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# ENERGY AUDIT AND ENERGY SAVING MANAGEMENT

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**Abstract -** *This paper presents the study of the importance of energy auditing and the process of energy auditing are presented in detail. The implementation of energy-saving strategies has become a necessity and improving the performance of various facilities is no longer a prestige, it has now become mandatory for all sectors. The main objective is to analyze and reduce the existing energy demand and system response for a particular operation. This project aims to carry out lighting audit and electric load management audits in commercial, educational, and industrial buildings. This paper describes suggesting cost-effective measures to improve the efficiency of energy use.*

***Key Words*: Energy audit, Energy comsumption, Energy management, solutions.**

## 1. INTRODUCTION

An energy audit sometimes referred to as an energy survey or an energy inventory, is an examination of the total energy used in a particular property. The analysis is designed to provide a relatively quick and simple method of determining not only how much energy is being consumed but where and when. The energy audit will identify deficiencies in operating procedures and in physical facilities. Once these deficiencies have been identified, it will be apparent where to concentrate efforts in order to save energy. The energy audit is the beginning of and the basis for an effective energy-management programmers system.[5]We have carried out the assignment for the Detailed Energy Audit of an overall survey of two different sites.[2] We found this assignment to be very challenging and also very interesting because it has been constructed recently and the selection of various Energy consuming items -Pumps, Cooling Towers, Lifts, Lighting, etc are as per the latest Technology. These steps contribute to a great extent for Energy Efficiency. [6]We have carried out very elaborate measurements for various Operating Parameters, related to Energy efficiency, covering each area. We have studied all the common areas under the control of Management.

### 1.1 MAIN OBSERVATION

Based on the measurement data, analysis of the performance and our observation, it is observed that Energy utilization is very well managed.

- **Methodology Adopted**

The methodology adopted for this audit was a three step process comprising :

**1. Data Collection –** In the preliminary data collection phase, exhaustive data collection was made using different methods such as observation, interviewing key persons, and measurements. Following steps were taken for data collection:

- ✓ Visited each department, center, laboratories, library, canteen, auditorium and other entities of the institution.
- ✓ Information about the general electrical appliances was collected by observation and interviewing.
- ✓ Obtained Site drawing of available building lay-out and Electricity distribution.
- ✓ Collection of Electricity bill from the in-charge personnel.
- ✓ The power consumption of appliances was measured using power analyser in some cases (such as fans) while in other cases, rated power was used (CFL for example).
- ✓ Information collected on redundant / non-operational energy systems
- ✓ The details of usage of the appliances were collected by interviewing key persons e.g. Electrician, caretaker (in case of departments) etc.
- ✓ Approximations and generalizations were done at places with lack of information.

**2. Data Analysis -** Detailed analysis of data collected was done. Energy consumption per month in kWh is calculated based on each department and block-wise. The analysis of data is done in following way:

- ✓ Power Flow diagram
- ✓ Evaluation of collected data department wise analysis, block wise analysis and location wise analysis.

- ✓ Reasons for the Variance between connected load and actual consumption was evaluated.
- ✓ The database prepared was further studied and the results have been graphically represented.

This helped to identify the areas with maximum energy saving potential.

**3. Recommendation –** On the basis of results of data analysis and observations, some steps for reducing power consumption were taken. The recommended measures will not affect the present working conditions and at the same time substantial energy savings will arise. Following were the steps involved in this process:

- ✓ The capital cost involved in replacing an appliance and/or process was estimated.
- ✓ The energy saving by the move was calculated in terms of price of energy per year.
- ✓ These two costs were compared to calculate the capital cost recovery time which is defined as the total time by which the saving in energy bill balances the capital cost involved.
- ✓ If capital cost recovery time is less than the product life, the move can be supported.

Some other recommendations were also made which are based on lighting intensity, computer usage, fans and motion sensors.

## 1.2 CASE STUDY 1:

**1. case study on MSRTC Swargate Station and Depot.** We connected the power quality analyzer Fluke 430-II across various non-linear loads like energy meter, machinery transformer.

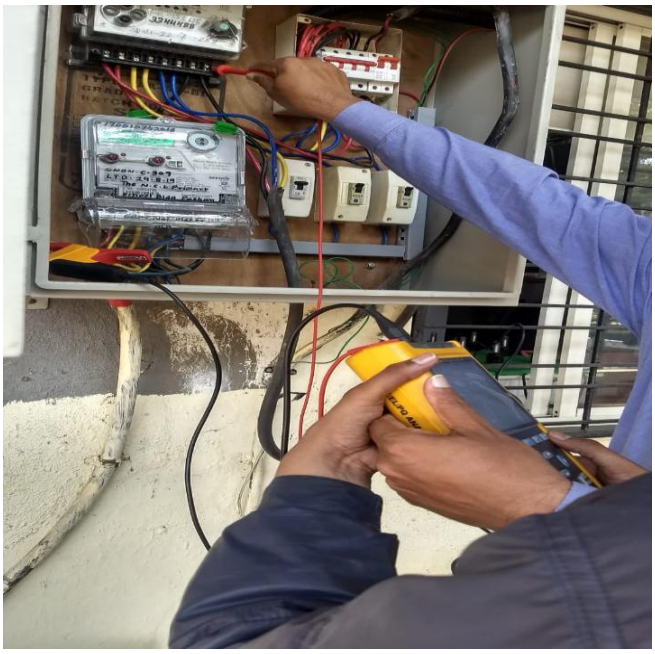


**Table -1:** Equipment wise Connected Load:

| No | Equipment | Qty | Load, W/Unit | Load, kW |
|---|---|---|---|---|
| 1 | T-12 FTL | 128 | 51 | 6.53 |
| 2 | 2* T-12 FTL Fitting | 134 | 102 | 13.67 |
| 3 | Ceiling Fan | 77 | 65 | 5.01 |
| 4 | Exhaust Fan | 25 | 65 | 1.63 |
| 5 | Air conditioner | 2 | 1650 | 3.3 |
| 6 | Air Compressor | 1 | 3730 | 3.73 |
| 7 | Water Pump-Pump House | 1 | 2238 | 2.24 |
| 8 | Water Pump-Bore Well | 1 | 1492 | 1.49 |
| 9 | PCs | 15 | 150 | 2.25 |
| 10 | Sodium Vapor Lamp | 4 | 165 | 0.66 |
| 11 | Electric Geyser | 3 | 3000 | 9 |
| 12 | Others | 25 | 100 | 2.5 |
| 13 | **Total** | | | **52** |

**STUDY OF ELECTRICAL ENERGY CONSUMPTION**

Here we present the trend in Electrical Energy Consumption, as under.

There are three meters in the facility, namely: Meter No: 49729, 74270 and 77724. The meter no: 77724 is for Depot while the other meters are for the Bus Stand.

The tariff is **LT-VB-II**. For calculation purpose, we take the Rate of Electrical Energy to be **Rs.7.85 / kWh.**

Table No-3: Electrical Bill Analysis: 2018-19:

| No | Month | Meter No: 49279 | Meter No: 74270 | Meter No: 77724 | Total Energy Consumed, kWh |
|---|---|---|---|---|---|
| 1 | Oct-18 | 1327 | 2962 | 3467 | 7756 |
| 2 | Nov-18 | 1104 | 2870 | 3377 | 7351 |
| 3 | Dec-18 | 1121 | 2151 | 3069 | 6341 |
| 4 | Jan-19 | 1314 | 2096 | 2823 | 6233 |
| 5 | Feb-19 | 1335 | 3276 | 2978 | 7589 |
| 6 | Mar-19 | 1377 | 3165 | 3373 | 7915 |
| 7 | Apr-19 | 1252 | 3546 | 3222 | 8020 |
| 8 | May-19 | 1257 | 3833 | 3567 | 8657 |
| 9 | Jun-19 | 1822 | 4338 | 2893 | 9053 |
| 10 | Jul-19 | 1976 | 3885 | 2820 | 8681 |
| 11 | Aug-19 | 1944 | 3112 | 2833 | 7889 |
| 12 | Sep-19 | 1726 | 3565 | 2435 | 7726 |
| 13 | Maximun | 1976 | 4338 | 3567 | 9053 |
| 14 | Minimun | 1104 | 2096 | 2435 | 6233 |
| 15 | Average | 1462.92 | 3233.25 | 3071.42 | 7767.58 |
| 16 | Total | 17555 | 38799 | 36857 | 93211 |

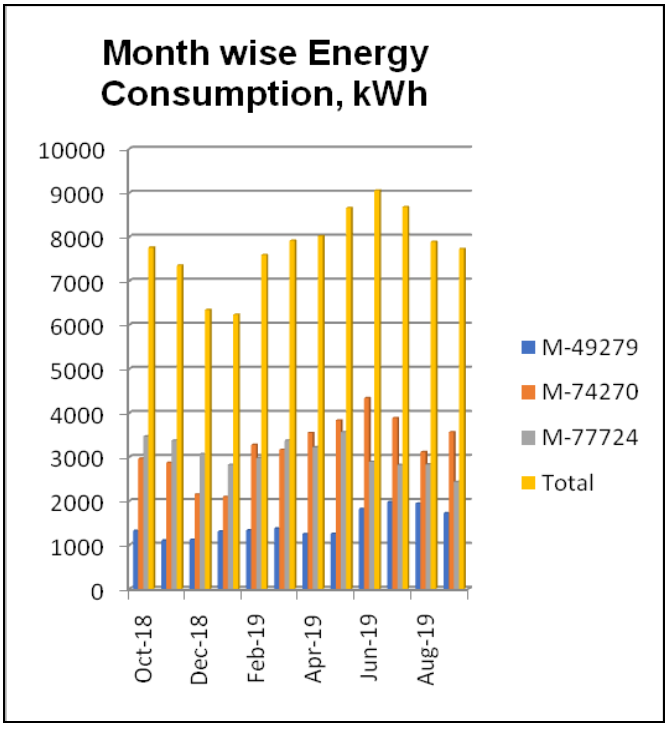



**Chart -1: Variation in Energy Consumed, kWh**

Table No-3: Key Observations

| No | Parameter /Value | Energy Consumed, kWh | | | |
|---|---|---|---|---|---|
| | | Meter No: 49279 | Meter No: 74270 | Meter No: 77724 | Total Energy Consumed, kWh |
| 1 | Maximum | 1976 | 4338 | 3567 | 9053 |
| 2 | Minimum | 1104 | 2096 | 2435 | 6233 |
| 3 | Average | 1462.92 | 3233.25 | 3071.42 | 7767.58 |
| **4** | **Total** | **17555** | **38799** | **36857** | **93211** |

We present the Data in a PIE Chart as under :

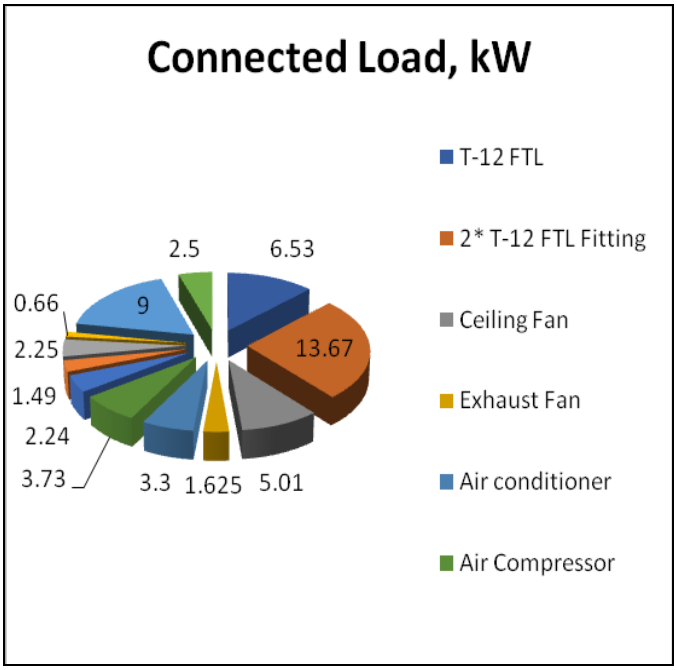



**Chart No-2: Connected Load**

Table No-4: Total Summary of Savings: Bus Depot and Bus Stand:

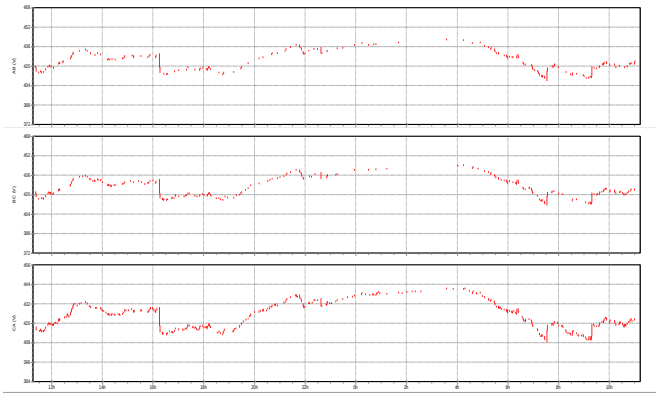
| **Summary Savings- Bus Depot:** | | | | | |
|---|---|---|---|---|---|
| **No** | **Recommendation** | **Annual Energy Saving, kWh** | **Annual Monetary Saving, Rs** | **Investment, Rs** | **Payback Period, Months** |
| 1 | Replacement of 60 Nos 2*T-12 FTL fittings by 40W LED Panel Fittings | 8928 | 70084.8 | 228160.8 | 40 |
| 2 | Replacement of 60 Nos T-12 Fittings by 18 W LED Tube Light Fittings | 3801.6 | 29842.56 | 30748.032 | 12.4 |
| 3 | Replacement of 4 Nos 150 W SVL Fittings by 48 W LED Fittings | 2049.84 | 16091.244 | 15519.392 | 12 |
| 4 | Replacement of 5 Nos Old Exhaust Fans by En Efficient Exhaust Fans | 1980 | 15543 | 17521.84 | 13.5 |
| 5 | Replacement of Old Ceiling Fans by 5 STAR Rated Fans | 1188 | 9325.8 | 43477.28 | 55.9 |
| 6 | Replacement of 24 Nos 2*T-12 FTL by 30 W LED fitting | 4561.92 | 35811.072 | 103200 | 34.6 |
| 7 | Installation of 40 kVAr APFC Panel | 0 | 48000 | 155417 | 38.9 |
| **8** | **Sub Total- Depot** | **22508.8** | **224698.47** | **594044** | **32** |
| | | | | | |
| **Summary Savings- Bus Stand:** | | | | | |
| **No** | **Recommendation** | **Energy Saving, kWh/Annum** | **Annual Monetary Saving, Rs** | **Investment** | **Payback Period, Months** |
| 1 | Replacement of 50 Nos 2*T-12 FTL fittings by 40W LED Panel Fittings | 9052 | 71058 | 199206 | 34 |
| 2 | Replacement of 80 Nos T-12 Fittings by 18 W LED Tube Light Fittings | 7709 | 60514 | 51247 | 11 |
| 3 | Replacement of 57 Nos Old Ceiling Fans by 5 STAR Rated Fans | 2257 | 17719 | 123910 | 84 |
| 4 | Replacement of 1 No Old 3 HP Centrifugal Water Pump by Submersible Pump | 2759 | 21661 | 26005 | 15 |
| 5 | Replacement of 1 No Old 3 HP Submersible Water Pump by New En Efficient Submersible Pump | 4668 | 36642 | 34466 | 12 |
| 6 | Installation of 2500 LPD Solar Thermal System | 4380 | 34383 | 375195 | 131 |
| 7 | Replacement of 20 Nos Exhaust Fans by Energy Efficient Fans | 13140 | 103149 | 70080 | 9 |
| **8** | **Sub Total: Bus Stand** | **43965** | **345127** | **880108** | 30 |
| | | | | | |
| | **Grand Total** | **64474** | **569824.5** | **1474153** | **32** |

**Total Summary of Savings: Bus Depot and Bus Stand:**

1. **Voltage**
2. Voltages have been measured during the interval

- Line Voltage
- Phase Voltage
- Neutral to Ground Voltage

**The Readings are represented as follows: -**



**Remarks: -**

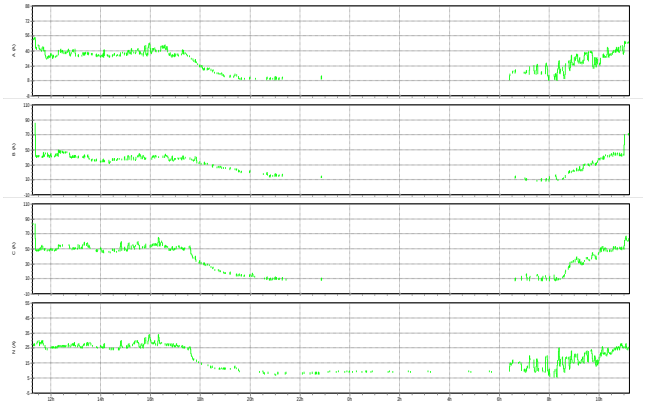
- Line Voltage and Phase Voltage – No abnormality Seen in voltage, Voltage is varying around 415 V.

**Standards Referred: -**

**IEC60364-5-52 – Voltage tolerance of 5%.**

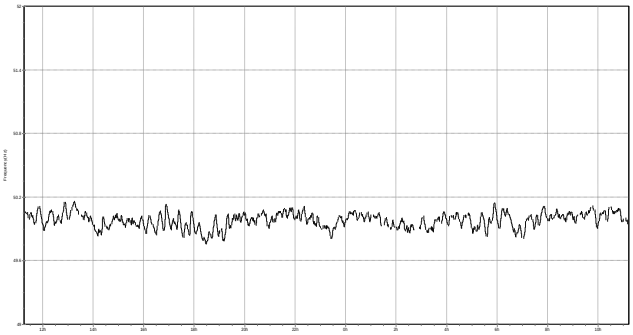
### 3. Current

During the logging period, Line current has been measured



### 4. Frequency

Nominal Frequency for Indian Grid Code is 50Hz, the system frequency has been measured.



**Remarks: -**

Frequency is within range and no abnormality seen.

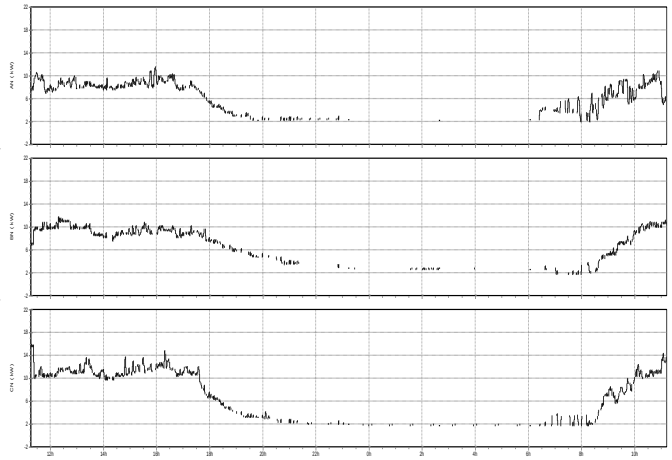
**CERC India -Range 49.0 to 50.5 Hz**

### 5. Power & Power Factor

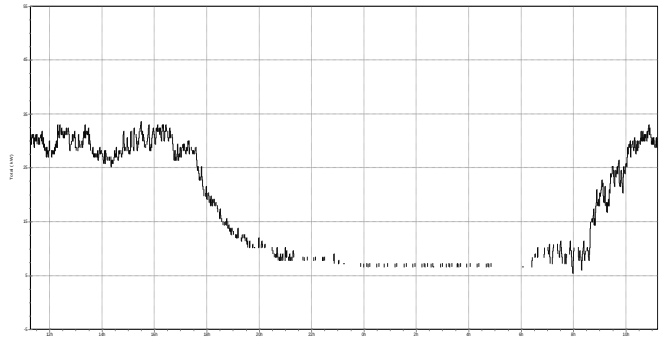
Power parameters measured –

- Active Power(W)
- Power Factor

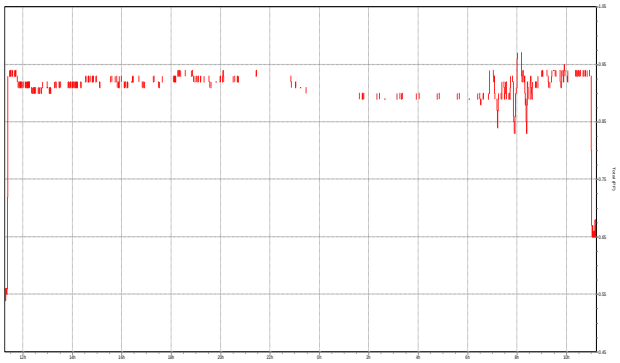
The data can be represented as follows: -



3 Phase Power - Total



**Power factor**



Power Factor

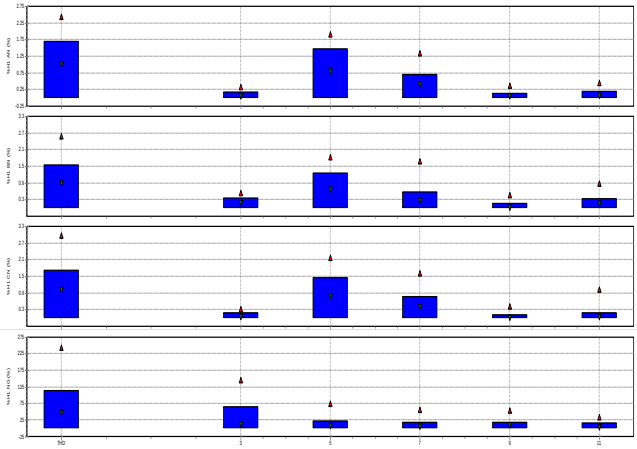
| | |
|---|---|
| Average | 0.90 |
| Maximum | 0.97 |
| Minimum | 0.54 |

### 6. Harmonics and Distortion (THD)

Harmonic distortion is the noise in the circuit accounting to the conversion of Power from AC to DC or vice versa.

We have recorded voltage and current harmonics and the total distortion as follows -

**Voltage –**

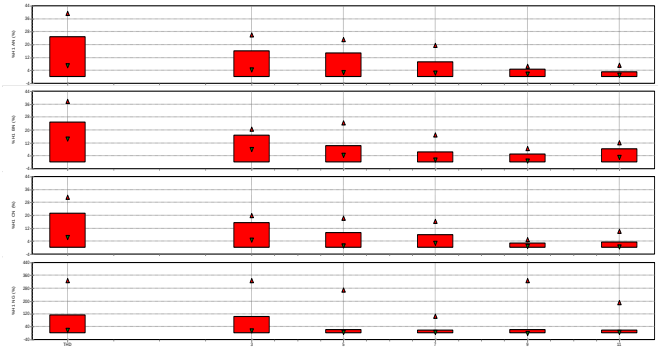


**Remarks: -**

- Voltage Distortion is normal, No abnormality seen
- Neutral Harmonics are High at 75%, needs attention

**Reference: - IEEE 519 – 1992 allows 5 % Vthd**

**Current-**



**Remarks: -**

- Current Distortion is high. Harmonics will traverse towards the Source.
- Action recommended to be taken to mitigate harmonics at main terminal, if Total TDD is high at the main PCC panel

**Reference:- IEEE 519 – 1992 allows 5-8 % Ithd Based on Isc/IL Configuration**

### 4. RESULT OF CASE 1

Energy audit is an effective tool in identifying and perusing a comprehensive energy management program. A careful audit of any type will give the organization a plan with which it can effectively manage the organization energy system at minimum energy cost. In this study, a detailed study has been made to reduce the electrical energy consumption in the complete Bus Stand area. It highlights the amount of energy savings that can be obtained in an educational Institution, thereby energy crisis can be reduced considerably. The Following facts have emerged after the detailed energy auditing of said building

1. Energy saving per year is **64474** kWh
2. Total Cost reduction per year is **569824.5** rupees
3. total Investment is **1474153 rupees**
3. Pay-back Period of various appliances. Is **32**

The Proposed audit gives strong warning to the consumer not only in terms of the energy bills, but also the energy crisis in the near future to all sectors of people. By implementing the recommendations suggested in this project, there will be a reduction of around **41.66 %** of the energy and **30.6 %** of cost reduction. The total investment required for implementing the recommendations would be to the extent of Rs 2, 42,062 and The Pay-Back period for various appliances have also been calculated. Energy Auditing is a continuous process and organizations should carryout auditing periodically.

## 5. CASE STUDY 2:

### Case study on MSRTC Swargate Station and Depot.

After the Field measurements & analysis, we present herewith important observations made and various measures to reduce the Energy Consumption & mitigate the $CO_2$ emissions

1. **Industrial Training Institute, Aundh, Pune** consumes Energy in the form of Electrical Energyused for various gadgets, Office & other facilities.

2. **Present Energy Consumption**:

Table No-5: we present the details of Energy Consumption.

| No | Parameter | Energy consumed, kWh/ Month | Maximum Demand, kVA | Power Factor |
|---|---|---|---|---|
| 1 | Maximum | 33180 | 135 | 0.994 |
| 2 | Minimum | 17615 | 100 | 0.977 |
| 3 | Average | 25139 | 110 | 0.99 |

3. **Energy Conservation Projects already installed:**

1. Usage of LED tube lights at some locations
2. Maintenance of Power Factor close to Unity.

4. **Key Observations:**

1. There are about **880 Nos** old T-8 type fittings AT VARIOUS LOCATIONS LIKE Office, Workshop etc. which need to be replaced by **18 W LED** fittings & 20 W LED fittings at Workshops.
2. There are about **48 Nos** 70 W SVL fittings at AVTS workshop. It is recommended to replace these fittings with 36 W LED fittings.
3. There are about **405 Nos** Old Ceiling Fans which need to be replaced with 5 STAR Rated Fans
4. There are about **17 Nos** Old Exhaust Fans in the premises. It is recommended to replace these old fans by New Energy Efficient Fans.

5. **Recommendations:**

Table No-5:

| Recommendation | Expected Annual Energy Saving, kWh | Expected Annual Monetary Saving, Rs | Investment required, Rs. | Simple Payback Period, Month |
|---|---|---|---|---|
| Replacement of 600 Nos T-8 fittings with 18W LED fittings | 22176 | 188496 | 384600 | 25 |
| Replacement of 280 Nos T-8 fittings by 140 Nos 40 W LED Fitting | 12544 | 106624 | 532375. | 60 |
| Replacement of 48 Nos, 125 W SVL fittings by 70 W LED fittings | 5241.6 | 44553.6 | 531272 | 144 |
| Replacement of 450 Nos Old Ceiling Fans by BEE 5 STAR Rated Fans | 17550 | 149175 | 978300 | 49 |
| Replacement of old 17 Nos Exhaust Fans by Energy efficient exhaust fans | 952 | 8092 | 31025 | 17 |
| **Total** | **58464** | **496941** | **2457573** | **60** |

**6. Notes& Assumptions:**

1. Daily working hours-10 Nos
2. Annual working Days-280 Nos
3. Average Rate of Electrical Energy : **Rs 8.50/- per kWh**
4. The various rates considered in the Report of various Electrical equipment have been taken from **PWD-CSR-2019-20**

**7. Details of Costing of equipment as per PWD-CSR-19-20:**

| No | Equipment | PWD CSR No | Page No | Basic Price, Rs/Unit (A) | Labor Charges, Rs/Unit (B) | Total (A)+(B) | GST @ 12 % (C) | Total Cost, Rs A+B+C |
|---|---|---|---|---|---|---|---|---|
| 1 | 18 W LED Tube Light fitting | 2-1-22 | 32 | 531 | 40.95 | 571.95 | 68.63 | 641 |
| 2 | 40 W LED Fitting | 2-1-12 | 31 | 3285 | 110.25 | 3395.25 | 407.43 | 3802.68 |
| 3 | 70 W High bay LED fitting | 2-7-1 | 38 | 9708 | 174.3 | 9882.3 | 1185.87 | 11068.17 |
| 4 | 5 STAR Rated Ceiling Fan | 2-12-21 | 44 | 1858 | 82.95 | 1940.95 | 232.9 | 2174 |
| 5 | Exhaust Fan | 2-12-15 | 43 | 1505 | 123.9 | 1628.9 | 195.4 | 1825 |

**CONSUMPTION**

In this Chapter, we present the trend in Electrical Energy Consumption, as under.

Table No-8: Electrical Bill Analysis: 2018-19:

| No | Month | Energy Consumed, kWh | Maximum Demand, kVA | Power Factor |
|---|---|---|---|---|
| 1 | Sep-18 | 22075 | 103 | 0.988 |
| 2 | Oct-18 | 23600 | 100 | 0.977 |
| 3 | Nov-18 | 17615 | 100 | 0.981 |
| 4 | Dec-18 | 20225 | 100 | 0.979 |
| 5 | Jan-19 | 25750 | 100 | 0.99 |
| 6 | Feb-19 | 23075 | 100 | 0.98 |
| 7 | Mar-19 | 29345 | 115 | 0.978 |
| 8 | Apr-19 | 29085 | 123 | 0.988 |
| 9 | May-19 | 33180 | 135 | 0.99 |
| 10 | Jun-19 | 29330 | 122 | 0.991 |
| 11 | Jul-19 | 28735 | 113 | 0.992 |
| 12 | Aug-19 | 19653 | 105 | 0.994 |
| 13 | **Total** | **301668** | - | - |
| 14 | Maximum | 33180 | 135 | 0.994 |
| 15 | Minimum | 17615 | 100 | 0.977 |
| 16 | Average | 25139.00 | 109.67 | 0.99 |

**Chart No-3: Variation in Energy Consumed, kWh:**

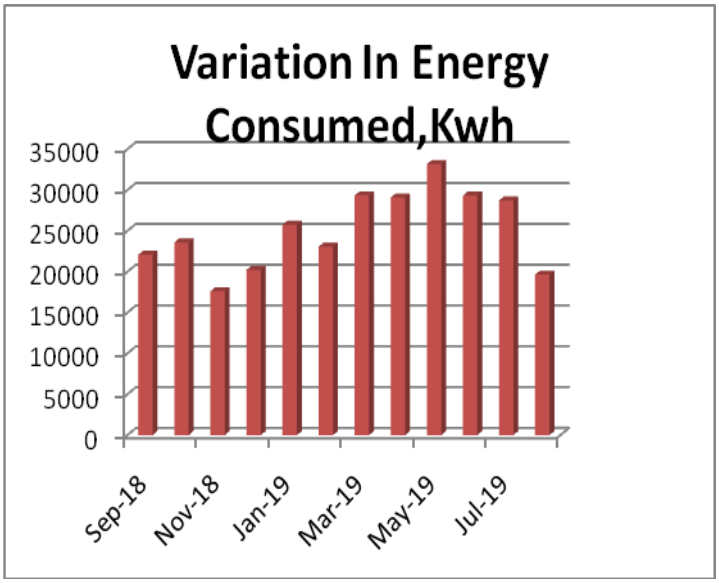


**Chart No-4: Variation in Maximum Demand, kVA:**

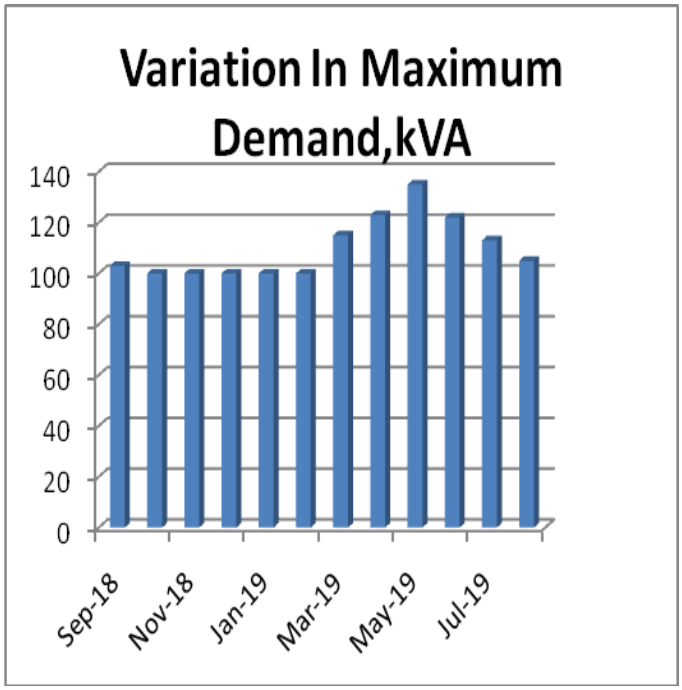



**Chart No-5: Variation in Power Factor:**

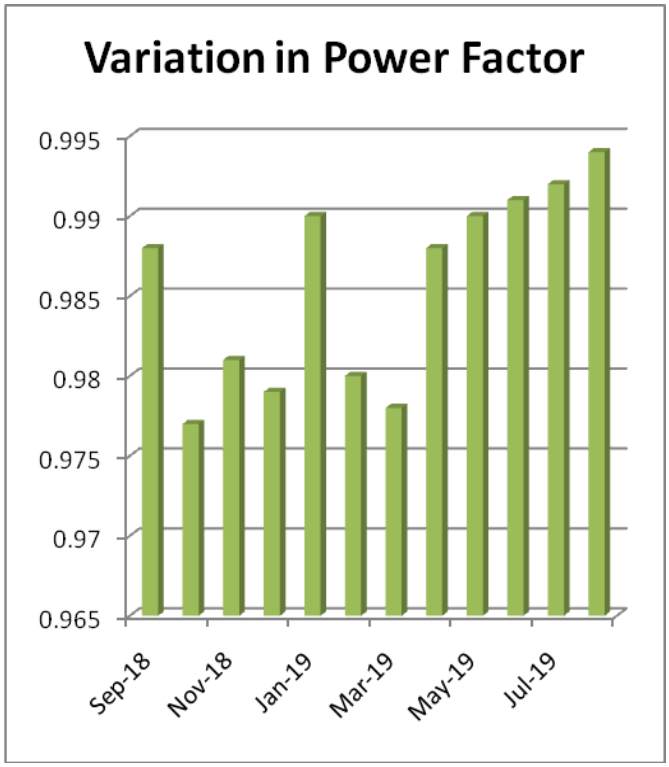



Table No-9: we present the details of Energy Consumption

| Recommendation | Expected Annual Energy Saving, kWh | Expected Annual Monetary Saving, Rs | Investment required, Rs. | Simple Payback Period, Month |
|---|---|---|---|---|
| Replacement of 600 Nos T-8 fittings with 18W LED fittings | 22176 | 188496 | 384600 | 25 |
| Replacement of 280 Nos T-8 fittings by 140 Nos 40 W LED Fitting | 12544 | 106624 | 532375. | 60 |
| Replacement of 48 Nos, 125 W SVL fittings by 70 W LED fittings | 5241.6 | 44553.6 | 531272 | 144 |
| Replacement of 450 Nos Old Ceiling Fans by BEE 5 STAR Rated Fans | 17550 | 149175 | 978300 | 49 |
| Replacement of old 17 Nos Exhaust Fans by Energy efficient exhaust fans | 952 | 8092 | 31025 | 47 |
| **Total** | **58464** | **496941** | **2457573** | **60** |

## CONCLUSION AND RESULT 2

1. Expected saving in Electrical Energy is **58464kWh/Annum**
2. Expected monetary gain is **Rs. 496941/- per Annum**
3. The total investment in Energy Efficiency Projects is: **Rs. 2457573/- lump sum.**
4. Simple payback period works out to be **60 Months.**

## 6. ACKNOWLEDGEMENT

I hereby take this opportunity to express my profound thanks and deep sense of gratitude towards my on-site guidance by MR. A.Y MEHENDALE ,Proprietor, Enrich consultants, pune who gave his valuable guidance and my project guide and the faculty of Department of Electrical Engineering whose constant encouragement and expert advice was instrumental in the completion of this research. Let me, at the end, express gratitude to all those from whom received co-operation and motivation during the research

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