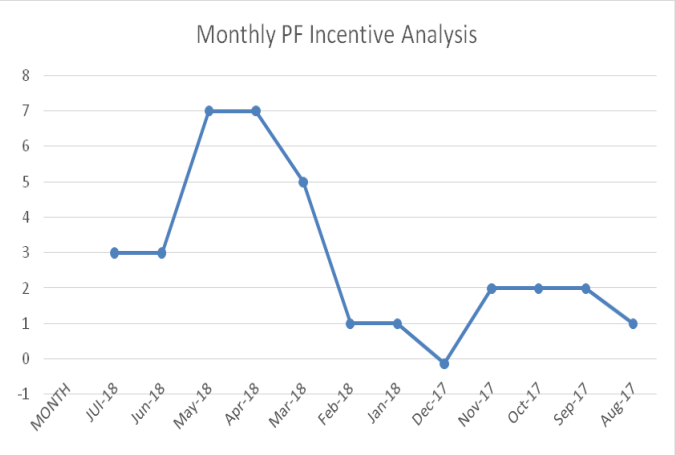


Fig5.2: Graph of monthly PF incentive analysis

The details of the bill are as below

Table-5.3: Electricity Bill Analysis

Electricity Bill - The Executive Engineer,Churchgate											
consumer : the Executive engineer											
CONSUMER NO. : 102557000°9											
UTILITY : Brihan Mumbai Electric Supply & Transport Undertaking											
INCOMING VOLTAGE : 440V											
TARIFF : LT IX BT											
CONNECTED LOAD (KW) : 813											
CONTRACT DEMAND (KVA) : 771											
50% OF CONTRACT DEMAND(KVA) : 385											
MONTH	KWH	BILLED DEMAND(KVA)	Energy Charges	Demand Charges	Wheeling Charges	FAC	TOD	PF	PF Incentive/Penalty	BILL(Rs)	Rate (Rs./kWh)
JUI-18	145500	0	1040325	300	210975	37830	21675	0.976	-39333	1257204	8.64
Jun-18	150300	0	1074645	300	217935	141282	22650	0.976	-43704	1397555	9.30
May-18	160200	0	1145430	300	232290	153792	23475	0.998	-108870	1432112	8.94
Apr-18	139800	0	1097430	290	201312	110442	21000	0.998	-100133	1319384	9.44
Mar-18	115800	0	909030	290	166752	2316	17325	0.992	-54786	1030232	8.90
Feb-18	112500	0	883125	290	162000	7875	16275	0.960	-10696	1048399	9.32
Jan-18	104100	0	817185	290	149904	64542	15075	0.961	-10470	1022583	9.82
Dec-17	146100	0	11446885	290	210384	14610	22125		13943	1366792	9.36
Nov-17	148500	0	1165725	290	213840	-46035	22125	0.967	-27119	1315248	8.86
Oct-17	146100	0	1146885	290	210384	-21915	22125	0.967	-27155	1317608	9.02
Sep-17	140700	0	1104495	290	202608	-28140	21300	0.965	-26011	1261026	8.96
Aug-17	152400	0	1196340	290	219456	-88392	23925	0.964	-13516	1323287	8.68
AVERAGE	**138500**	**0**	**1918958**	**292.5**	**199820**	**29017**	**20756**	**0.975**	**-37321**	**1257619**	**9.10**

6. Recommendation in Billing – Power Factor Incentive

Utility has not maintained the power factor to unity (i.e. 1). It causes incentive benefits at lower rate. It is recommended that to replace the faulty capacitor and check the power factor on daily basis to get benefit of 7% incentive. Monthly saving of Rs.1, 14,498/- is possible by maintaining power factor unity

7. Lighting and Fan System

7.1 Recommendation in Lighting and Fan System

Table-7.1: Recommendation in Lighting and Fan System

Bldg	Floor	Location	Type	Change	New Wattage	New kWh	Monthly Saving kWh	Monthly Saving Rs	Unit Rate Rs	Inv. Rs	Payback
Old CGO Building	Ground floor to 5th floor	AG canteen building lift lobby	2 X 2 LED Panel	No Change	36	75.348	0.00	0.00	0.00	0.00	0.00
Old CGO Building	Ground floor to 4th floor	AG canteen building lift lobby	LED SDL	No Change	18	92.736	0.00	0.00	0.00	0.00	0.00
Old CGO Building	Ground floor to 3rd floor	AG canteen kitchen passage	LED SDL	No Change	18	34.776	0.00	0.00	0.00	0.00	0.00
Old CGO Building	Ground floor to 3rd floor	AG canteen kitchen passage	LED SDL	No Change	10	19.32	0.00	0.00	0.00	0.00	0.00
Old CGO Building	Ground floor to 3rd floor	Gaikwad lift passage	LED SDL	No Change	18	86.94	0.00	0.00	0.00	0.00	0.00
Old CGO Building	Ground floor to 4th floor	Gaikwad lift lobby	2 X 2 LED Panel	No Change	36	46.368	0.00	0.00	0.00	0.00	0.00
Old CGO Building	Ground floor to 4th floor	Account audit passage	LED SDL	No Change	18	115.92	0.00	0.00	0.00	0.00	0.00
Old CGO Building	Staircase	Gaikwad lift	LED SDL	No Change	18	23.184	0.00	0.00	0.00	0.00	0.00
Old CGO Building	Staircase	Central Lift	LED SDL	No Change	18	23.184	0.00	0.00	0.00	0.00	0.00
Old CGO Building	Ground floor	Central Lift Lobby	2 X 2 LED Panel	No Change	36	34.776	0.00	0.00	0.00	0.00	0.00
Old CGO Building	Ground floor	Central Lift Lobby	LED SDL	No Change	18	11.592	0.00	0.00	0.00	0.00	0.00
Old CGO Building	Gr flr to 3rd flr	All India association passage	No Change	10	19.32	0.00	0.00	0.00	0.00	0.00	
Old CGO Building	Gr flr to 3rd flr	All India association passage	LED SDL	No Change	18	43.47	0.00	0.00	0.00	0.00	0.00
Old CGO Building	Staircase	All India association	LED SDL	No Change	18	46.368	0.00	0.00	0.00	0.00	0.00
Old CGO Building	Gr flr to 4th flr	CGS lab passage	2 X 2 LED Panel	No Change	36	231.84	0.00	0.00	0.00	0.00	0.00
Old CGO Building	Ground floor	CGS Card	2 X 36W PL	28W Led Panel	28	31.556	49.59	451.25	2200.00	15400.00	34.13
Old CGO Building	1st floor	SSC Department	4 X 28 PL (2' X 2')	28W Led Panel	28	36.064	108.19	984.55	2200.00	17600.00	17.88
Old CGO Building	2nd floor		LED SDL	No Change	18	28.98	0.00	0.00	0.00	0.00	0.00
Old CGO Building	3rd flr		LED SDL	No Change	18	14.49	0.00	0.00	0.00	0.00	0.00
Old CGO Building	3rd flr		T5 TL	18W Led Tubelight	18	26.082	14.49	131.86	320.00	2880.00	21.84
Old CGO Building	4th flr	Court Passage	LED SDL	No Change	18	37.674	0.00	0.00	0.00	0.00	0.00
Old CGO Annex Building	Grd floor	Lift lobby	2 X 2 LED Panel	No Change	36	34.776	0.00	0.00	0.00	0.00	0.00
Old CGO Annex Building	1st flr to 18th flr	Lift lobby	LED SDL	No Change	18	208.656	0.00	0.00	0.00	0.00	0.00
Old CGO Annex Building	Grd floor	Parking	Dome Light LED	No Change	36	115.92	0.00	0.00	0.00	0.00	0.00
Old CGO Annex Building	Grd flr to 18th flr	Staircase	LED SDL	No Change	14	85.652	0.00	0.00	0.00	0.00	0.00
Old CGO Annex Building	Grd flr	Back side(Darga)	LED Street light	No Change	18	20.286	0.00	0.00	0.00	0.00	0.00
Old CGO Annex Building	Grd flr	Front side(Track)	2 X 12W LED	No Change	24	38.64	0.00	0.00	0.00	0.00	0.00
Old CGO Annex Building	Grd flr	for building	LED Flood	No Change	250	1046.5	0.00	0.00	0.00	0.00	0.00
Old CGO Annex Building	Grd flr	AG car parking	LED bulb	No Change	12	30.912	0.00	0.00	0.00	0.00	0.00
Sum						**2661**		**1567**		**35880.00**	**22.89**

- Present monthly lighting and fan system kWh = 2833 kWh
- New monthly lighting and fan system kWh = 2661 kWh
- Expected monthly energy savings in kWh = 172 kWh

- Expected monthly monetary savings = Rs.1567/-
- Expected investment = Rs. 35880/-
- Payback period = 22.89 Months

8. FUTURE WORK

Industrial energy audit

In order to reduce energy consumptions for sustainable and energy-efficient manufacturing, continuous energy audit and process tracking of industrial machines are essential. Compared to other non-residential buildings that have been widely researched, industrial buildings. After completing the commercial building energy audit, we go to industrial energy audit. The reduction of energy costs is a key to improve companies competitiveness and for this reason the realization of an energy audit of industrial sites is not only a specific obligation foreseen by the European Directives but also a real opportunity for the companies.

9. CONCLUSION

Energy audit is a powerful tool to achieve interesting energy savings. The reduction of energy costs is a key to improve companies competitiveness and for this reason the realization of an energy audit of industrial sites is not only a specific obligation foreseen by the European Directives but also a real opportunity for the companies. In this paper the energy audit, limited to the heating plants of the factory, of an industrial site devoted to the production of luxury cars is described. It has been demonstrated how the energy audit enables to collect information which are very useful to define a factory energy model by means of which the energy balance of the site is analyzed. By means of the factory energy model it is possible to study the impact of possible improvements of the site in order to achieve the mitigation of its environmental impact and to reduce energy costs.

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