Dr. Bhavesh Kanabar
Certified Energy Manager (Reg. No.16734/20)

Energy Audit Report

Client

Marwadi University

Rajkot-Morbi Highway
Rajkot – 360003

Date of Issue: 31/01/2023

Sr. No.	Specifications	Details
1.	Name of the customer	Marwadi Education Foundation
2.	Name of the customer (as per Electric Bill)	Marwadi Education Foundation
3.	Consumer No.	26437
4.	Address	Opp. Mahadev Vadi, Rajkot-Morbi Highway, Between Bedi & Gauridad, Dist:- Rajkot
5.	Contract Demand	1300 kVA
6.	Purpose of Consumer	HTP-I
7.	Name of Supplier	PGVCL(Electricity)
8.	Period of Audit	January 2022 to December 2022

PREFACE

Data collection for energy audit of MU campus was carried out during January 2023. This audit was conducted to seek opportunities to improve the energy efficiency of the campus. Reduction of energy consumption while maintaining or improving human comfort, health and safety was of primary concern. Besides simply identifying the energy consumption pattern, this audit seeks to identify the most energy efficient appliances. Moreover, some daily practices relating common appliances have been provided which may help reducing the energy consumption. The report accounts for the energy consumption patterns of the academic area, central facilities and hostels based on actual survey and detailed analysis during the audit. The work encompasses the area wise consumption traced using suitable equipments. The report compiles a list of possible actions to conserve and efficiently access the available scarce resources and their saving potential has been also identified. We look forward to optimum so that the authorities, students and staff would follow the recommendations in the best possible way. The report is based on certain generalizations and approximations wherever necessary. The views expressed may not reflect the general opinion. They merely represent the opinion of the team guided by the opinions of consumers.

ACKNOWLEDGEMENT

I express my sincere gratitude to the authorities of Marwadi University, Rajkot for entrusting and offering the opportunity of Energy Audit, which was conducted in January 2023.

I am thankful to management for their positive support in undertaking the task of energy efficiency assessment of all electrical system, air conditioners, utilities and other equipment. The field studies would not have been completed on time without their interaction and guidance. I am grateful to their cooperation during field studies and providing necessary data for the study.

I am also thankful to supporting staff working with whom we interacted during the field studies for their wholehearted support in undertaking measurements and eagerness to assess the system/equipment performance and saving potential. Also thankful to all concerned staff interacted during the conduct of this exercise for completing official documentations.

CONTENTS

Chapter 1: Introduction **1**
1.1 Objectives of Energy Audit **1**
1.2 Necessary steps in an energy audit **1**
1.3 Identification of Target Areas **2**
1.4 Grouping and strategy **2**
1.5 Advantages of Energy Audit **2**
Chapter 2: Existing Electrical Load Pattern **3**
2.1 Overall campus details **3**
2.2 Location wise load pattern **4**
2.3 Summary of location wise load **8**
2.4 Equipment wise load pattern **9**
2.5 Observation during survey **10**
2.6 Electricity Units Analysis **11**
2.6.1 Consumption of electricity units from grid **11**
Chapter 3: Energy Audit Methodology **12**
3.1 Data Collection **12**
3.2 Data Analysis **12**
3.3 Recommendation **12**
Chapter 4: Energy Conservation Measures & Utilization of Alternate Source of Energy **14**
4.1 LED light conservation project **14**
4.2 Solar energy utilization **16**
Chapter 5: Recommendation **18**
5.1 Lightning **18**
5.1.1 Cost Analysis of Replacing T-12 (28W) Tube Lights with Energy Efficient LED Light (12 W) **18**
5.1.2 Cost Analysis of Replacing T-12 (28W) Tube Lights with Energy Efficient LED Light (8 W) **18**
5.1.3 Cost Analysis of Replacing T-12 (18W) Tube Lights with Energy Efficient LED Light (8 W) **19**
5.1.4 Cost Analysis of Replacing CFL (18W) with Energy Efficient LED Light (8 W) **19**
5.2 Fans **19**
5.2.1 Cost Benefit Analysis of Replacing Existing Fans by Energy Efficient BLDC Fans **19**
5.3 Other Recommendations **20**
5.3.1 Use of master switch outside each room **20**
5.3.2 Use of reflectors in tube lights and cleaning of tube lights **20**
5.3.3 Proper insulation of refrigerant pipe line **20**
5.3.4 Use of time based lightning system in lobby area and parking area **20**
5.3.5 Proper insulation of room **20**
5.3.6 Curtains **20**
5.3.7 Maintenance **20**

LIST OF FIGURES

2.3 Percentage representation of MU load **8**

2.4 Load shared by different equipment **10**

4.1.1 Decrement in uses of conventional lightning equipments **14**

4.1.2 Increment in uses of LED lightning equipments **15**

4.2 Increment in unit generation by solar energy in year 2021 and 2022 **16**

4.3 Increment in unit generation by solar energy in year 2021 and 2022 **17**

LIST OF TABLES

2.1 Demand and power factor details	**3**
2.2.1 Main Building	**4**
2.2.2 PG Building	**4**
2.2.3 Law Building	**5**
2.2.4 Campus area and other premises	**5**
2.2.5 Hostel – A Building	**6**
2.2.6 Hostel – B Building	**6**
2.2.7 Hostel – C Building	**7**
2.2.8 Canteen Area	**7**
2.2.9 Workshop Building	**7**
2.3 Summary of location wise load	**8**
2.4 Equipment wise load pattern	**9**
2.6.1 Monthly Electricity Units	**11**
4.1 Energy saving data by LED project	**14**
4.2 Units generated by solar plant	**16**

1. Introduction

Marwadi University is a private university located in Rajkot, Gujarat, India. It was established on 9 May 2016 by the Marwadi Education Foundation through the Gujarat Private Universities Act, 2016. As of 2023, it offers more than 50 courses.

International Students from more than 52 countries have chosen Marwadi University for higher education. The university is supported by 450+ faculties from 22 states of the country with around 150 PhD qualified faculty members. It has Incubation, Innovation and Research centre, which is an ecosystem that weaves industry and academia, steering the institutions' focus towards building products, services, businesses, and intellectual property, addressing real problems faced by the economy and the society at large.

1.1 Objectives of Energy Audit

The objective of the energy audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs at Marwadi University, Rajkot.

The intention of this energy audit is to identify, measure, and describe energy consumption by different loads in hostels, administrative areas, academic areas, meeting halls, street lights and to recommend energy-saving methods.

The main objectives are:

- Identification of possible uses of renewable energy sources like solar energy to minimise cost.
- Suggesting to replace highly power-consuming loads with low-power-consuming and efficient loads.
- Improving the efficiency of our target loads
- Documenting results and indispensable information generated through these activities.

1.2 Necessary steps in an energy audit

1. Planning Phase: Before getting an energy audit, the criteria for the audit are reviewed and defined.
2. Data Collection: Data can be collected in many ways at the facility and labs by appropriate measuring devices.
3. System Measurements: Some of the system measurements that may be taken include electrical, speed, and light intensity measurements.
4. Review Operating Practices: The operating practices at any facility can have a large impact on the energy audit as well.
5. Data Analysis: During the energy audit, massive amounts of data will be accumulated, and software may be used to analyse the data and to look for any issues that may exist.
6. Reporting and Recommendations: A comprehensive report will be provided, and any recommendations for improving energy usage at the facility will be given at that time.

1.3 Identification of Target Areas

We have considered the power dissipation by the loads as the primary factor to identify the target areas. Hence, we have analysed the energy consumption of various loads. Main focus is given to the loads that take more power, like fans, lighting, elevators, and air conditioners, as they are the key target areas where improvement is required.

1.4 Grouping and strategy

The following steps were done with specific target areas and end users assigned.

Step 1: Collecting electrical data related to lighting, fans, elevators, air conditioner etc... in our University.

Step 2: Data Collection from labs and their specifications

Step 3: Data Analysis by Means of Calculations

Step 4: Creating Charts and Graphs based on the collected data.

1.5 Advantages of Energy Audit

- Reducing environmental damage and pollution.
- Increasing the performance and life span of electrical loads.
- It helps lower energy bills.
- Discovering any unaccounted consumption that may exist at the facility.
- Better safety and protection.

2. Existing Electrical Load Pattern

Electrical load pattern gives us the information about the distribution of load. Electrical load data are collected by equipment, application as well as location wise.

2.1 Overall campus building details

Marwadi University campus sanctioned contract demand is 1300 kVA. Presently institute has 612 kW solar roof top generations. In addition to that capacity of DG set for power back up is 1380 kVA/1104kW. Total connected equipment load of the university is 3566kW.

Table 2.1 Demand and power factor details

Month	Contract Demand (kVA)	85%Contract demand (kVA)	Billing Demand (kVA)	Average P.F.
Jan-22	1300	1105	427	1
Feb-22	1300	1105	368	1
Mar-22	1300	1105	631	1
Apr-22	1300	1105	938	1
May-22	1300	1105	1115	1
Jun-22	1300	1105	1168	1
Jul-22	1300	1105	932	1
Aug-22	1300	1105	1166	1
Sep-22	1300	1105	1105	1
Oct-22	1300	1105	953	1
Nov-22	1300	1105	783	1
Dec-22	1300	1105	605	1

As APFC panel installed in control room, the average power factor is maintained nearly unity and the utility provide the rebate for maintaining power factor is about 2.5% in every billing cycle.

2.2 Location wise load pattern

Table 2.2.1 Main Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Circle CFLs	18 W	920	16.56
2	Tube Light(x4)	18 W	3592	64.66
3	Fan	73 W	2137	156
4	AC	1119 HP	-	834.77
5	Tubelight Single	28 W	468	13.104
6	C Fan	125 W	90	11.25
7	Table Fan	125 W	91	11.38
8	LED	12 W	1667	20.004
9		20 W	682	13.64
10	Cooler	3100 W	14	43.4
11	Elevators for students	26800 W	6	160.8
12	Elevators for staff	3100 W	2	6.2
13	Speakers	45 W	310	13.95
14	Projector Set	653 W	157	102.521
15	Printer	750 W	47	35.25
16	PC	32 W	1354	43.328
Total Connected Load (kW)				**1546.817**

Table 2.2.2 PG Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Fan	73 W	92	6.716
2	AC	620 HP	-	462.52
3	Tubelight Single	28 W	55	1.54
4	LED	12 W	736	8.832
5		20 W	8	0.16
6	Cooler	575 W	5	2.875
7	Elevators for staff	3100 W	1	3.1
8	Speakers	700 W	9	6.3
9	Projector Set	653 W	3	1.959
10	Printer	750 W	5	3.75
11	PC	32 W	26	0.832
Total Connected Load (kW)				**498.584**

Table 2.2.3 Law Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tubelight Single	28 W	30	0.84
2	LED	12 W	1672	20.064
3		20 W	6	0.12
4	Fan	73 W	690	50.37
5	AC	108 HP	-	80.568
6	Cooler	575 W	6	3.45
7	Elevators for students	13400 W	2	26.8
8	Elevators for staff	3100 W	3	9.3
9	Speakers	45 W	5	0.225
10	Projector Set	653 W	77	50.281
Total Connected Load (kW)				**242.018**

Table 2.2.4 Campus area and other premises

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Street Light	70 W	44	3.08
2	Halogen On Tower	250 W	16	4
3	Fox	400 W	4	1.6
4	Tubelight Single	28 W	232	6.496
5	CFL	18 W	172	3.096
6	Fan	73 W	132	9.636
7	LED	12 W	188	2.256
8		20 W	29	0.58
9		36 W	24	0.864
Total Connected Load (kW)				**31.608**

Table 2.2.5 Hostel – A Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tubelight Single	28 W	669	18.732
3	CFL	18 W	28	0.504
4	Fan	73 W	444	32.412
5	AC	239 HP	-	178.294
6	C Fan	80 W	48	3.84
7	Table Fan	125 W	30	3.75
8	LED	12 W	75	0.9
9		20 W	291	5.82
10	Cooler	575 W	11	6.325
11	Elevators	3100 W	2	6.2
12	Speakers	45 W	48	2.16
13	Washing Machine	1700 W	2	3.4
14	Geyser	4000 W	5	20
Total Connected Load (kW)				**282.337**

Table 2.2.6 Hostel – B Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tubelight Single	28 W	378	10.584
3	CFL	18 W	9	0.162
4	Fan	73 W	462	33.726
5	AC	172 HP	-	128.312
6	Table Fan	125 W	6	0.75
7	LED	12 W	35	0.42
8		20 W	230	4.6
9	Cooler	575 W	11	6.325
10	Elevators	3100 W	2	6.2
11	Speakers	45 W	48	2.16
12	Washing Machine	1700 W	2	3.4
13	Geyser	4000 W	4	16
Total Connected Load (kW)				**212.639**

Table 2.2.7 Hostel – C Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tubelight Single	28 W	597	16.716
2	CFL	18 W	6	0.108
3	LED	12 W	4	0.048
4		20 W	415	8.3
5	Fan	73 W	902	65.846
6	AC	598 HP	-	446.108
7	Cooler	575 W	11	6.325
8	Elevators	3100 W	2	6.2
9	Speakers	45 W	60	2.7
10	Washing Machine	1700 W	4	6.8
11	Geyser	3000 W	5	15
Total Connected Load (kW)				**574.151**

Table 2.2.8 Canteen Area

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Deep Freeze	391	3	1.173
2	Refrigerator	200	3	0.6
3	LED	9W	606	5.454
4	Fan	73 W	200	14.6
Total Connected Load (kW)				**21.827**

Table 2.2.9 Workshop Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tubelight Single	28 W	21	0.588
2	Fox Light	400 W	3	1.2
3	Fan	80 W	19	1.52
4	C Fan	70 W	12	0.84
5	Table Fan	125 W	16	2
6	Cooler	1550 W	1	1.55
7	CNC Machine	20000 W	1	20
8	VMC machine	25000 W	1	25
9	Lathe Machine	2200 W	18	39.6
10	Sharpner Machine	550 W	2	1.1
11	Cutter Machine	750 W	1	0.75
Total Connected Load (kW)				**94.148**

2.3 Summary of location wise load

The table shows the summary of load of Marwadi University campus.

Table 2.3 Summary of location wise load

Sr. No.	Area	Present Connected Load (kW)
1	Main Building	1546.817
2	PG Building	498.584
3	Law Building	242.018
4	Campus area and other premises	31.608
5	Hostel - A Building	282.337
6	Hostel - B Building	212.639
7	Hostel - C Building	574.151
8	Canteen Area	21.827
9	Workshop Building	94.148
Total Connected Load (kW) =		**3504.129**

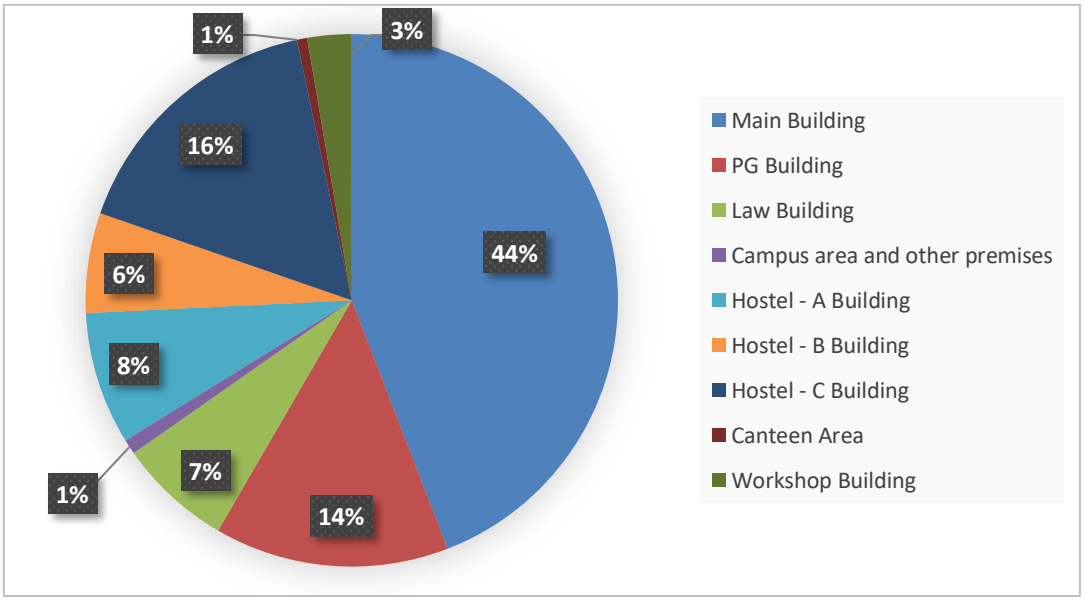


Figure 2.3 Percentage representation of MU load

The load of main building is 44%, which is highest among all shares. In main building, the majority load connected is air conditioner load i.e. 53%. Campus area and other premises takes least load i.e. 1%. Hostel- C building takes major load among all other hostel buildings. In workshop building, majority load are shared by CNC, VMC, Lathe, Sharpner and cutter machines.

2.4 Equipment wise load pattern

Equipment wise load analysis has been performed in order to identify the equipments, with same application area, which consume more power as compared to others. During equipment wise analysis of the overall campus, the equipments with load less than 1% of the total load of the campus were ignored so as to make the analysis results simple and easy to comprehend. Following table summarizes the result of equipment wise analysis of load of MU campus.

Table 2.4 Equipment wise load pattern

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tubelight	18 W	3592	64.656
		28 W	2450	68.6
2	Street Light	70 W	44	3.080
3	CFL	18 W	1135	20.43
4	LED	9 W	904	8.136
		12 W	4377	52.524
		20 W	1661	33.22
		36 W	24	0.864
5	Halogen on tower	250 W	16	4
6	Fox	400 W	7	2.8
7	Fan	73 W	5071	370.183
		80 W	67	5.36
8	Table fan	125 W	233	29.125
9	Water cooler	575 W	44	25.3
		1550 W	1	1.55
		3100 W	14	43.4
10	Elevator	3100 W	12	37.2
		13400 W	2	26.8
		26800 W	6	160.8
11	Air conditioner	2856 HP	-	2130.576
12	Speaker	45 W	471	21.195
		700 W	9	6.3
13	Projector Set	653 W	237	154.761
14	PC	32 W	1380	44.16
15	Printer	750 W	52	39
16	Washing machine	1700 W	8	13.6
17	Geyser	4000 W	9	36
		3000 W	5	15
18	CNC Machine	20000 W	1	20
19	VMC machine	25000 W	1	25
20	Lathe Machine	2200 W	18	39.6
21	Sharpner Machine	550 W	2	1.1

22	Cutter Machine	750 W	1	0.75
23	Deep Freeze	391 W	3	1.173
24	Refrigerator	200 W	3	0.6
Total Connected Load (kW) =				**3504.129**

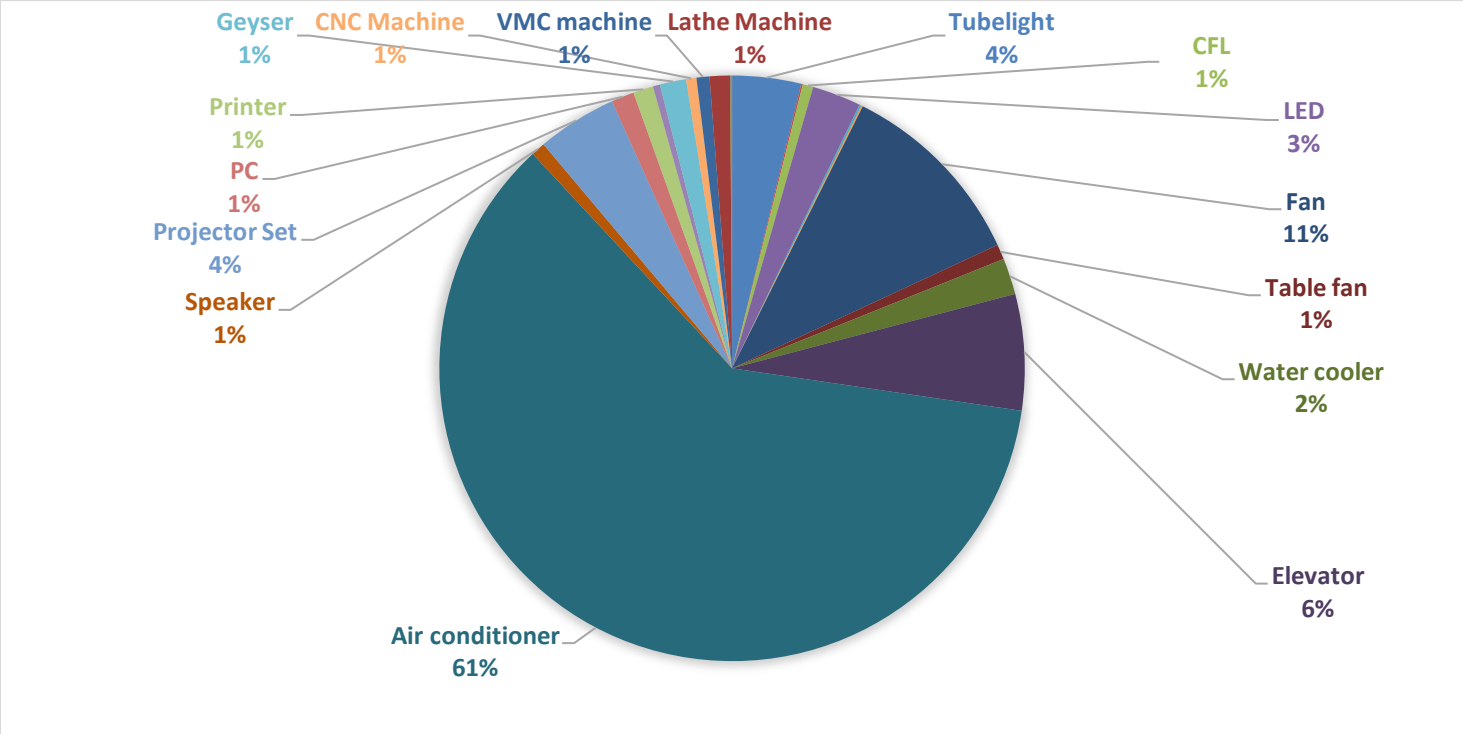


Figure 2.4 Load shared by different equipment

According to the above fig. the maximum power is consumed by air conditioner system (61%), followed by fan (11%). The other connected loads (<1% of total load) are not showing in above chart.

2.5 Observation during survey

- In campus, automatic street light timer base control system is installed.
- Pump sets are operated on their rated capacity by V/f control drive system.
- Air conditioner is operated on default temperature set at 24^0 C. The maintenance of equipment are properly done at regular intervals.
- Using adequate ventilated class room and lab premises.
- APFC panel is installed in control room to maintain power factor nearly unity.

2.6 Electricity Units Analysis

2.6.1 Consumption of electricity units from grid

Table 2.6.1 Monthly Electricity Units

Months	PGVCL Units	DG Units	Solar Units
January	145718	1536	68332.40
February	120743	5200	77566.00
March	189119	4320	76459.40
April	358336	832	86912.40
May	398480	5472	102497.00
June	340423	8624	95469.00
July	331972	11952	67509.80
August	342545	4304	62595.60
September	348045	4752	69839.00
October	362686	4288	85370.80
November	244630	1712	78767.00
December	213166	1680	68023.00
Total Unit Consumed	**3395863**	**54672**	**939341.40**

The consumption of units is more in summer due to the use of AC system.

3. Energy Audit Methodology

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

- Data collection: In preliminary data collection phase, exhaustive data collection was performed using different tools such as observation, interviewing key persons, and measurement.
- Data analysis: Collected data were analyzed using MS Excel. The database generated by MS Excel was used for producing graphical representations.
- Recommendation: On the basis of results of data analysis and observations, some steps for reducing power consumption, without affecting the comfort and satisfaction, were recommended along with their cost analysis.

3.1 Data Collection

For suggesting any corrective measures to reduce power consumption, it is first necessary to know the power consumption pattern in detail. For this, the exhaustive data collection exercise has been performed at all the departments, academic area, hostels, and other supporting entities such as library, computer labs etc. Following steps have been taken for data collection:

- The team visited to academic area administrative area, labs, hostels etc.
- Information about the general electrical appliances is collected by observation and interviewing.
- The power consumption of appliances is measured using power analyzer in some cases (such as monitors) while in other cases, rated power was used like CFL, AC, Fan etc.
- The details of usage of the appliances were collected by interviewing key persons e.g. warden care taker (in case of hostels), personnel of institute maintenance and project department etc.
- Intensity of light was measured using lux meter at administrative area, academic area hostels, corridors etc.
- In case of air conditioning, insulation is checked by visual inspection.
- Approximations and generalizations were done at places with lack of information available.

3.2 Data Analysis

In data analysis, the data collected is processed to draw significant conclusions to pinpoint loopholes and identify the areas to focus upon. Analysis of the power consumption data is used to obtain the power consumption pattern and to get the information about the areas where electric power is wasted.

3.3 Recommendation

Energy as well as cost benefits analysis of different appliances are performed and recommendations are made based on the capital cost recovery time (simple payback period).
Following steps are involved in this process:
The capital cost involved in replacement of an appliance and/or retrofit is estimated.

- Energy saving by the recommendation is calculated in terms of price of energy per year.
- These two costs were compared to calculate the capital cost recovery time.

- If capital cost recovery time is less than the product life, the recommendation can be implemented.

Some other recommendations are also made which are based on lighting intensity, AC insulation etc.

4. Energy Conservation Measures & Utilization of Alternate Source of Energy

4.1 LED Light Conservation Project

Marwadi University always believe in energy conservation and use of energy efficient equipment in premises. Some of the conventional lightning equipments such as Tube lights and CFLs are replaced with LED as shown in below:

Table 4.1 Energy saving data by LED project (2022)

Sr. No.	Types of LEDs Purchase				Investment	Annually Power Saving (kWh)				Total Annually Power Saving (kWh)
	9W	12W	20W	36W	332445/-	14 W Tube Replace with 9 W LED Tube	36 W CLFs Replace with 12 W LED Lamp	28W Tube Replace with 20 W LED Tube	70 W Street Light Replace with 36 W LED Light	
1	182	338	924	24		2730	24336	22176	2160	51402

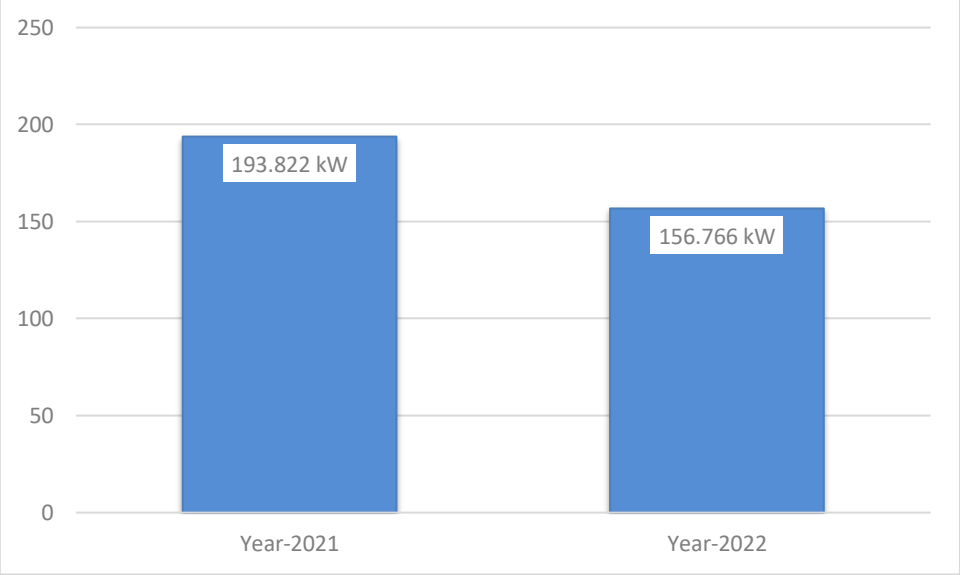


Figure 4.1.1 Decrement in uses of conventional lightning equipment

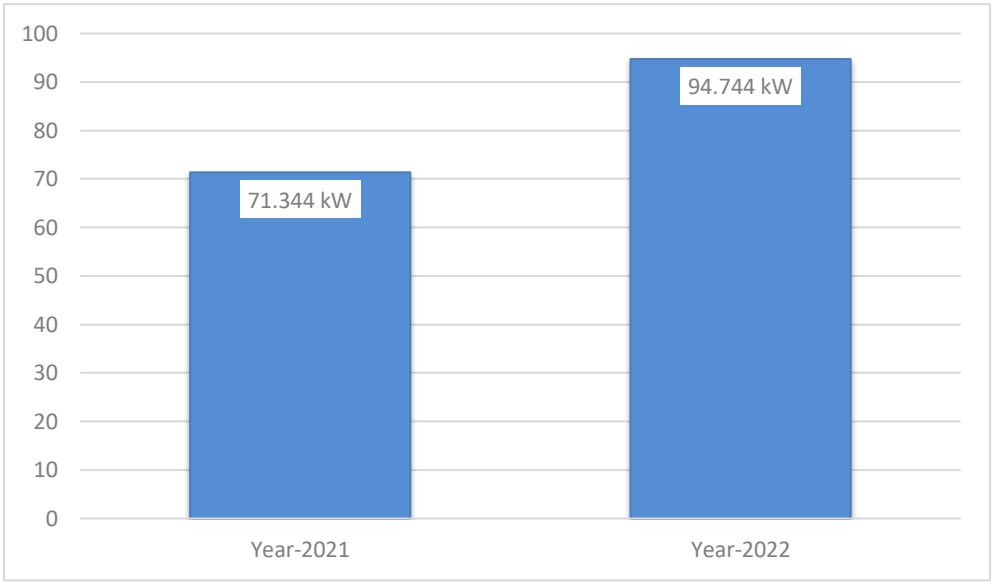
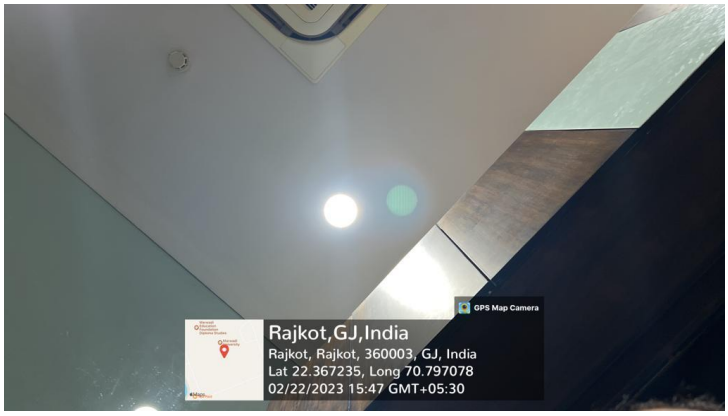
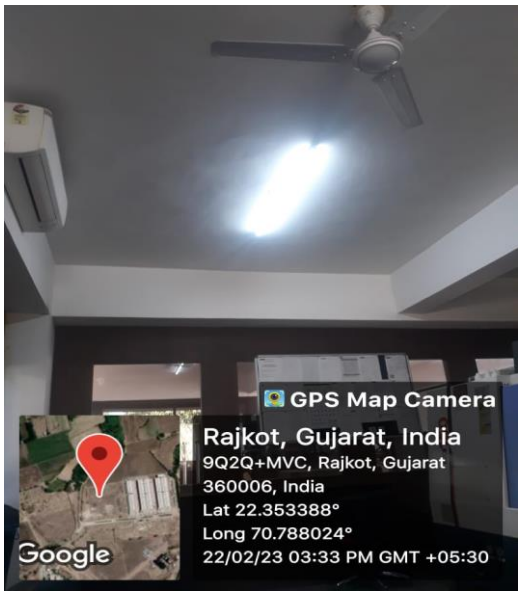


Figure 4.1.2 Increment in uses of LED lightning equipments





4.2 Solar energy utilization

Table 4.2 Units generated by solar plant

Months	Units Generated
January	68332.40
February	77566.00
March	76459.40
April	86912.40
May	102497.00
June	95469.00
July	67509.80
August	62595.60
September	69839.00
October	85370.80
November	78767.00
December	68023.00
Total Unit Generated	**939341.40**

Power generation by renewable energy = 939341.40 kWh

Percentage utilization of solar energy

= (Power generated by solar panels/Total power utilized) *100

= 21%

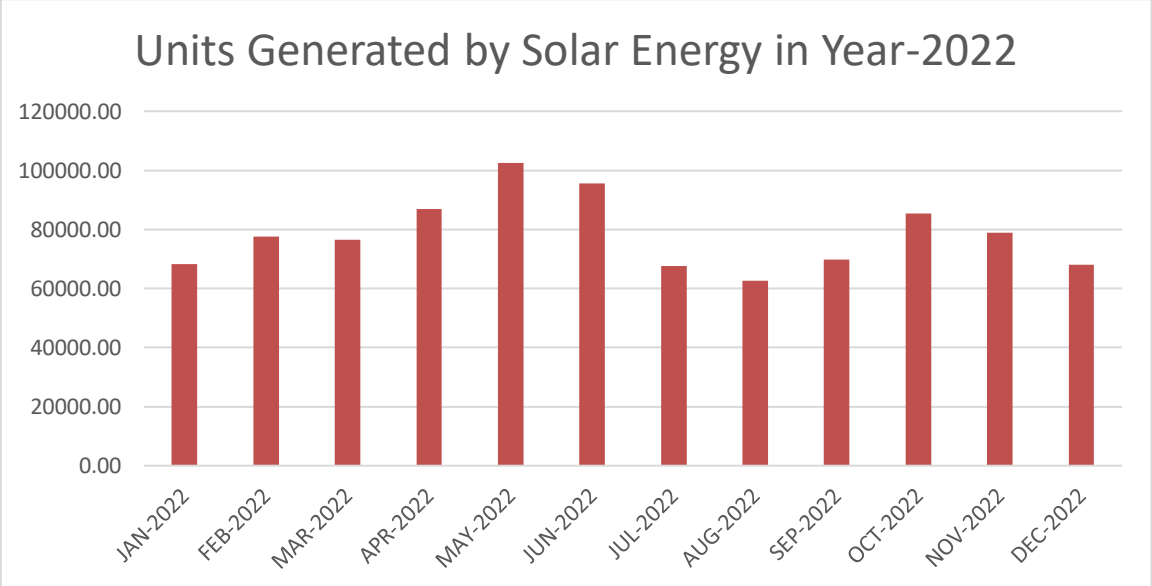


Figure 4.2 Unit generated by solar energy in year-2022

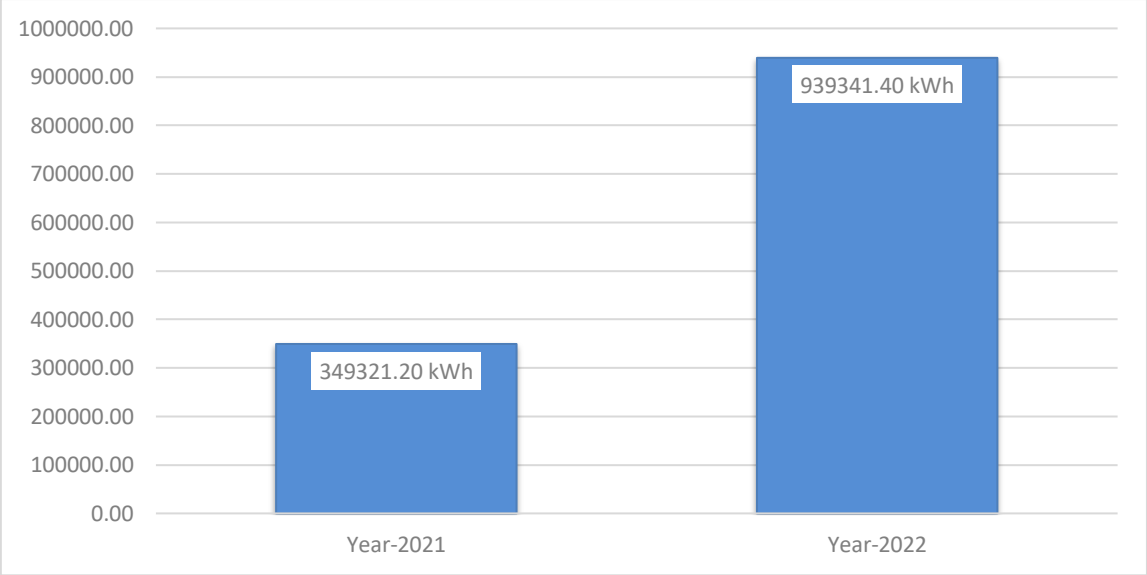
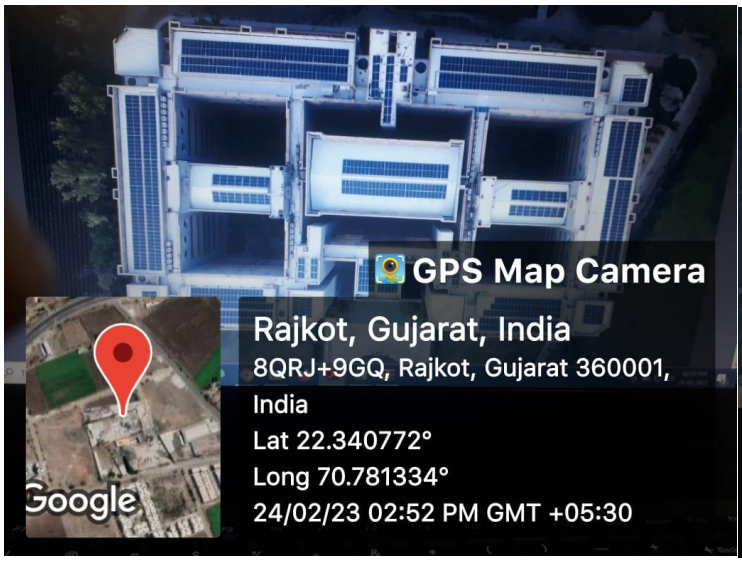
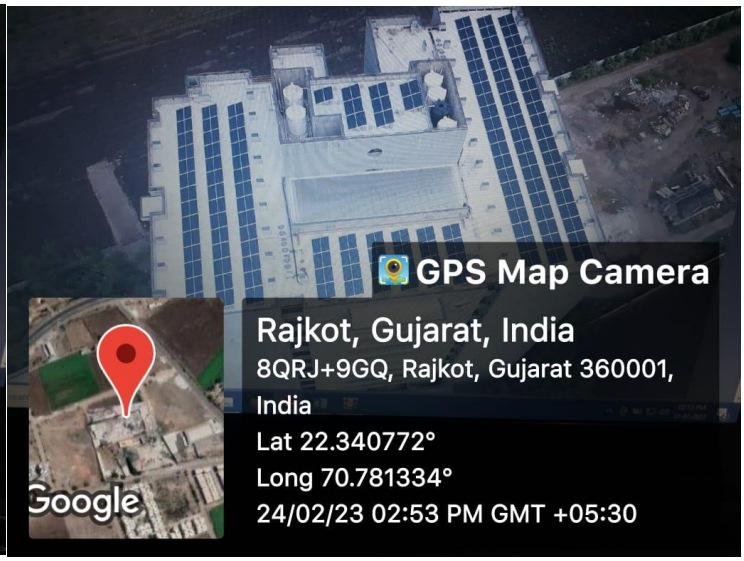
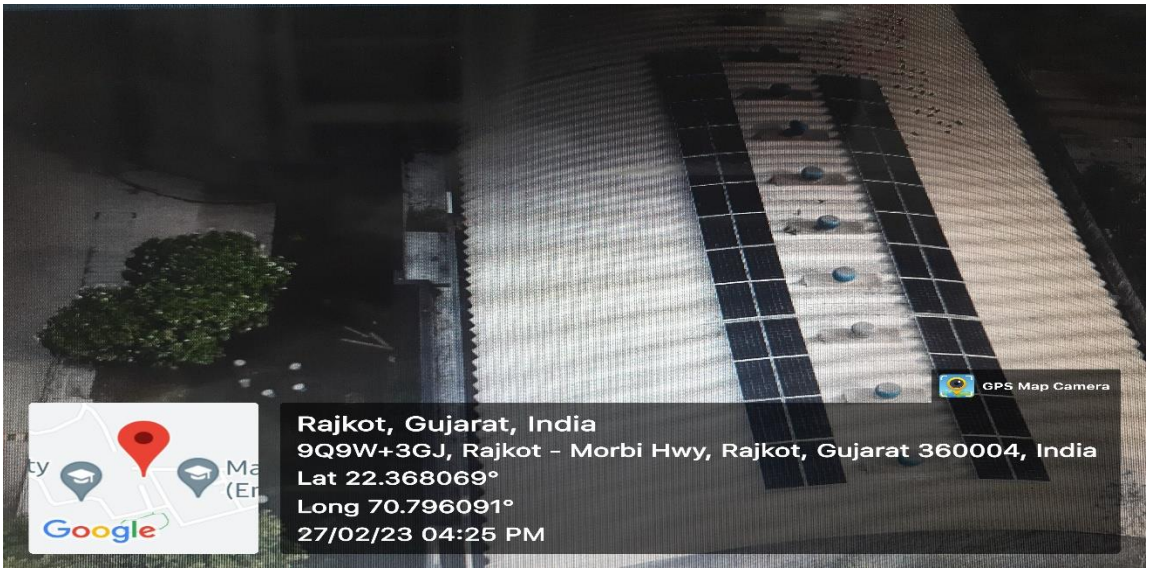


Figure 4.3 Increment in unit generation by solar energy in year 2021 and 2022







5. Recommendations

Based on the analysis of the power consumption data, certain steps have been recommended for improving energy efficiency of the campus. Complete cost benefit analysis of implementation of recommended measures has been performed wherever necessary. Also, a number of general measures for energy efficiency have been listed. Some important recommendations for better energy efficiency are described below:

5.1 Lightning

Dominant light source at most places in the campus is T-l2 (28W & 18W) & CFL(18W). FTLs with electronic Ballast which averagely consumes 30W & 20W. As per our data collection, the campus has in total 4111 & 3592 T-12 FTLs and 3119 CFLs. If this T-12 electronic Ballast [Choke] and CFLs is replaced by LED tube light 12W or 8W power can be saved per FTL/CFLs. LED Lighting is 3 to 4 times costly then T-12 FTL/CFL, but this is compensated by saving in units and by saving in fix charge by reduction of load.

5.1.1 Cost Analysis of Replacing T-12 (28W) Tube Lights with Energy Efficient LED Light (12 W)

Total No. of T-12 in campus =	4111	
Average power of T-12 (28W) =	30	W
Average power of LED Light (12W) =	12	W
Power saved per tube light =	18	W
Total power saving =	73.998	kW
Working hours is 12 hrs, then total units saved =	887.976	Unit/day
Units saving in one year =	319671	
Savings in Rs per year =	2557371	
Average cost of replacement of T-12 tube light =	600	
Total cost of replacing all T-12 (28W) =	2466600	
Capital cost recovery time =	0.9	Year

5.1.2 Cost Analysis of Replacing T-12 (28W) Tube Lights with Energy Efficient LED Light (8 W)

Total No. of T-12 in campus =	4111	
Average power of T-12 (28W) =	30	W
Average power of LED Light (8W) =	8	W
Power saved per tube light =	22	W
Total power saving =	90.442	kW
Working hours is 12 hrs, then total units saved =	1085.3	Unit/day
Units saving in one year =	390709	
Savings in Rs per year =	3125676	
Average cost of replacement of T-12 tube light =	500	
Total cost of replacing all T-12 (28W) =	2055500	
Capital cost recovery time =	0.6	Year

5.1.3 Cost Analysis of Replacing T-12 (18W) Tube Lights with Energy Efficient LED Light (8 W)

Total No. of T-12 in campus =	3592	
Average power of T-12 (18W) =	20	W
Average power of LED Light (8W) =	8	W
Power saved per tube light =	12	W
Total power saving =	43.104	kW
Working hours is 12 hrs, then total units saved =	517.248	Unit/day
Units saving in one year =	186209	
Savings in Rs per year =	1489674	
Average cost of replacement of T-12 tube light =	500	
Total cost of replacing all T-12 (28W) =	1796000	
Capital cost recovery time =	1.2	Year

5.1.4 Cost Analysis of Replacing CFL (18W) with Energy Efficient LED Light (8 W)

Total No. of CFL in campus =	3119	
Average power of CFL (18W) =	20	W
Average power of LED Light (8W) =	8	W
Power saved per CFL =	12	W
Total power saving =	37.428	kW
Working hours is 12 hrs, then total units saved =	449.136	Unit/day
Units saving in one year =	161689	
Savings in Rs per year =	1293512	
Average cost of replacement of CFL =	500	
Total cost of replacing all T-12 (28W) =	1559500	
Capital cost recovery time =	1.2	Year

5.2 Fans

Most of the buildings in MU campus are 10 years old and so are the fans. Most of the fans here are not energy efficient fans. According to the data collected, there are a total of 4871 regular fans. A saving of 45W per fan can be obtained by replacing these fans by energy efficient fans.

5.2.1 Cost Benefit Analysis of Replacing Existing Fans by Energy Efficient BLDC Fans

Total No. of existing fans in campus =	4871	
Average power saved per fan =	45	W
Total power saving =	219	kW
Working hours is 12 hrs, then total units saved in a day =	2630	
Total Rs saving in a year =	5260680	
Average cost of replacing per fan =	3000	
Total cost of replacing all fans =	14613000	
Capital cost recovery time =	2.8	Year

5.3 Other Recommendations

5.3.1 Use of master switch outside each room

Installation of a master switch outside a room can make it easy for a person to switch off all the appliances of a room in case someone forgets to switch off while leaving the room. This can help improving energy efficiency.

5.3.2 Use of reflectors in tube lights and cleaning of tube lights

Use reflector in tube lights to improve the lux levels. This is clear from photo that mostly light is falling on ceiling where it is not required. By using reflector this light can reflect towards floor (when it's required). Cleaning of tube lights increases its lux level.

5.3.3 Proper insulation of refrigerant pipe line

During audit mostly Refrigerant pipe line of outdoor units found without insulation. This increases the temperature of refrigerant entering into the evaporator and thus reduces the refrigerant effect. For getting same refrigerant effect (cooling) more energy is consumed.

5.3.4 Use of time based lightning system in lobby area and parking area

Installation of time based lightning system can reduce power consumption while no occupancy in that area.

5.3.5 Proper insulation of room

Good quality insulation must be maintained in the air conditioned rooms by keeping all doors and windows closed properly so as to prevent cool air go out and hot air come in.

5.3.6 Curtains

Always keep curtains on windows to prevent direct sunlight inside the room to avoid heating of cooled air. This reduces load of AC significantly.

5.3.7 Maintenance

Proper maintenance and cleaning of ACs is required at regular intervals to make it work at highest efficiency. Any dirt in filter will reduce efficiency of ACs very significantly. (During Audit it has been seen that many ACs filters were not clean).

Date of issue: 31/01/2023

Mr. Bhaveshkumar K. Kanabar

Energy Manager BEE (16734/20)

Dr. Bhavesh Kanabar
Certified Energy Manager (Reg. No.16734/20)

Energy Audit Report

Client

Marwadi University

Rajkot-Morbi Highway
Rajkot – 360003

Date of Issue: 06/02/2022

101, Tej-Avenue Appartment, Nr. Nageshwar Jain Mandir, B/h Bhavanimata Temple, Jamnagar Road, Rajkot - 360006

Sr. No.	Specifications	Details
1.	Name of the customer	Marwadi Education Foundation
2.	Name of the customer (as per Electric Bill)	Marwadi Education Foundation
3.	Consumer No.	26437
4.	Address	Opp. Mahadev Vadi, Rajkot-Morbi Highway, Between Bedi & Gauridad, Dist:- Rajkot
5.	Contract Demand	1300 kVA
6.	Purpose of Consumer	HTP-I
7.	Name of Supplier	PGVCL(Electricity)
8.	Period of Audit	January 2021 to December 2021

PREFACE

Data collection for energy audit of MU campus was carried out during February 2022. This audit was conducted to seek opportunities to improve the energy efficiency of the campus. Reduction of energy consumption while maintaining or improving human comfort, health and safety was of primary concern. Besides simply identifying the energy consumption pattern, this audit seeks to identify the most energy efficient appliances. Moreover, some daily practices relating common appliances have been provided which may help reducing the energy consumption. The report accounts for the energy consumption patterns of the academic area, central facilities and hostels based on actual survey and detailed analysis during the audit. The work encompasses the area wise consumption traced using suitable equipments. The report compiles a list of possible actions to conserve and efficiently access the available scarce resources and their saving potential has been also identified. We look forward to optimum so that the authorities, students and staff would follow the recommendations in the best possible way. The report is based on certain generalizations and approximations wherever necessary. The views expressed may not reflect the general opinion. They merely represent the opinion of the team guided by the opinions of consumers.

ACKNOWLEDGEMENT

I express my sincere gratitude to the authorities of Marwadi University, Rajkot for entrusting and offering the opportunity of Energy Audit, which was conducted in February, 2022.

I am thankful to management for their positive support in undertaking the task of energy efficiency assessment of all electrical system, air conditioners, utilities and other equipment. The field studies would not have been completed on time without their interaction and guidance. I am grateful to their cooperation during field studies and providing necessary data for the study.

I am also thankful to supporting staff working with whom we interacted during the field studies for their wholehearted support in undertaking measurements and eagerness to assess the system/equipment performance and saving potential. Also thankful to all concerned staff interacted during the conduct of this exercise for completing official documentations.

CONTENTS

Chapter 1: Introduction **1**
1.1 Objectives of Energy Audit **1**
1.2 Necessary steps in an energy audit **1**
1.3 Identification of Target Areas **2**
1.4 Grouping and strategy **2**
1.5 Advantages of Energy Audit **2**
Chapter 2: Existing Electrical Load Pattern **3**
2.1 Overall campus details **3**
2.2 Location wise load pattern **4**
2.3 Summary of location wise load **8**
2.4 Equipment wise load pattern **9**
2.5 Observation during survey **10**
2.6 Electricity Units Analysis **11**
2.6.1 Consumption of electricity units from grid **11**
Chapter 3: Energy Audit Methodology **12**
3.1 Data Collection **12**
3.2 Data Analysis **12**
3.3 Recommendation **12**
Chapter 4: Energy Conservation Measures & Utilization of Alternate Solar Energy **13**
4.1 LED light conservation project **13**
4.2 Solar energy utilization **15**
Chapter 5: Recommendation **17**
5.1 Lightning **17**
5.1.1 Cost Analysis of Replacing T-12 (28W) Tube Lights with Energy Efficient LED Light (12 W) **17**
5.1.2 Cost Analysis of Replacing T-12 (28W) Tube Lights with Energy Efficient LED Light (8 W) **17**
5.1.3 Cost Analysis of Replacing T-12 (18W) Tube Lights with Energy Efficient LED Light (8 W) **18**
5.1.4 Cost Analysis of Replacing CFL (18W) with Energy Efficient LED Light (8 W) **18**
5.2 Fans **18**
5.2.1 Cost Benefit Analysis of Replacing Existing Fans by Energy Efficient BLDC Fans **18**
5.3 Other Recommendations **19**
5.3.1 Use of master switch outside each room **19**
5.3.2 Use of reflectors in tube lights and cleaning of tube lights **19**
5.3.3 Proper insulation of refrigerant pipe line **19**
5.3.4 Use of time based lightning system in lobby area and parking area **19**
5.3.5 Proper insulation of room **19**
5.3.6 Curtains **19**
5.3.7 Maintenance **19**

LIST OF FIGURES

2.3 Percentage representation of MU load **7**

2.4 Load shared by different equipment **9**

4.2 Unit generated by solar energy **15**

LIST OF TABLES

2.1 Demand and power factor details	**3**
2.2.1 Main Building	**4**
2.2.2 PG Building	**4**
2.2.3 Law Building	**5**
2.2.4 Campus area and other premises	**5**
2.2.5 Hostel – A Building	**5**
2.2.6 Hostel – B Building	**6**
2.2.7 Hostel – C Building	**6**
2.2.8 Canteen Area	**6**
2.2.9 Workshop Building	**7**
2.3 Summary of location wise load	**8**
2.4 Equipment wise load pattern	**9**
2.6.1 Monthly Electricity Units	**11**
4.1 Energy saving data by LED project	**13**
4.2 Units generated by solar plant	**15**

1. Introduction

Marwadi University is a private university located in Rajkot, Gujarat, India. It was established on 9 May 2016 by the Marwadi Education Foundation through the Gujarat Private Universities Act, 2016. As of 2022, it offers more than 50 courses.

International Students from more than 50 countries have chosen Marwadi University for higher education. The university is supported by 450+ faculties from 22 states of the country with around 150 PhD qualified faculty members. It has Incubation, Innovation and Research centre, which is an ecosystem that weaves industry and academia, steering the institutions' focus towards building products, services, businesses, and intellectual property, addressing real problems faced by the economy and the society at large.

1.1 Objectives of Energy Audit

The objective of the energy audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs at Marwadi University, Rajkot.

The intention of this energy audit is to identify, measure, and describe energy consumption by different loads in hostels, administrative areas, academic areas, meeting halls, street lights and to recommend energy-saving methods.

The main objectives are:

- Identification of possible uses of renewable energy sources like solar energy to minimise cost.
- Suggesting to replace highly power-consuming loads with low-power-consuming and efficient loads.
- Improving the efficiency of our target loads
- Documenting results and indispensable information generated through these activities.

1.2 Necessary steps in an energy audit

1. Planning Phase: Before getting an energy audit, the criteria for the audit are reviewed and defined.
2. Data Collection: Data can be collected in many ways at the facility and labs by appropriate measuring devices.
3. System Measurements: Some of the system measurements that may be taken include electrical, speed, and light intensity measurements.
4. Review Operating Practices: The operating practices at any facility can have a large impact on the energy audit as well.
5. Data Analysis: During the energy audit, massive amounts of data will be accumulated, and software may be used to analyse the data and to look for any issues that may exist.
6. Reporting and Recommendations: A comprehensive report will be provided, and any recommendations for improving energy usage at the facility will be given at that time.

1.3 Identification of Target Areas

We have considered the power dissipation by the loads as the primary factor to identify the target areas. Hence, we have analysed the energy consumption of various loads. Main focus is given to the loads that take more power, like fans, lighting, elevators, and air conditioners, as they are the key target areas where improvement is required.

1.4 Grouping and strategy

The following steps were done with specific target areas and end users assigned.

Step 1: Collecting electrical data related to lighting, fans, elevators, air conditioner etc... in our University.

Step 2: Data Collection from labs and their specifications

Step 3: Data Analysis by Means of Calculations

Step 4: Creating Charts and Graphs based on the collected data.

1.5 Advantages of Energy Audit

- Reducing environmental damage and pollution.
- Increasing the performance and life span of electrical loads.
- It helps lower energy bills.
- Discovering any unaccounted consumption that may exist at the facility.
- Better safety and protection.

2. Existing Electrical Load Pattern

Electrical load pattern gives us the information about the distribution of load. Electrical load data are collected by equipment, application as well as location wise.

2.1 Overall campus building details

Marwadi University campus sanctioned contract demand is 1300 kVA. Presently institute has 612 kW solar roof top generations. In addition to that capacity of DG set for power back up is 1380 kVA/1104kW. Total connected equipment load of the university is 3566kW.

Table 2.1 Demand and power factor details

Month	Contract Demand (kVA)	85%Contract demand (kVA)	Billing Demand (kVA)	Average P.F.
Jan-21	1300	1105	240	1
Feb-21	1300	1105	240	1
Mar-21	1300	1105	650	1
Apr-21	1300	1105	831	1
May-21	1300	1105	616	1
Jun-21	1300	1105	804	1
Jul-21	1300	1105	804	1
Aug-21	1300	1105	605	1
Sep-21	1300	1105	726	1
Oct-21	1300	1105	990	1
Nov-21	1300	1105	644	1
Dec-21	1300	1105	516	1

As APFC panel installed in control room, the average power factor is maintained nearly unity and the utility provide the rebate for maintaining power factor is about 2.5% in every billing cycle.

The billing demand is less than 85% of contract demand. This is due to covid-19 pandemic situation with online teaching in majority of sections as well as less occupancy in hostel. The contact demand change is advised keeping the normal situation which may restored.

2.2 Location wise load pattern

Table 2.2.1 Main Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Circle CFLs	18 W	1300	23.4
2	Tube Light(x4)	18 W	3592	64.66
3	Fan	73 W	2137	156
4	AC	1119 HP	-	834.77
5	Tubelight Single	28 W	713	19.964
6	C Fan	125 W	90	11.25
7	Table Fan	125 W	91	11.38
8	LED	12 W	1477	17.724
9		20 W	437	8.74
10	Cooler	3100 W	14	43.4
11	Elevators for students	26800 W	6	160.8
12	Elevators for staff	3100 W	2	6.2
13	Speakers	45 W	310	13.95
14	Projector Set	653 W	157	102.521
15	Printer	750 W	47	35.25
16	PC	32 W	1354	43.328
Total Connected Load (kW)				**1553.337**

Table 2.2.2 PG Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Fan	73 W	92	6.716
2	AC	620 HP	-	462.52
3	Tube light Single	28 W	63	1.764
4	LED	12 W	736	8.832
5	Cooler	575 W	5	2.875
6	Elevators for staff	3100 W	1	3.1
7	Speakers	700 W	9	6.3
8	Projector Set	653 W	3	1.959
9	Printer	750 W	5	3.75
10	PC	32 W	26	0.832
Total Connected Load (kW)				**498.648**

Table 2.2.3 Law Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tube light Single	28 W	36	1.008
2	LED	12 W	1672	20.064
3	Fan	73 W	690	50.37
4	AC	108 HP	-	80.568
5	Cooler	575 W	6	3.45
6	Elevators for students	13400 W	2	26.8
7	Elevators for staff	3100 W	3	9.3
8	Speakers	45 W	5	0.225
9	Projector Set	653 W	77	50.281
Total Connected Load (kW)				**241.058**

Table 2.2.4 Campus area and other premises

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Street Light	70 W	68	4.76
2	Halogen On Tower	250 W	16	4
3	Fox	400 W	4	1.6
4	Tube light Single	28 W	261	7.308
5	CFL	18 W	307	5.526
6	Fan	73 W	132	9.636
7	LED	12 W	53	0.636
Total Connected Load (kW)				**33.466**

Table 2.2.5 Hostel – A Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tube light Single	28 W	897	25.116
3	CFL	18 W	34	0.612
4	Fan	73 W	444	32.412
5	AC	239 HP	-	178.294
6	C Fan	80 W	48	3.84
7	Table Fan	125 W	30	3.75
8	LED	9W	166	1.494
9		12 W	69	0.828
10		20W	63	1.26
12	Cooler	575 W	11	6.325
13	Elevators	3100 W	2	6.2
14	Speakers	45 W	48	2.16
15	Washing Machine	1700 W	2	3.4
16	Geyser	4000 W	5	20
Total Connected Load (kW)				**285.691**

Table 2.2.6 Hostel – B Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tube light Single	28 W	546	15.288
3	CFL	18 W	14	0.252
4	Fan	73 W	462	33.726
5	AC	172 HP	-	128.312
6	Table Fan	125 W	6	0.75
7	LED	9W	132	1.188
8		12W	30	0.36
9		20W	62	1.24
10	Cooler	575 W	11	6.325
11	Elevators	3100 W	2	6.2
12	Speakers	45 W	48	2.16
13	Washing Machine	1700 W	2	3.4
14	Geyser	4000 W	4	16
Total Connected Load (kW)				**215.201**

Table 2.2.7 Hostel – C Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tube light Single	28 W	837	23.436
2	CFL	18 W	8	0.144
3	LED	12W	2	0.024
4		20W	175	3.5
5	Fan	73 W	902	65.846
6	AC	598 HP	-	446.108
7	Cooler	575 W	11	6.325
8	Elevators	3100 W	2	6.2
9	Speakers	45 W	60	2.7
10	Washing Machine	1700 W	4	6.8
11	Geyser	3000 W	5	15
Total Connected Load (kW)				**576.083**

Table 2.2.8 Canteen Area

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Deep Freeze	391	3	1.173
2	Refrigerator	200	3	0.6
3	LED Tubes	9W	606	5.454
4	Fan	73 W	200	14.6
Total Connected Load (kW)				**21.827**

Table 2.2.9 Workshop Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tubelight Single	28 W	21	0.588
2	Fox Light	400 W	3	1.2
3	Fan	80 W	19	1.52
4	C Fan	70 W	12	0.84
5	Table Fan	125 W	16	2
6	Cooler	1550 W	1	1.55
7	CNC Machine	20000 W	1	20
8	VMC machine	25000 W	1	25
9	Lathe Machine	2200 W	18	39.6
10	Shaper Machine	550 W	2	1.1
11	Cutter Machine	750 W	1	0.75
Total Connected Load (kW)				**94.148**

2.3 Summary of location wise load

The table shows the summary of load of Marwadi University campus.

Table 2.3 Summary of location wise load

Sr. No.	Area	Present Connected Load (kW)
1	Main Building	1553.337
2	PG Building	498.648
3	Law Building	241.058
4	Campus area and other premises	33.466
5	Hostel - A Building	285.691
6	Hostel - B Building	215.201
7	Hostel - C Building	576.083
8	Canteen Area	21.827
9	Workshop Building	94.148
Total Connected Load (kW) =		**3519.459**

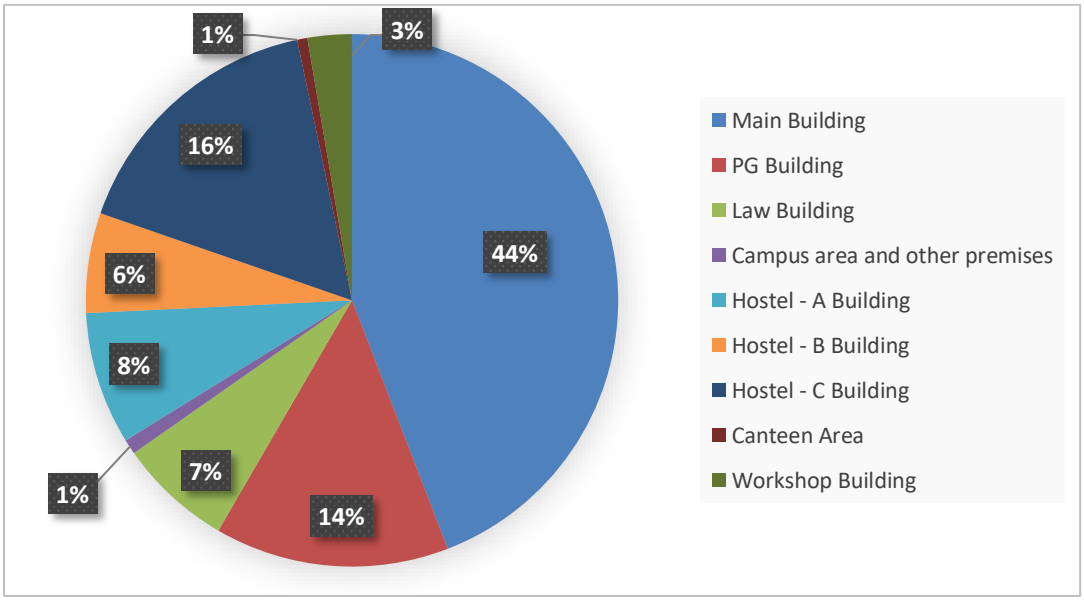


Figure 2.3 Percentage representation of MU load

The load of main building is 44%, which is highest among all shares. In main building, the majority load connected is air conditioner load i.e. 53%. Campus area and other premises takes least load i.e. 1%. Hostel- C building takes major load among all other hostel buildings. In workshop building, majority load are shared by CNC, VMC, Lathe, Sharpner and cutter machines.

2.4 Equipment wise load pattern

Equipment wise load analysis has been performed in order to identify the equipments, with same application area, which consume more power as compared to others. During equipment wise analysis of the overall campus, the equipments with load less than 1% of the total load of the campus were ignored so as to make the analysis results simple and easy to comprehend. Following table summarizes the result of equipment wise analysis of load of MU campus.

Table 2.4 Equipment wise load pattern

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tubelight	18 W	3592	64.656
		28 W	3374	94.472
2	Street Light	70 W	68	4.76
3	CFL	18 W	1663	29.934
4	LED	9 W	904	8.136
		12 W	4039	48.468
		20 W	737	14.74
5	Halogen on tower	250 W	16	4
6	Fox	400 W	7	2.8
7	Fan	73 W	5071	370.183
		80 W	67	5.36
8	Table fan	125 W	233	29.125
9	Water cooler	575 W	44	25.3
		1550 W	1	1.55
		3100 W	14	43.4
10	Elevator	3100 W	12	37.2
		13400 W	2	26.8
		26800 W	6	160.8
11	Air conditioner	2856 HP	-	2130.576
12	Speaker	45 W	471	21.195
		700 W	9	6.3
13	Projector Set	653 W	237	154.761
14	PC	32 W	1380	44.16
15	Printer	750 W	52	39
16	Washing machine	1700 W	8	13.6
17	Geyser	4000 W	9	36
		3000 W	5	15
18	CNC Machine	20000 W	1	20
19	VMC machine	25000 W	1	25
20	Lathe Machine	2200 W	18	39.6
21	Sharpner Machine	550 W	2	1.1
22	Cutter Machine	750 W	1	0.75
23	Deep Freeze	391 W	3	1.173

24	Refrigerator	200 W	3	0.6
Total Connected Load (kW) =				**3519.459**

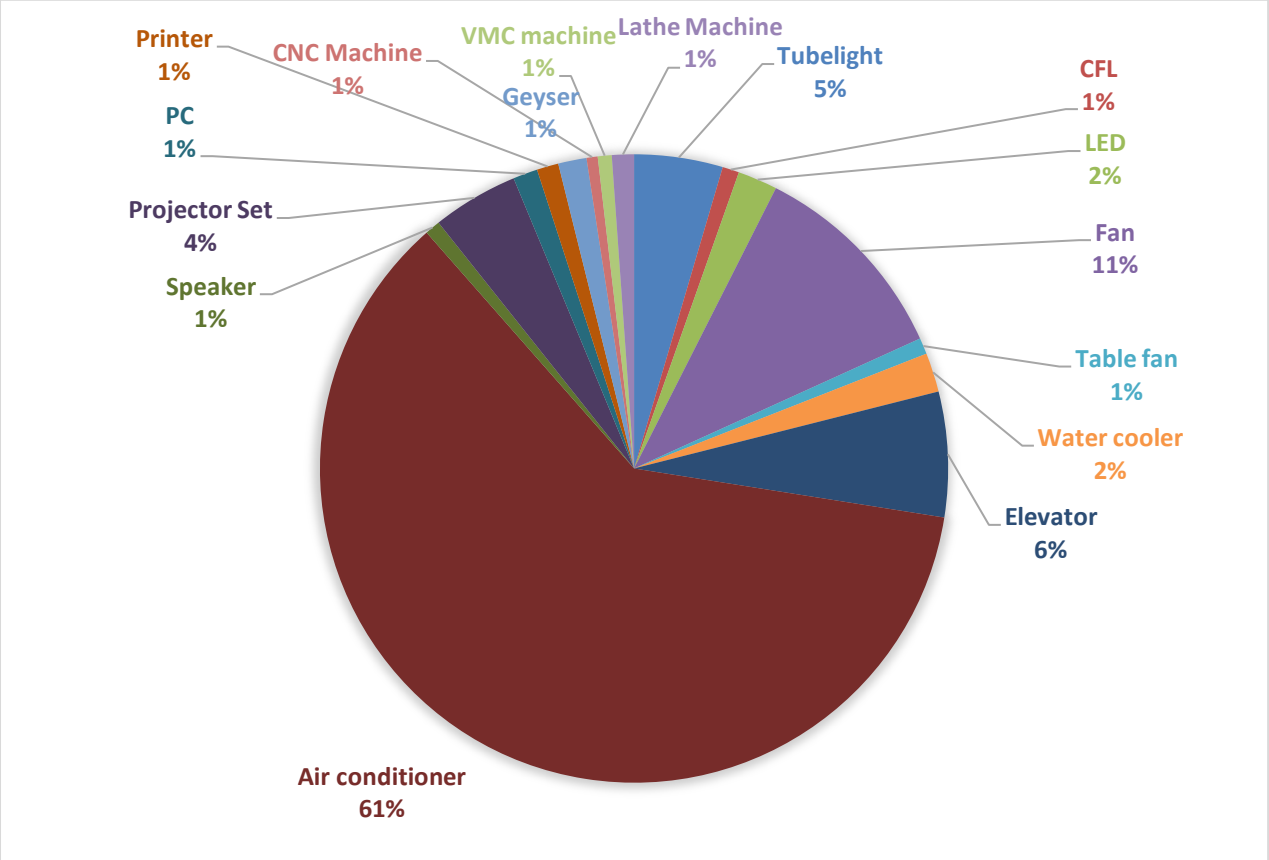


Figure 2.4 Load shared by different equipment

According to the above fig. the maximum power is consumed by air conditioner system (61%), followed by fan (11%). The other connected loads (<1% of total load) are not showing in above chart.

2.5 Observation during survey

- In campus, automatic street light timer base control system is installed.
- Pump sets are operated on their rated capacity by V/f control drive system.
- Air conditioner is operated on default temperature set at 24^0 C. The maintenance of equipments are properly done at regular intervals.
- Using adequate ventilated class room and lab premises.
- APFC panel is installed in control room to maintain power factor nearly unity.

2.6 Electricity Units Analysis

2.6.1 Consumption of electricity units from grid

Table 2.6.1 Monthly Electricity Units

Months	PGVCL Units	DG Units	Solar Units
January	116700	352	-
February	139950	2640	-
March	223598	832	-
April	290288	3984	-
May	262028	6752	-
June	290656	2960	-
July	274095	4432	25965.40
August	233520	4544	59885.00
September	242558	10208	60201.40
October	296873	12544	66455.60
November	203355	3792	76757.60
December	199980	2480	60056.20
Total Unit Consumed	**2773510**	**55520**	**349321.20**

As seen in the table the consumption of the electricity is increasing every year. Due to COVID-19 pandemic situation from march-2020, load consumption was reduced. The consumption of units is more in summer due to the use of AC system. The solar power plant is erected in the month of June-2021 and start function from month of July-2021.

3. Energy Audit Methodology

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

- Data collection: In preliminary data collection phase, exhaustive data collection was performed using different tools such as observation, interviewing key persons, and measurement.
- Data analysis: Collected data were analyzed using MS Excel. The database generated by MS Excel was used for producing graphical representations.
- Recommendation: On the basis of results of data analysis and observations, some steps for reducing power consumption, without affecting the comfort and satisfaction, were recommended along with their cost analysis.

3.1 Data Collection

For suggesting any corrective measures to reduce power consumption, it is first necessary to know the power consumption pattern in detail. For this, the exhaustive data collection exercise has been performed at all the departments, academic area, hostels, and other supporting entities such as library, computer labs etc. Following steps have been taken for data collection:

- The team visited to academic area administrative area, labs, hostels etc.
- Information about the general electrical appliances is collected by observation and interviewing.
- The power consumption of appliances is measured using power analyzer in some cases (such as monitors) while in other cases, rated power was used like CFL, AC, Fan etc.
- The details of usage of the appliances were collected by interviewing key persons e.g. warden care taker (in case of hostels), personnel of institute maintenance and project department etc.
- Intensity of light was measured using lux meter at administrative area, academic area hostels, corridors etc.
- In case of air conditioning, insulation is checked by visual inspection.
- Approximations and generalizations were done at places with lack of information available.

3.2 Data Analysis

In data analysis, the data collected is processed to draw significant conclusions to pinpoint loopholes and identify the areas to focus upon. Analysis of the power consumption data is used to obtain the power consumption pattern and to get the information about the areas where electric power is wasted.

3.3 Recommendation

Energy as well as cost benefits analysis of different appliances are performed and recommendations are made based on the capital cost recovery time (simple payback period).
Following steps are involved in this process:
The capital cost involved in replacement of an appliance and/or retrofit is estimated.

- Energy saving by the recommendation is calculated in terms of price of energy per year.
- These two costs were compared to calculate the capital cost recovery time.
- If capital cost recovery time is less than the product life, the recommendation can be implemented.

Some other recommendations are also made which are based on lighting intensity, AC insulation etc.

4. Energy Conservation Measures & Utilization of Alternate Source of Energy

4.1 Energy Efficient Project (LED Light)

Marwadi University always believe in energy conservation and use of energy efficient equipment in premises. Some of the conventional lightning equipment such as Tube lights and CFLs are replaced with LED as shown in below:

Table 4.1 Energy saving data by LED project (2021)

Sr. No.	Types of LEDs Purchase			Investment	Annually Power Saving (kWh)			Total Annually Power Saving (kWh)
	9W	12W	20W	754828/-	14 W Tube Replace with 9 W LED Tube	36 W CLFs Replace with 12 W LED Lamp	28W Tube Replace with 20 W LED Tube	
1	904	935	737		13560	67320	17688	98568

The first and second floor of canteen building is established with new LED lightning facilities. The other loads such as fans, deep freeze and refrigerator are used with same capacity.

4.2 Solar energy utilization

The grid connected solar power plant was installed in June-2021.

Specifications of installed plant:

1. Total no. of modules = 1530
2. Capacity of each = 400 W
3. Total generation capacity = 612 kW

Table 4.2 Units generated by solar plant

Months	Units
July – 2021	25965.40
August – 2021	59885.00
September – 2021	60201.40
October – 2021	66455.60
November – 2021	76757.60
December – 2021	60056.20
Total Unit Generated	**349321.20**

Power generation by renewable energy = 349321.20 kWh

Percentage utilization of solar energy

= (Power generated by solar panels/Total power utilized) *100

= 11%

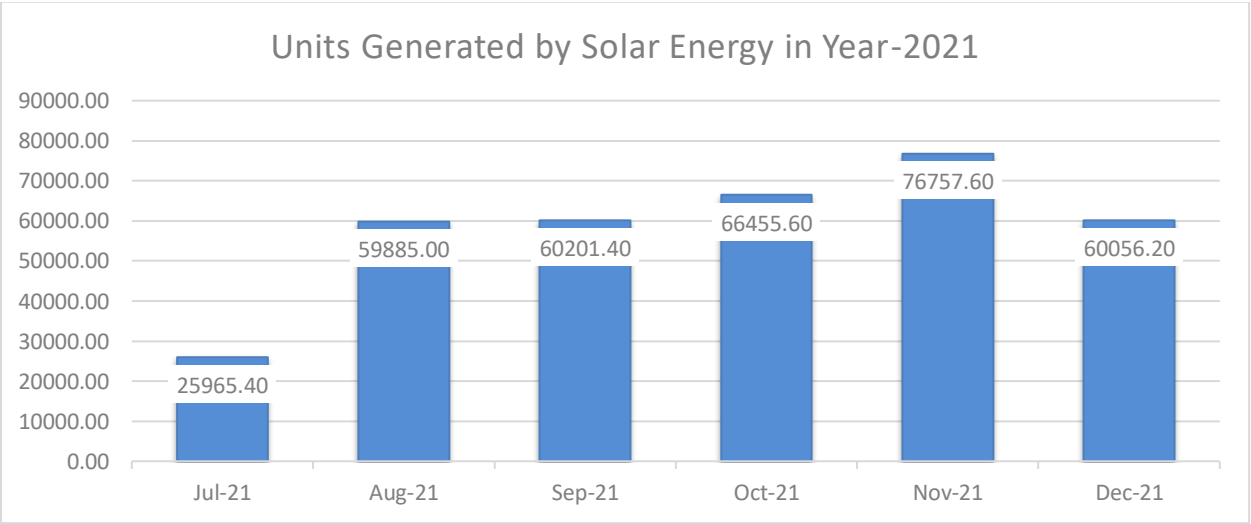
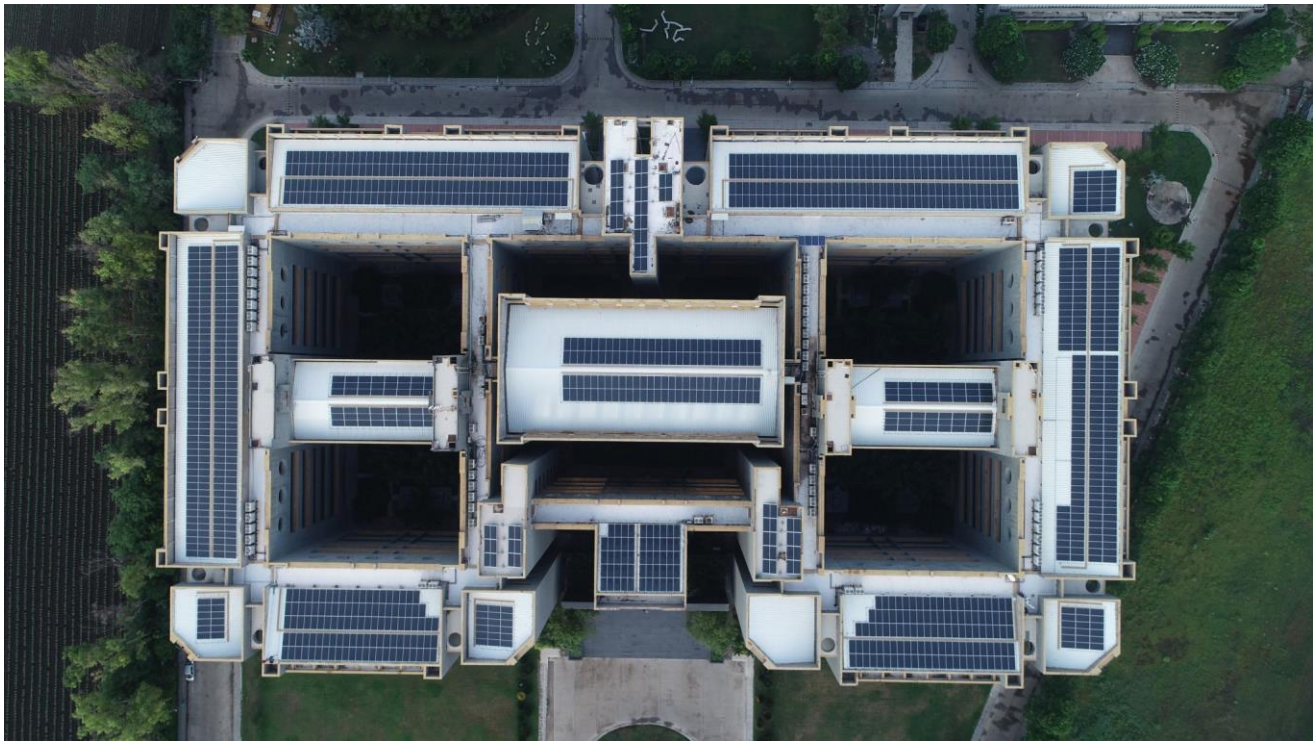


Figure 4.2 Unit generated by solar energy



5. Recommendations

Based on the analysis of the power consumption data, certain steps have been recommended for improving energy efficiency of the campus. Complete cost benefit analysis of implementation of recommended measures has been performed wherever necessary. Also, a number of general measures for energy efficiency have been listed. Some important recommendations for better energy efficiency are described below:

5.1 Lightning

Dominant light source at most places in the campus is T-l2 (28W & 18W) & CFL(18W). FTLs with electronic Ballast which averagely consumes 30W & 20W. As per our data collection, the campus has in total 4111 & 3592 T-12 FTLs and 3119 CFLs. If this T-12 electronic Ballast [Choke] and CFLs is replaced by LED tube light 12W or 8W power can be saved per FTL/CFLs. LED Lighting is 3 to 4 times costly then T-12 FTL/CFL, but this is compensated by saving in units and by saving in fix charge by reduction of load.

5.1.1 Cost Analysis of Replacing T-12 (28W) Tube Lights with Energy Efficient LED Light (12 W)

Total No. of T-12 in campus =	4111	
Average power of T-12 (28W) =	30	W
Average power of LED Light (12W) =	12	W
Power saved per tube light =	18	W
Total power saving =	73.998	kW
Working hours is 12 hrs, then total units saved =	887.976	Unit/day
Units saving in one year =	319671	
Savings in Rs per year =	2557371	
Average cost of replacement of T-12 tube light =	600	
Total cost of replacing all T-12 (28W) =	2466600	
Capital cost recovery time =	0.9	Year

5.1.2 Cost Analysis of Replacing T-12 (28W) Tube Lights with Energy Efficient LED Light (8 W)

Total No. of T-12 in campus =	4111	
Average power of T-12 (28W) =	30	W
Average power of LED Light (8W) =	8	W
Power saved per tube light =	22	W
Total power saving =	90.442	kW
Working hours is 12 hrs, then total units saved =	1085.3	Unit/day
Units saving in one year =	390709	
Savings in Rs per year =	3125676	
Average cost of replacement of T-12 tube light =	500	
Total cost of replacing all T-12 (28W) =	2055500	

Capital cost recovery time =	0.6	Year

5.1.3 Cost Analysis of Replacing T-12 (18W) Tube Lights with Energy Efficient LED Light (8 W)

Total No. of T-12 in campus =	3592	
Average power of T-12 (18W) =	20	W
Average power of LED Light (8W) =	8	W
Power saved per tube light =	12	W
Total power saving =	43.104	kW
Working hours is 12 hrs, then total units saved =	517.248	Unit/day
Units saving in one year =	186209	
Savings in Rs per year =	1489674	
Average cost of replacement of T-12 tube light =	500	
Total cost of replacing all T-12 (28W) =	1796000	
Capital cost recovery time =	1.2	Year

5.1.4 Cost Analysis of Replacing CFL (18W) with Energy Efficient LED Light (8 W)

Total No. of CFL in campus =	3119	
Average power of CFL (18W) =	20	W
Average power of LED Light (8W) =	8	W
Power saved per CFL =	12	W
Total power saving =	37.428	kW
Working hours is 12 hrs, then total units saved =	449.136	Unit/day
Units saving in one year =	161689	
Savings in Rs per year =	1293512	
Average cost of replacement of CFL =	500	
Total cost of replacing all T-12 (28W) =	1559500	
Capital cost recovery time =	1.2	Year

5.2 Fans

Most of the buildings in MU campus are 10 years old and so are the fans. Most of the fans here are not energy efficient fans. According to the data collected, there are a total of 4871 regular fans. A saving of 45W per fan can be obtained by replacing these fans by energy efficient fans.

5.2.1 Cost Benefit Analysis of Replacing Existing Fans by Energy Efficient BLDC Fans

Total No. of existing fans in campus =	4871	
Average power saved per fan =	45	W
Total power saving =	219	kW
Working hours is 12 hrs, then total units saved in a day =	2630	
Total Rs saving in a year =	5260680	
Average cost of replacing per fan =	3000	
Total cost of replacing all fans =	14613000	
Capital cost recovery time =	2.8	Year

5.3 Other Recommendations

5.3.1 Use of master switch outside each room

Installation of a master switch outside a room can make it easy for a person to switch off all the appliances of a room in case someone forgets to switch off while leaving the room. This can help improving energy efficiency.

5.3.2 Use of reflectors in tube lights and cleaning of tube lights

Use reflector in tube lights to improve the lux levels. This is clear from photo that mostly light is falling on ceiling where it is not required. By using reflector this light can reflect towards floor (when it's required). Cleaning of tube lights increases its lux level.

5.3.3 Proper insulation of refrigerant pipe line

During audit mostly Refrigerant pipe line of outdoor units found without insulation. This increases the temperature of refrigerant entering into the evaporator and thus reduces the refrigerant effect. For getting same refrigerant effect (cooling) more energy is consumed.

5.3.4 Use of time based lightning system in lobby area and parking area

Installation of time based lightning system can reduce power consumption while no occupancy in that area.

5.3.5 Proper insulation of room

Good quality insulation must be maintained in the air conditioned rooms by keeping all doors and windows closed properly so as to prevent cool air go out and hot air come in.

5.3.6 Curtains

Always keep curtains on windows to prevent direct sunlight inside the room to avoid heating of cooled air. This reduces load of AC significantly.

5.3.7 Maintenance

Proper maintenance and cleaning of ACs is required at regular intervals to make it work at highest efficiency. Any dirt in filter will reduce efficiency of ACs very significantly. (During Audit it has been seen that many ACs filters were not clean).

Date of issue: 06/02/2022

Mr. Bhaveshkumar Kanabar
Energy Manager BEE (16734/20)

Dr. Bhavesh Kanabar
Certified Energy Manager (Reg. No.16734/20)

Energy Audit Report

Client

Marwadi University

Rajkot-Morbi Highway
Rajkot – 360003

Date of Issue: 12/04/2021

101, Tej-Avenue Appartment, Nr. Nageshwar Jain Mandir, B/h Bhavanimata Temple, Jamnagar Road, Rajkot - 360006

Sr. No.	Specifications	Details
1.	Name of the customer	Marwadi Education Foundation
2.	Name of the customer (as per Electric Bill)	Marwadi Education Foundation
3.	Consumer No.	26437
4.	Address	Opp. Mahadev Vadi, Rajkot-Morbi Highway, Between Bedi & Gauridad, Dist:- Rajkot
5.	Contract Demand	1300 kVA
6.	Purpose of Consumer	HTP-I
7.	Name of Supplier	PGVCL(Electricity)
8.	Period of Audit	January 2020 to December 2020

PREFACE

Data collection for energy audit of MU campus was carried out during April 2021. This audit was conducted to seek opportunities to improve the energy efficiency of the campus. Reduction of energy consumption while maintaining or improving human comfort, health and safety was of primary concern. Besides simply identifying the energy consumption pattern, this audit seeks to identify the most energy efficient appliances. Moreover, some daily practices relating common appliances have been provided which may help reducing the energy consumption. The report accounts for the energy consumption patterns of the academic area, central facilities and hostels based on actual survey and detailed analysis during the audit. The work encompasses the area wise consumption traced using suitable equipment. The report compiles a list of possible actions to conserve and efficiently access the available scarce resources and their saving potential has been also identified. We look forward to optimum so that the authorities, students and staff would follow the recommendations in the best possible way. The report is based on certain generalizations and approximations wherever necessary. The views expressed may not reflect the general opinion. They merely represent the opinion of the team guided by the opinions of consumers.
T

ACKNOWLEDGEMENT

I express my sincere gratitude to the authorities of Marwadi University, Rajkot for entrusting and offering the opportunity of Energy Audit, which was conducted in April, 2021.

I am thankful to management for their positive support in undertaking the task of energy efficiency assessment of all electrical system, air conditioners, utilities and other equipment. The field studies would not have been completed on time without their interaction and guidance. I am grateful to their cooperation during field studies and providing necessary data for the study.

I am also thankful to supporting staff working with whom we interacted during the field studies for their wholehearted support in undertaking measurements and eagerness to assess the system/equipment performance and saving potential. Also thankful to all concerned staff interacted during the conduct of this exercise for completing official documentations.

CONTENTS

Chapter 1: Introduction **1**
1.1 Objectives of Energy Audit **1**
1.2 Necessary steps in an energy audit **1**
1.3 Identification of Target Areas **2**
1.4 Grouping and strategy **2**
1.5 Advantages of Energy Audit **2**
Chapter 2: Existing Electrical Load Pattern **3**
2.1 Overall campus details **3**
2.2 Location wise load pattern **4**
2.3 Summary of location wise load **8**
2.4 Equipment wise load pattern **9**
2.5 Observation during survey **10**
2.6 Electricity Units Analysis **11**
2.6.1 Consumption of electricity units from grid **11**
Chapter 3: Energy Audit Methodology **12**
3.1 Data Collection **12**
3.2 Data Analysis **12**
3.3 Recommendation **12**
Chapter 4: Energy Conservation Measures & Utilization of Alternate Sources of Energy **14**
4.1 LED light conservation project **14**
Chapter 5: Recommendation **16**
5.1 Installation of renewable energy resources **16**
5.2 Lightning **16**
5.2.1 Cost Analysis of Replacing T-12 (28W) Tube Lights with Energy Efficient LED Light (12 W) **16**
5.2.2 Cost Analysis of Replacing T-12 (28W) Tube Lights with Energy Efficient LED Light (8 W) **17**
5.2.3 Cost Analysis of Replacing T-12 (18W) Tube Lights with Energy Efficient LED Light (8 W) **17**
5.2.4 Cost Analysis of Replacing CFL (18W) with Energy Efficient LED Light (8 W) **17**
5.3 Fans **18**
5.3.1 Cost Benefit Analysis of Replacing Existing Fans by Energy Efficient BLDC Fans **18**
5.4 Other Recommendations **18**
5.4.1 Use of master switch outside each room **18**
5.4.2 Use of reflectors in tube lights and cleaning of tube lights **18**
5.4.3 Proper insulation of refrigerant pipe line **18**
5.4.4 Use of time based lightning system in lobby area and parking area **18**
5.4.5 Proper insulation of room **18**
5.4.6 Curtains **18**
5.4.7 Maintenance **18**

LIST OF FIGURES

2.3 Percentage representation of MU load **7**

2.4 Load shared by different equipment **9**

LIST OF TABLES

2.1 Demand and power factor details	**3**
2.2.1 Main Building	**4**
2.2.2 PG Building	**4**
2.2.3 Law(Satyarthi) Building	**5**
2.2.4 Campus area and other premises	**5**
2.2.5 Hostel – A Building	**5**
2.2.6 Hostel – B Building	**6**
2.2.7 Hostel – C Building	**6**
2.2.8 Canteen Area	**6**
2.2.9 Workshop Building	**7**
2.3 Summary of location wise load	**8**
2.4 Equipment wise load pattern	**9**
2.6.1 Monthly Electricity Units	**11**

1. Introduction

Marwadi University is a private university located in Rajkot, Gujarat, India. It was established on 9 May 2016 by the Marwadi Education Foundation through the Gujarat Private Universities Act, 2016. As of 2021, it offers more than 40 courses.

International Students from more than 45 countries have chosen Marwadi University for higher education. It has Incubation, Innovation and Research centre, which is an ecosystem that weaves industry and academia, steering the institutions' focus towards building products, services, businesses, and intellectual property, addressing real problems faced by the economy and the society at large.

1.1 Objectives of Energy Audit

The objective of the energy audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs at Marwadi University, Rajkot.

The intention of this energy audit is to identify, measure, and describe energy consumption by different loads in hostels, administrative areas, academic areas, meeting halls, street lights and to recommend energy-saving methods.

The main objectives are:

- Identification of possible uses of renewable energy sources like solar energy to minimise cost.
- Suggesting to replace highly power-consuming loads with low-power-consuming and efficient loads.
- Improving the efficiency of our target loads
- Documenting results and indispensable information generated through these activities.

1.2 Necessary steps in an energy audit

1. Planning Phase: Before getting an energy audit, the criteria for the audit are reviewed and defined.
2. Data Collection: Data can be collected in many ways at the facility and labs by appropriate measuring devices.
3. System Measurements: Some of the system measurements that may be taken include electrical, speed, and light intensity measurements.
4. Review Operating Practices: The operating practices at any facility can have a large impact on the energy audit as well.
5. Data Analysis: During the energy audit, massive amounts of data will be accumulated, and software may be used to analyse the data and to look for any issues that may exist.
6. Reporting and Recommendations: A comprehensive report will be provided, and any recommendations for improving energy usage at the facility will be given at that time.

1.3 Identification of Target Areas

We have considered the power dissipation by the loads as the primary factor to identify the target areas. Hence, we have analysed the energy consumption of various loads. Main focus is given to the loads that take more power, like fans, lighting, elevators, and air conditioners, as they are the key target areas where improvement is required.

1.4 Grouping and strategy

The following steps were done with specific target areas and end users assigned.

Step 1: Collecting electrical data related to lighting, fans, elevators, air conditioner etc... in our University.

Step 2: Data Collection from labs and their specifications

Step 3: Data Analysis by Means of Calculations

Step 4: Creating Charts and Graphs based on the collected data.

1.5 Advantages of Energy Audit

- Reducing environmental damage and pollution.
- Increasing the performance and life span of electrical loads.
- It helps lower energy bills.
- Discovering any unaccounted consumption that may exist at the facility.
- Better safety and protection.

2. Existing Electrical Load Pattern

Electrical load pattern gives us the information about the distribution of load. Electrical load data are collected by equipment, application as well as location wise.

2.1 Overall campus details

Marwadi University campus sanctioned contract demand is 1300 kVA. In addition to that capacity of DG set for power back up is 1380 kVA/1104kW. Total connected equipment load of the university is 3527kW.

Table 2.1 Demand and power factor details

Month	Contract Demand (kVA)	85%Contract demand (kVA)	Billing Demand (kVA)	Average P.F.
Jan-20	1300	1105	458	1
Feb-20	1300	1105	492	1
Mar-20	1300	1105	710	1
Apr-20	1300	1105	710	1
May-20	1300	1105	492	1
Jun-20	1300	1105	840	1
Jul-20	1300	1105	875	1
Aug-20	1300	1105	527	1
Sep-20	1300	1105	456	1
Oct-20	1300	1105	416	1
Nov-20	1300	1105	635	1
Dec-20	1300	1105	321	1

As APFC panel installed in control room, the average power factor is maintained nearly unity and the utility provide the rebate for maintaining power factor is about 2.5% in every billing cycle.

The billing demand is less than 85% of contract demand. Due to covid-19 pandemic situation with online teaching in majority of sections as well as less occupancy in hostel, the electrical consumptions are reduced. The contact demand change is advised keeping the normal situation which may restored.

2.2 Location wise load pattern

Table 2.2.1 Main Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Circle CFLs	18 W	3050	54.9
2	Tube Light(x4)	18 W	3592	64.66
3	Fan	73 W	2137	156
4	AC	1119 HP	-	834.77
5	Tube light Single	28 W	1150	32.2
6	C Fan	125 W	90	11.25
7	Table Fan	125 W	91	11.38
8	LED	12 W	602	7.224
9	Cooler	3100 W	14	43.4
10	Elevators for students	26800 W	6	160.8
11	Elevators for staff	3100 W	2	6.2
12	Speakers	45 W	310	13.95
13	Projector Set	653 W	157	102.521
14	Printer	750 W	47	35.25
15	PC	32 W	1354	43.328
Total Connected Load (kW)				**1577.833**

Table 2.2.2 PG Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Fan	73 W	92	6.716
2	AC	620 HP	-	462.52
3	Tubelight Single	28 W	63	1.764
4	LED	12 W	736	8.832
5	Cooler	575 W	5	2.875
6	Elevators for staff	3100 W	1	3.1
7	Speakers	700 W	9	6.3
8	Projector Set	653 W	3	1.959
9	Printer	750 W	5	3.75
10	PC	32 W	26	0.832
Total Connected Load (kW)				**498.648**

Table 2.2.3 Law (Satyarthi) Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tube light Single	28 W	36	1.008
2	LED	12 W	1672	20.064
3	Fan	73 W	690	50.37
4	AC	108 HP	-	80.568
5	Cooler	575 W	6	3.45
6	Elevators for students	13400 W	2	26.8
7	Elevators for staff	3100 W	3	9.3
8	Speakers	45 W	5	0.225
9	Projector Set	653 W	77	50.281
Total Connected Load (kW)				**241.058**

Table 2.2.4 Campus area and other premises

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Street Light	70 W	68	4.76
2	Halogen On Tower	250 W	16	4
3	Fox	400 W	4	1.6
4	Tube light Single	28 W	261	7.308
5	CFL	18 W	342	6.048
6	Fan	73 W	132	9.636
7	LED	12 W	18	0.216
Total Connected Load (kW)				**33.57**

Table 2.2.5 Hostel – A Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tube light Single	28 W	960	26.88
2	Tube light Single	14 W	166	2.52
3	CFL	18 W	49	0.648
4	Fan	73 W	444	32.412
5	AC	239 HP	-	178.294
6	C Fan	80 W	48	3.84
7	Table Fan	125 W	30	3.75
8	LED	12 W	54	0.648
9	Cooler	575 W	11	6.325
10	Elevators	3100 W	2	6.2
11	Speakers	45 W	48	2.16
12	Washing Machine	1700 W	2	3.4
13	Geyser	4000 W	5	20
Total Connected Load (kW)				**287.077**

Table 2.2.6 Hostel – B Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tube light Single	28 W	608	17.024
2	Tube light Single	14 W	132	1.848
3	CFL	18 W	22	0.27
4	Fan	73 W	462	33.726
5	AC	172 HP	-	128.312
6	Table Fan	125 W	6	0.75
7	LED	12 W	22	0.348
8	Cooler	575 W	11	6.325
9	Elevators	3100 W	2	6.2
10	Speakers	45 W	48	2.16
11	Washing Machine	1700 W	2	3.4
12	Geyser	4000 W	4	16
Total Connected Load (kW)				**216.363**

Table 2.2.7 Hostel – C Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tubelight Single	28 W	1012	28.336
2	CFL	18 W	10	0.18
3	Fan	73 W	902	65.846
4	AC	598 HP	-	446.108
5	Cooler	575 W	11	6.325
6	Elevators	3100 W	2	6.2
7	Speakers	45 W	60	2.7
8	Washing Machine	1700 W	4	6.8
9	Geyser	3000 W	5	15
Total Connected Load (kW)				**577.495**

Table 2.2.8 Canteen Area

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Deep Freeze	391	3	1.173
2	Refrigerator	200	3	0.6
3	Tube light	14W	606	8.484
4	Fan	73 W	200	14.6
Total Connected Load (kW)				**24.857**

Table 2.2.9 Workshop Building

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tube light Single	28 W	21	0.588
2	Fox Light	400 W	3	1.2
3	Fan	80 W	19	1.52
4	C Fan	70 W	12	0.84
5	Table Fan	125 W	16	2
6	Cooler	1550 W	1	1.55
7	CNC Machine	20000 W	1	20
8	VMC machine	25000 W	1	25
9	Lathe Machine	2200 W	18	39.6
10	Shaping Machine	550 W	2	1.1
11	Cutter Machine	750 W	1	0.75
Total Connected Load (kW)				**94.148**

2.3 Summary of location wise load

The table shows the summary of load of Marwadi University campus.

Table 2.3 Summary of location wise load

Sr. No.	Area	Present Connected Load (kW)
1	Main Building	1577.833
2	PG Building	498.648
3	Law(Satyarthi) Building	241.058
4	Campus area and other premises	33.57
5	Hostel - A Building	287.077
6	Hostel - B Building	216.363
7	Hostel - C Building	577.495
8	Canteen Area	24.857
9	Workshop Building	94.148
Total Connected Load (kW) =		**3551.049**

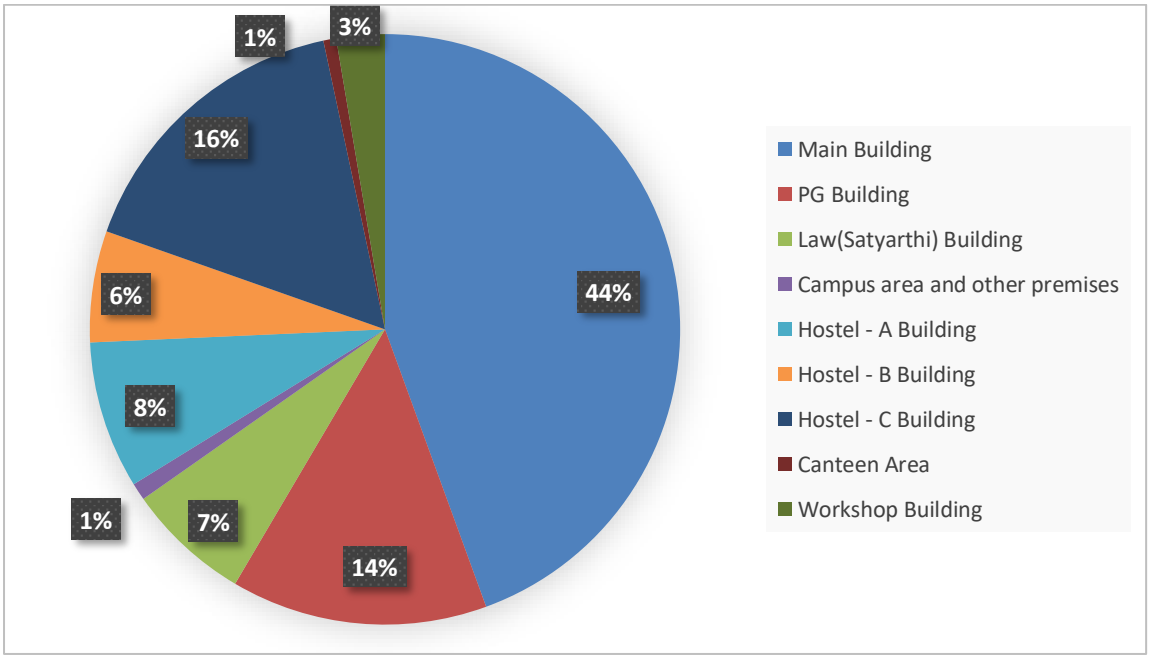


Figure 2.3 Percentage representation of MU load

The load of main building is 44%, which is highest among all shares. In main building, the majority load connected is air conditioner load i.e. 53%. Campus area and other premises takes least load i.e. 1%. Hostel- C building takes major load among all other hostel buildings. In workshop building, majority load is shared by CNC, VMC, Lathe, Sharpner and cutter machines. Also, the load is increased due to establishment of new building name as law(Satyarthi) building.

2.4 Equipment wise load pattern

Equipment wise load analysis has been performed in order to identify the equipments, with same application area, which consume more power as compared to others. During equipment wise analysis of the overall campus, the equipments with load less than 1% of the total load of the campus were ignored so as to make the analysis results simple and easy to comprehend. Following table summarizes the result of equipment wise analysis of load of MU campus.

Table 2.4 Equipment wise load pattern

Sr. No	Equipment	Type	Quantity	Load (kW)
1	Tubelight	14 W	904	12.656
		18 W	3592	64.656
		28 W	4111	115.108
2	Street Light	70 W	68	4.76
3	CFL	18 W	3473	62.514
4	LED	12 W	3104	37.248
5	Halogen on tower	250 W	16	4
6	Fox	400 W	7	2.8
7	Fan	73 W	5071	370.183
		80 W	67	5.36
8	Table fan	125 W	233	29.125
9	Water cooler	575 W	44	25.3
		1550 W	1	1.55
		3100 W	14	43.4
10	Elevator	3100 W	12	37.2
		13400 W	2	26.8
		26800 W	6	160.8
11	Air conditioner	2856 HP	-	2130.576
12	Speaker	45 W	471	21.195
		700 W	9	6.3
13	Projector Set	653 W	237	154.761
14	PC	32 W	1380	44.16
15	Printer	750 W	52	39
16	Washing machine	1700 W	8	13.6
17	Geyser	4000 W	9	36
		3000 W	5	15
18	CNC Machine	20000 W	1	20
19	VMC machine	25000 W	1	25
20	Lathe Machine	2200 W	18	39.6
21	Sharpner Machine	550 W	2	1.1
22	Cutter Machine	750 W	1	0.75
23	Deep Freeze	391 W	3	1.173
24	Refrigerator	200 W	3	0.6
Total Connected Load (kW) =				**3551.049**

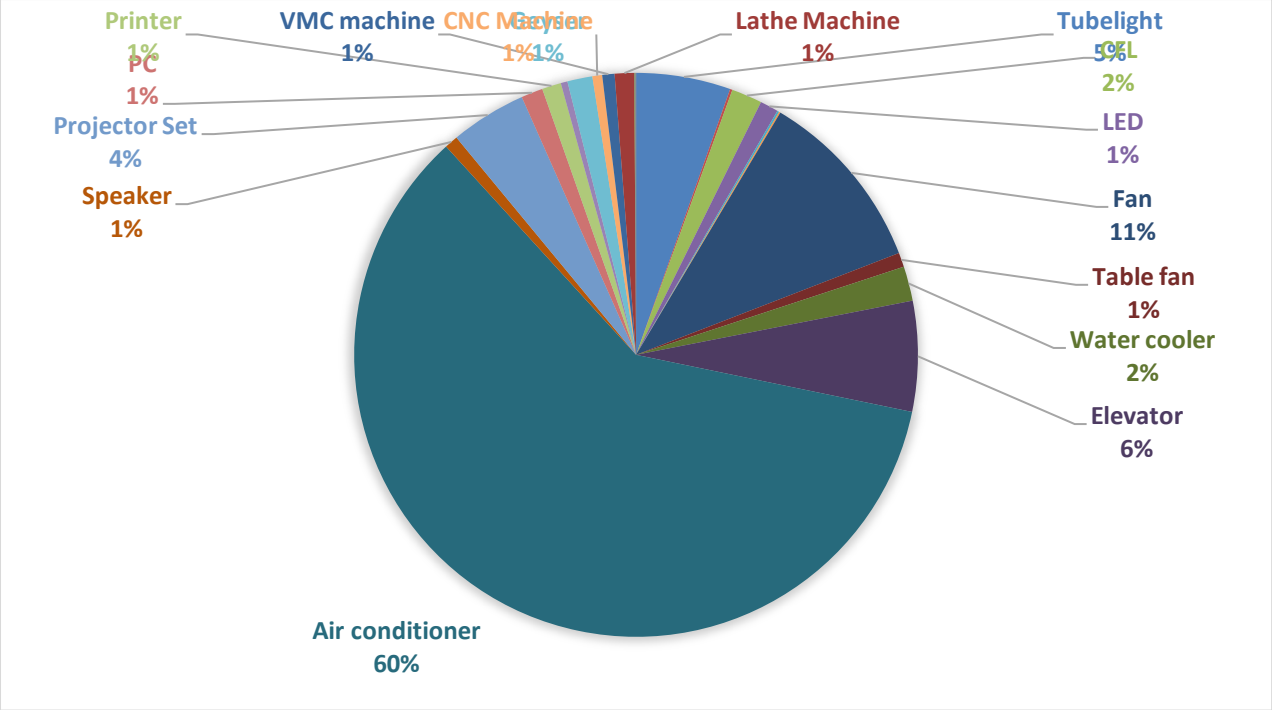


Figure 2.4 Load shared by different equipment

According to the above fig. the maximum power is consumed by air conditioner system (60%), followed by fan (11%). The other connected loads (<1% of total load) are not showing in above chart.

2.5 Observation during survey

- In campus, automatic street light timer base control system is installed.
- Pump sets are operated on their rated capacity by V/f control drive system.
- Air conditioner is operated on default temperature set at 24^0 C. The maintenance of equipment are properly done at regular intervals.
- Using adequate ventilated class room and lab premises.
- APFC panel is installed in control room to maintain power factor nearly unity.

2.6 Electricity Units Analysis

2.6.1 Consumption of electricity units from grid

Table 2.6.1 Monthly Electricity Units

Months	PGVCL Units	DG Units
January	201113	3760
February	214148	8720
March	254708	1616
April	179730	976
May	213885	6288
June	261480	6400
July	235148	4848
August	191445	4960
September	169290	2144
October	171833	1568
November	169290	2496
December	120975	2176
Total Unit Consumed	**2374075**	**45952**

As seen in the table the consumption of the electricity is increasing every year. Due to COVID-19 pandemic situation from march-2020, load consumption was reduced. The consumption of units is more in summer due to the use of AC system.

3. Energy Audit Methodology

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

- Data collection: In preliminary data collection phase, exhaustive data collection was performed using different tools such as observation, interviewing key persons, and measurement.
- Data analysis: Collected data were analyzed using MS Excel. The database generated by MS Excel was used for producing graphical representations.
- Recommendation: On the basis of results of data analysis and observations, some steps for reducing power consumption, without affecting the comfort and satisfaction, were recommended along with their cost analysis.

3.1 Data Collection

For suggesting any corrective measures to reduce power consumption, it is first necessary to know the power consumption pattern in detail. For this, the exhaustive data collection exercise has been performed at all the departments, academic area, hostels, and other supporting entities such as library, computer labs etc. Following steps have been taken for data collection:

- The team visited to academic area administrative area, labs, hostels etc.
- Information about the general electrical appliances is collected by observation and interviewing.
- The power consumption of appliances is measured using power analyzer in some cases (such as monitors) while in other cases, rated power was used like CFL, AC, Fan etc.
- The details of usage of the appliances were collected by interviewing key persons e.g. warden care taker (in case of hostels), personnel of institute maintenance and project department etc.
- Intensity of light was measured using lux meter at administrative area, academic area hostels, corridors etc.
- In case of air conditioning, insulation is checked by visual inspection.
- Approximations and generalizations were done at places with lack of information available.

3.2 Data Analysis

In data analysis, the data collected is processed to draw significant conclusions to pinpoint loopholes and identify the areas to focus upon. Analysis of the power consumption data is used to obtain the power consumption pattern and to get the information about the areas where electric power is wasted.

3.3 Recommendation

Energy as well as cost benefits analysis of different appliances are performed and recommendations are made based on the capital cost recovery time (simple payback period).
Following steps are involved in this process:
The capital cost involved in replacement of an appliance and/or retrofit is estimated.

- Energy saving by the recommendation is calculated in terms of price of energy per year.
- These two costs were compared to calculate the capital cost recovery time.
- If capital cost recovery time is less than the product life, the recommendation can be implemented.

Some other recommendations are also made which are based on lighting intensity, AC insulation etc.

4. Energy Conservation Measures & Utilization of Alternate Source of Energy

4.1 LED Light Conservation Project

Marwadi University always believe in energy conservation and taking steps towards efficient utilization of energy such as to replace CFLs with LED lights. Also, In the new building erected during this period, all lightning sources are utilized with LED technology.

Table 4.1 Energy saving by LED project (2021)

Sr. No.	Types of LEDs Purchase		Investment	Annually Power Saving (kWh)		Total Annually Power Saving (kWh)
	9W	12W	13760/-	14 W Tube Replace with 9 W LED Tube	36 W CLFs Replace with 12 W LED Lamp	
1	14	30		210	2160	2370

Fig. 4.1 LED Light installed

5. Recommendation

Based on the analysis of the power consumption data, certain steps have been recommended for improving energy efficiency of the campus. Complete cost benefit analysis of implementation of recommended measures has been performed wherever necessary. Also, a number of general measures for energy efficiency have been listed. Some important recommendations for better energy efficiency are described below:

5.1 Installation of Renewable Energy Resources

The University campus is connected to the State Electricity Grid through a grid interactive system. By implementing solar energy solutions, university buildings can reduce their carbon footprint, save money on energy costs, and contribute to a more sustainable future.

5.2 Lightning

Dominant light source at most places in the campus is T-l2 (28W & 18W) & CFL(18W). FTLs with electronic Ballast which averagely consumes 30W & 20W. As per our data collection, the campus has in total 4111 & 3592 T-12 FTLs and 3119 CFLs. If this T-12 electronic Ballast [Choke] and CFLs is replaced by LED tube light 12W or 8W power can be saved per FTL/CFLs. LED Lighting is 3 to 4 times costly then T-12 FTL/CFL, but this is compensated by saving in units and by saving in fix charge by reduction of load.

5.2.1 Cost Analysis of Replacing T-12 (28W) Tube Lights with Energy Efficient LED Light (12 W)

Total No. of T-12 in campus =	4111	
Average power of T-12 (28W) =	30	W
Average power of LED Light (12W) =	12	W
Power saved per tube light =	18	W
Total power saving =	73.998	kW
Working hours is 12 hrs, then total units saved =	887.976	Unit/day
Units saving in one year =	319671	
Savings in Rs per year =	2557371	
Average cost of replacement of T-12 tube light =	540	
Total cost of replacing all T-12 (28W) =	2219940	
Capital cost recovery time =	0.8	Year

5.2.2 Cost Analysis of Replacing T-12 (28W) Tube Lights with Energy Efficient LED Light (8 W)

Total No. of T-12 in campus =	4111	
Average power of T-12 (28W) =	30	W
Average power of LED Light (8W) =	8	W
Power saved per tube light =	22	W
Total power saving =	90.442	kW
Working hours is 12 hrs, then total units saved =	1085.3	Unit/day

Units saving in one year =	390709	
Savings in Rs per year =	3125676	
Average cost of replacement of T-12 tube light =	450	
Total cost of replacing all T-12 (28W) =	1849950	
Capital cost recovery time =	0.6	Year

5.2.3 Cost Analysis of Replacing T-12 (18W) Tube Lights with Energy Efficient LED Light (8 W)

Total No. of T-12 in campus =	3592	
Average power of T-12 (18W) =	20	W
Average power of LED Light (8W) =	8	W
Power saved per tube light =	12	W
Total power saving =	43.104	kW
Working hours is 12 hrs, then total units saved =	517.248	Unit/day
Units saving in one year =	186209	
Savings in Rs per year =	1489674	
Average cost of replacement of T-12 tube light =	450	
Total cost of replacing all T-12 (28W) =	1616400	
Capital cost recovery time =	1	Year

5.2.4 Cost Analysis of Replacing CFL (18W) with Energy Efficient LED Light (8 W)

Total No. of CFL in campus =	3326	
Average power of CFL (18W) =	20	W
Average power of LED Light (8W) =	8	W
Power saved per CFL =	12	W
Total power saving =	39.912	kW
Working hours is 12 hrs, then total units saved =	478.944	Unit/day
Units saving in one year =	172420	
Savings in Rs per year =	1379359	
Average cost of replacement of CFL =	450	
Total cost of replacing all T-12 (28W) =	1496700	
Capital cost recovery time =	1	Year

5.3 Fans

Most of the buildings in MU campus are 10 years old and so are the fans. Most of the fans here are not energy efficient fans. According to the data collected, there are a total of 4871 regular fans. A saving of 45W per fan can be obtained by replacing these fans by energy efficient fans.

5.3.1 Cost Benefit Analysis of Replacing Existing Fans by Energy Efficient BLDC Fans

Total No. of existing fans in campus =	4871	
Average power saved per fan =	45	W
Total power saving =	219	kW
Working hours is 12 hrs, then total units saved in a day =	2630	
Total Rs saving in a year =	5260680	
Average cost of replacing per fan =	2700	
Total cost of replacing all fans =	13151700	
Capital cost recovery time =	2.5	Year

5.4 Other Recommendations

5.4.1 Use of master switch outside each room

Installation of a master switch outside a room can make it easy for a person to switch off all the appliances of a room in case someone forgets to switch off while leaving the room. This can help improving energy efficiency.

5.4.2 Use of reflectors in tube lights and cleaning of tube lights

Use reflector in tube lights to improve the lux levels. This is clear from photo that mostly light is falling on ceiling where it is not required. By using reflector this light can reflect towards floor (when it's required). Cleaning of tube lights increases its lux level.

5.4.3 Proper insulation of refrigerant pipe line

During audit mostly Refrigerant pipe line of outdoor units found without insulation. This increases the temperature of refrigerant entering into the evaporator and thus reduces the refrigerant effect. For getting same refrigerant effect (cooling) more energy is consumed.

5.4.4 Use of time based lightning system in lobby area and parking area

Installation of time based lightning system can reduce power consumption while no occupancy in that area.

5.4.5 Proper insulation of room

Good quality insulation must be maintained in the air conditioned rooms by keeping all doors and windows closed properly so as to prevent cool air go out and hot air come in.

5.4.6 Curtains

Always keep curtains on windows to prevent direct sunlight inside the room to avoid heating of cooled air. This reduces load of AC significantly.

5.4.7 Maintenance

Proper maintenance and cleaning of ACs is required at regular intervals to make it work at highest efficiency. Any dirt in filter will reduce efficiency of ACs very significantly. (During Audit it has been seen that many ACs filters were not clean).

Date of issue: 12/04/2021

Mr. Bhaveshkumar Kanabar
Energy Manager BEE (16734/20)