EXPLORATION TO LOAD REDUCTION IN A UNIVERSITY CAMPUS USING ENERGY CONSERVATIOIN STRATEGIES- A CASE STUDY

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Abstract: Electrical energy conservation is an important element of energy policy which is very essential as the energy demand of the society increasing day by day. Energy audit plays a vital role in estimating the energy conserved and the steps needed to be taken while reducing the energy consumption. It consists of several tasks and it is a periodic activity to ascertain the objective of energy usage and the amount of energy can be calculated and minimized by collecting historical data and energy consumption. This work aims to conduct energy audit in JNTUK-UCEV campus. Energy consumption of the university campus is estimated and also the areas where electrical energy consumed highly are discovered. The equipment which is consuming high energy is replaced with energy efficient ones to reduce the electrical energy consumption and also the payback period is estimated. Further some recommendations are made with renewable sources to meet the energy consumption of the university campus. Finally ETAP software is used to conduct the load flow analysis using the data of the university campus to represent the reduction in load.

Index Terms - Electrical energy conservation; Electrical energy audit; JNTUK- UCEV campus; Renewable sources and ETAP software.

I. INTRODUCTION

India is the world's fourth largest consumer of electricity in the world with gross electricity consumption of 1,122 KWh in the year 2016-17[1]. The Indian electricity sector has one national grid as on 31st January, 2018 with an installed capacity of 334.40 GW and the total generation in India was 1236.39 TWh [2]. The generation in India is mostly dependent on fossil fuels, particularly on coal, which constitutes two third of all electricity generation India. Now, the country is looking towards generation through renewable energy sources [3]. But there is less attention is paid towards electricity wastage in our country. It is also important to consider the areas of electrical energy wastage and steps to reduce electrical energy wastage and consumption, so that the electrical energy demand could be reduced, which is called as the Electrical energy audit.

Electrical energy audit is the process of identifying areas of energy wastage and thereby reducing the energy wastage so that the energy consumption is reduced in an industry, buildings, home, etc. electrical energy is beneficial for not only the generating companies to reduce generation but also for consumers in such a way that it can reduce the tariff on the industry or commercial building or residential home, wherever it is practiced.

The electrical energy audit was conducted at UKA Tarsadia University, in which the average monthly energy consumption was 1.3 lack kWh [4]. The energy auditing was carried out on lighting and air conditioning system and also fans and PC's which consumes most and it saves up to 21% of electrical energy. The electrical energy audit was carried out at Durban city on low income consumers to understand their load profiles which in turn gives load variations of the grid system[5]. The electrical energy audit at the Universiti Teknologi MARA(UiTM) Penang shows that the buildings consumed 1.5 million kWh of electrical energy monthly [6]. The auditing was carried out on lighting and air conditioning system and the equipment are found to be operating at low efficiency. The audit provides 10% electrical energy saving.

The electrical energy audit has immense influence on industries too, which was conducted on an Electroplating unit in Vidharbha region of Maharashtra [7]. It suggests an annual energy reduction of 25.70% of total energy and saves Rs 57,083 per year with a payback period of 1.3 years. The energy audit can also be carried out on medium size industries [8]. It focuses mainly on load management, power factor and motor losses manage in the concerned industries. The energy audit can also be done using load flow analysis by ETAP software [9][10]. Moreover ETAP software can provide various kinds of applications in power system [11].

From the above literature, it is observed that energy audit is important to reduce energy wastage. So that electrical energy audit is carried out in JNTUK-UCEV campus and also some recommendations are made to reduce the energy wastage. Then ETAP software is used to conduct load flow study on the data obtained from university campus.

II. ENERGY AUDIT METHODOLOGY

Electrical energy audit mostly concerned about the ways of energy reduction. There are different procedures to follow for electrical energy audit [12][13]. The generalized procedure to conduct electrical energy audit is as follows:

a). Visit the area, where auditing is going to be done.
b). Collect the general information regarding area i.e., distance from grid and type of transformers used.
c). Load details of electrical equipment with maximum demand are collected.
d). Prepare the single line diagram of the entire site area.
e). Calculate the daily utilization of equipment and the daily utilization of entire area.
f). Identify the equipment with maximum and minimum utilization.
g). Draw the single line diagram in ETAP software and enter the values of each block in the software.
h). Energy saving opportunities is then identified.
i). Give suitable recommendations to save electrical energy and prepare a report on recommendations with and without audit.
j). Compare the results obtained by connecting the single line diagram in the ETAP software with and without recommendations.
k). Then the report is submitted to the customer and provide awareness about electrical energy saving.

It is also advisable to provide the customer with suitable generating method with renewable sources. The payback time also should be mentioned so that the customer will have a better understanding about the investment that they should undergo. The proposed renewable energy sources are also should be simulating using the ETAP software to get the better results with auditing [12].

III. ENERGY ESTIMATION OF JNTUK – UCEV CAMPUS :

The proposed electrical energy audit is done in Jawaharlal Nehru Technological University Kakinada – University College of Engineering, Vizianagaram Campus. The main campus consists of Hostels and college campus. The college campus has different blocks in it namely Block I, Block II, First year block and other blocks which include library, sports complex, etc. The hostel campus has mainly three blocks, Boys hostel, ladies hostel and Staff quarters.

In the campus i.e., in both college campus and in hostel campus the loading details are to be noted to observe electrical energy wastage and can also observe the equipment having high consumption of electrical energy.

Energy consumption of JNTUK - UCEV:

The data of the overall university campus can be provided with respect to each block in table 1. The figure 1 represents the graphical representation of energy consumption at each block. The electrical energy consumption of each block with respect to the connected electrical equipment is shown in the below figures 3-7. This gives the electrical energy consumption of each equipment in their respective block and also gives the information about the highly energy consumed equipment.

Table 1 Energy consumption at each block.

Block name		Units consumed per day (kWh)
ACADEMIC BLOCK - 01	floor 1	79.99
	floor 2	121.064
	floor 3	47.082
FIRST YEAR BLOCK	floor 1	27.531
	floor 2	42.26
ACADEMIC BLOCK - 02	floor 1	50.677
	floor 2	111.887
	floor 3	71.911
LABS	work shop lab	4.75
	metallurgy lab	20.194
	machines lab	14.891
LIBRARY		23.075
CANTEEN		13.68
DISPENSARY		0.1632
SPROTS COMPLEX		73.23
GUEST HOUSE		5.09
GYM		8.102
STREET LIGHTS		18.4
BOYS HOSTEL - I		191570
BOYS HOSTEL II		248315
LADIES HOSTEL - I		173200
LADIES HOSTEL II		315345
FACULTY QUARTERS		272968

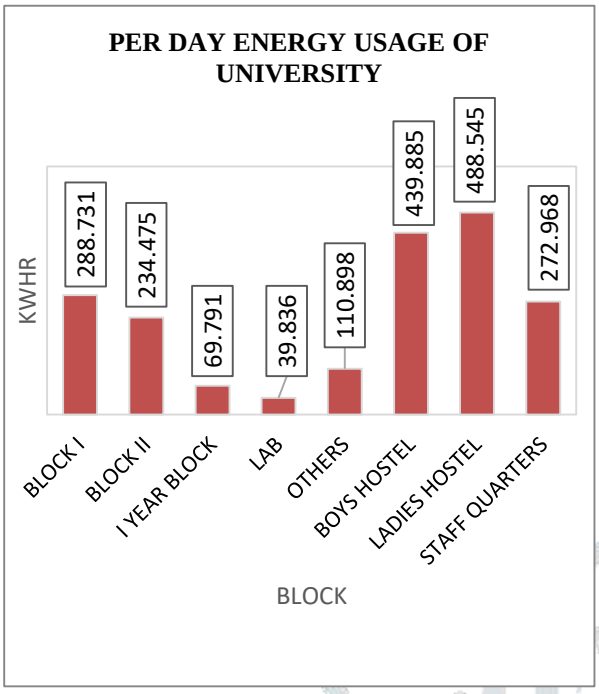

Fig. 1. Per day energy usage at different blocks.

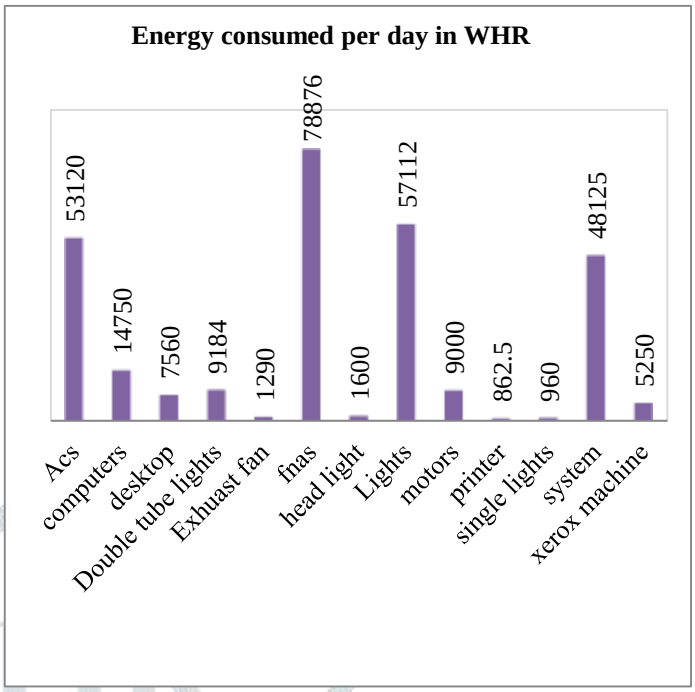

Fig. 2. Per day usage of different equipment in academic Block 1.

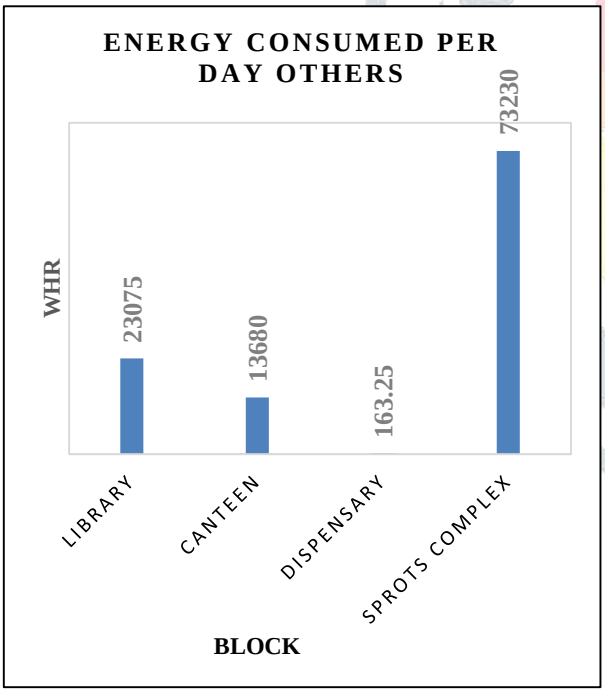

Fig. 3. Per day usage of different equipment in Other academic blocks.

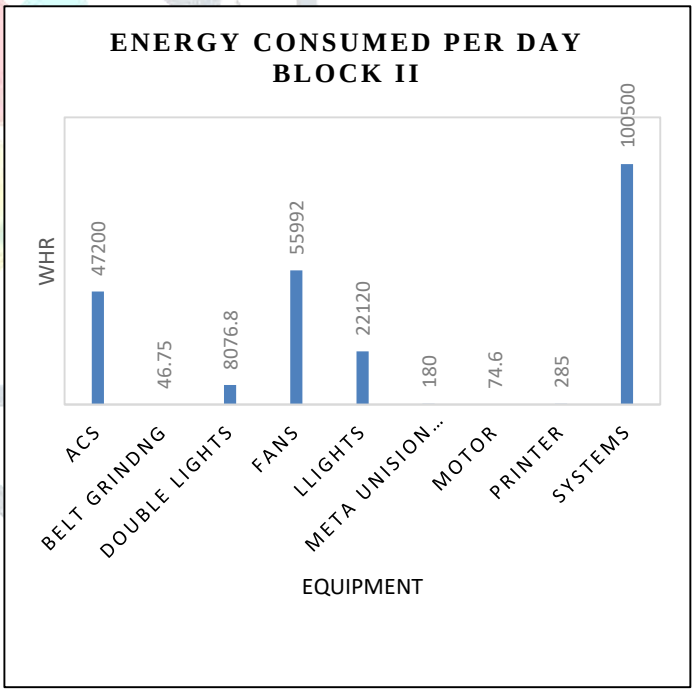

Fig.4. Per day energy consumption of different equipment in academic Block II.

By analyzing the data of university campus in fig 1-5, it is clearly indicates that the major energy consuming equipment are lights, fans, air conditioners and monitors. These are the major equipment which consists almost 70 % of energy consumption of each block. Also, there is some inadvertent usage of equipment which causes high amount of energy consumption.

By observing the figure 6, it is noted that the tube lights, fans, ACs and monitors are the main equipment, responsible high electrical energy consumption in the hostel area. Therefore, to reduce the energy consumption of the hostel area is possible by replacing the particular equipment with energy efficient equipment.

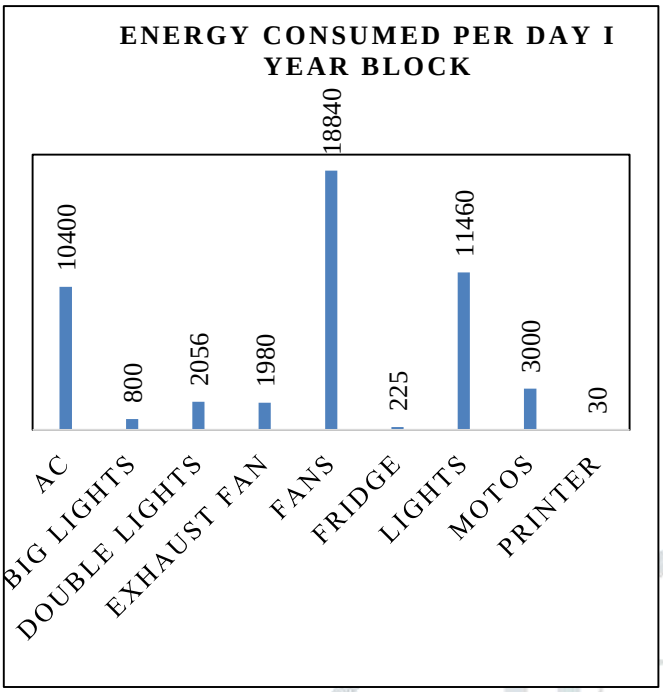

Fig.5. Per day energy consumption of different equipment in first year block.

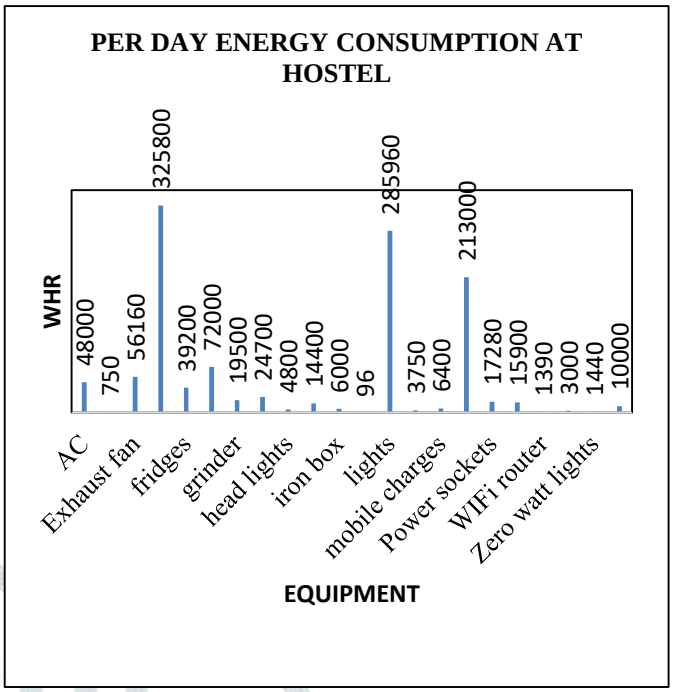

Fig. 6. Per day energy consumption of different equipment in hostel campus

IV. Recommendations

From the analysis of the data of the JNTUK – UCEV Campus, the areas of electrical energy utilization are observed. Now the recommendations are made to reduce the electrical energy utilization. The following types of recommendations are made to reduce the electrical energy consumption of the University Campus. They are:

1. Recommendations without Investment
2. Recommendations with investment
3. Recommendation with DG

4.1 Recommendations without Investment:

According to the layout of the Campus, there are some energy saving recommendations by which electrical energy and tariff can be saved without any investment. By proper utilization also the electrical energy can be conserved and the tariff can be reduced in the monthly bills. They are:

a). Always tightly shut windows and doors, when running the AC or Heater.
b). Turn off exhaust fans as soon as possible.
c). Use ceiling fans to cool a room instead of AC.
d). Clean Air conditioners air filters at least once a month.
e). Always keep the refrigerator fully loaded.
f). Use power saving mode on refrigerator
g). Avoid frequent opening and closing of refrigerators.
h). Always turn off electronic devices when they are not in use.
i). Unplug device when it is fully charged or not in use, otherwise it will consume some energy.
J). Change or turn off factory settings of Television.
k). Keep your computer in sleep mode for longer periods of inactivity.
l).In class rooms, opt for natural sun light than going for lighting load.
m).In mechanical and metallurgical labs, it is observed that most of the motors are rarely used. It is advisable to use suitable lubricants for them, otherwise dust will remain on the moving parts of the motor which tends the motor to consume more amount of electrical energy.
n). Clean the blades of fans regularly and also repairs should be done in time.
o). Always go for energy saving modes for equipment.

4.2 Recommendations with Investment:

Replacement of ACs:-It is observed from the data analysis chart that ACs are one of the major equipment that consumes high amount of electrical energy. Most of the currently installed ACs in the Campus is Three-Star rated ones. It is recommended to replace these ACs with Five-Star rated ACs. The increase in star rating indicates reduction in power consumption of the respective appliance. The energy saving details due to the replacement is in table 1.

Replacement of Tube light with LED light:-One of the major loads in the university campus is lighting load. Most of the lighting load is based on tube lights. Power rating of LED light is very less when compared to Tube lights and also LED lights have larger life span than conventional Tube lights. It can save more electrical energy when the fluorescent lights are replaced by LED. The respective energy saving details are given in tabular form in table 2.

Replacement of FAN:-Fans and exhaust fans are also the most power consuming equipment in both College campus and also in Hostel area. It is observed in table 3 that all the fans are not star rated. It is recommended that these conventional fans are replaced with star rated fans. Star rated fans consume much less energy when compared with non-star rated.

Replacement of Computer Monitors:-Monitor is the major power consuming component in the Computer system. Most of the present installed computers in the campus are having CRT monitors. CRT monitors consumes around 220-300 watts of power and also they are harmful for human eyes. These CRT monitors are needed to be replaced with LED monitors. LED monitors consumes much less energy and also good for human eyes. The energy saving details due to the replacement is as in table 4.

Replacement of motors:-Motors are also one of the major loads in the campus. No motor in the campus is driven by solar power. So it is recommended to replace the current motors with solar powered so the tariff bill will be reduced. The energy saving details of the solar powered motors are given in table 5.

Replacement of fridges:-The currently installed fridges in the campus are not star rated. It is recommended to replace these fridges with star rated ones to reduce electrical energy consumption. The energy saving details is given as in table 6.

Replacement of Street Lights:-LED lights that are used for street lighting should consume less energy. The energy saving details will be as in table 7.

Replacement of Geysers:-Geysers consume much more energy than what we expected. Each geyser may consume up to 2 kW. So these geysers are needed to be replaced with solar water heaters. Solar water heaters don't impose any tariff. The details are as in table 8.

The total load reduction is given in table 9, which shows the total payback period.

Table2. Replacement of AC's with star rated**.**

No. of AC's	50
wattage of each Ac	1600
energy consumed per day(kWh)	112.32
energy consumed per year(kWh)	40996.8
cost annually	491961.6
star rating	5
no of ACs	50
wattage of each Ac	1200
energy consumed per day(kWh)	84.24
energy consumed per year(kWh)	30747.6
cost annually	368971.12
cost of each equipment	35000
total investment	7050000
payback time(months)	170
annual saving	122990.48

Table3. Replacement of Tube lights with Led lights at both college and Hostel.

COLLEGE LIGHTS AND DOUBLE LIGHTS REPLACED WITH LED'S	
Total number of tube lights need to change	2671
Total number of units consumed daily(kWh)	369.064
Total number of double tube lights need to change	216
Total number of units consumed daily(kWh)	18.7648
Total number of units consumed daily(light and double lights)(KWh)	387.8288
Total number of units consumed annually(light and double lights) (KWh)	141557.51
total cost annually (light and double lights)(Rs)	1072437.7
Total no of LEDs(40w+32w)(931+216)	2887
Total number of units consumed annually(kWh)	58076.464
total cost with LEDs annually(Rs)	195915.65
Energy saved annually(kWh)	20855.808
Money saved annually(Rs)	626021.14
LED cost(Rs)	450
Total investment cost (Rs)	1254150
Payback time (years)	2.0033669

Table 4. Replacement of fans with star rated fans at both college and hostel.

EXAST FANS AND FANS REPLACED WITH STAR RATED FANS	
total no of exhaust fans	257
total no of fans	1983
wattage of each exhaust fans	60
wattage of each fan	60
energy consumed per day exhaust fans(kWh)	132.1
energy consumed per day fans(kWh)	498.288
energy consumed per year all fans(kWh)	927168.52
cost annually all fans(Rs.)	1924607.04
cost annually all fans(Rs.)	1924607.04
star rating	5
no of fans	2240
wattage of each fan	40
energy consumed per day all fans(kWh)	379.37
energy consumed per year all fans(kWh)	138470.78
cost annually of all fans	1103986.96
cost of each equipment	Rs. 2000
total investment(Rs.)	4480000
payback time(years)	5.459291671
annual saving(Rs.)	820619.28

Table 5. Replacement of CRT monitors with LED monitors.

REPLACEMENT OF MONITORS	
total no of monitors	544
wattage of each monitors	250
energy consumed per day(kWh)	192.435
energy consumed per year(kWh)	70238.775
cost annually	Rs. 842865.3
star rating	LED
no of LED monitors	544
wattage of each LED monitor	110
energy consumed per day(kWh)	84.42
energy consumed per year(kWh)	30813.3
cost annually	Rs. 369759.6
cost of each equipment	Rs. 8000
total investment	Rs. 4352000
payback time(months)	110
annual saving	Rs. 473105.7

Table 6. Replacement of motors with solar pumps.

REPLACEMENT OF MOTOR PUMPS	
Total number of pumps need to change(in hostel)	15
Total number of units consumed daily(kWh)	180
Total number of pumps need to change(in college)	4
Total number of units consumed daily(kWh)	12.75
Total number of units consumed daily(college and hostel)(kWh)	192.75
Total number of units consumed annually(college and hostel) (kWh)	70353.75
Total cost annually (college)(Rs)	55845
Total cost annually (hostel)(Rs)	394200
Total cost annually (college and hostel)(Rs)	450045
Total no of solar pumps	19
total cost of solar pumps	Rs. 2242000
Money saved annually(Rs)	Rs. 450045

cost of each solar pump(Rs)	Rs. 118000
investment cost (Rs)	Rs. 2242000
Payback time (months)	59.8 months

Table 7. Replacement of fridges with star rated fridges.

FRIDGES REPLACED WITH STAR RATED FRIDGES	
total no of fridges	20
wattage of each fridges	700
energy consumed per day(kWh)	39.2
energy consumed per year(kWh)	14308
cost annually	Rs. 85848
star rating	3
total no of star rated fridges	18
wattage of each star rated fridges	200
energy consumed per day(kWh)	13.6
energy consumed per year(kWh)	4964
annual cost	Rs. 29784
annual savings	Rs. 56064
cost of each star rated fridge	Rs. 13000
investment cost	Rs. 260000
payback period(months)	55.56

Table 8. Replacement of street lights with LED street lights

STREET LIGHTS ,HEAD LIGHTS AND BIG LIGHTS REPLACED WITH LED LIGHTS	
total no of street lights	80
wattage of each street light	200
energy consumed per day(kWh)	18.4
energy consumed per year(kWh)	6716
cost annually	Rs. 80592
total no of head lights	1
wattage of each head light	200
energy consumed per day(kWh)	16
energy consumed per year(kWh)	584
cost annually	Rs. 7008
total no of big lights	5
wattage of each big light	200
energy consumed per day(kWh)	0.8
energy consumed per year(kWh)	292
cost annually	Rs. 3504
total no of LED lights	86
cost of each LED	Rs. 2000
annual cost of LED lighting	Rs. 32192
annual savings	Rs. 58911
investment cost	Rs. 172000
payback period(months)	35

Table 9. Replacement of geysers with solar water heaters.

GREASERS REPLACED WITH SOLAR WATER HEATER	
total no of GREASERS	19
wattage of each GREASERS	2000
energy consumed per day(kWh)	82
energy consumed per year(kWh)	29930
cost annually	Rs. 179580
annual savings	Rs. 179580
no of solar water heaters	19
cost of each solar water heater	Rs. 22000
investment cost	Rs. 418000
payback period(months)	27.93

Table 10. Total savings in the campus

TOTAL SAVINGS IN THE CAMPUS	
total no of equipments need to change	5863
energy consumed per day(kWh)	1527.2748
energy consumed per year (kWh)	1302175.4
cost annually	Rs. 5139048.6
investment cost of energy saving equipment	Rs. 20228180
annual savings with energy saving equipments	Rs.2787336.6
payback period(years)	7.2571706

V. Comparative Analysis Of Jntuk-Ucev Campus

After employing all the above mentioned recommendations, the load of each block in the JNTUK – UCEV campus can be considerably reduced. This can be shown in figure 07-11.

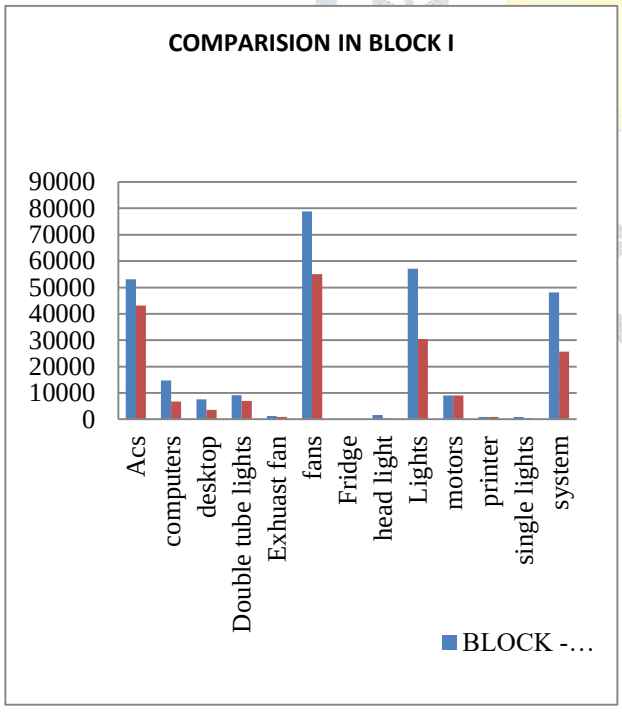

Fig. 7. Comparison of energy consumption of each equipment before and after audit at Block I

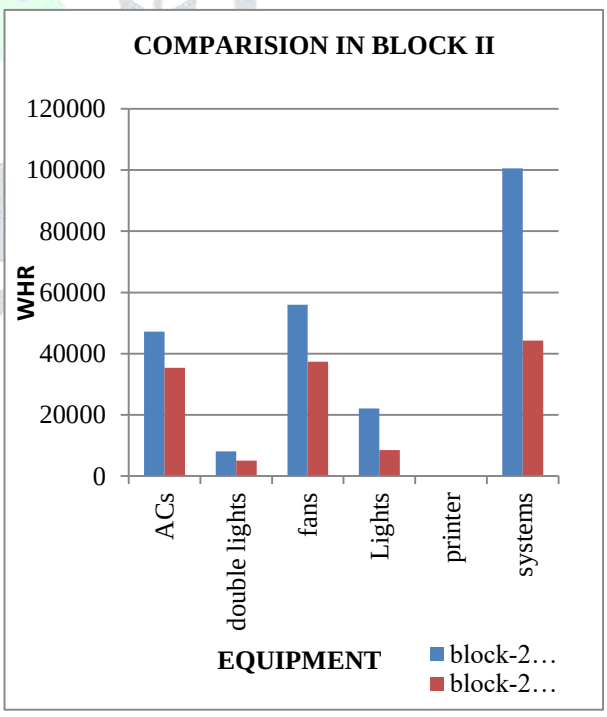

Fig. 8. Comparison of per day energy consumption at Block II

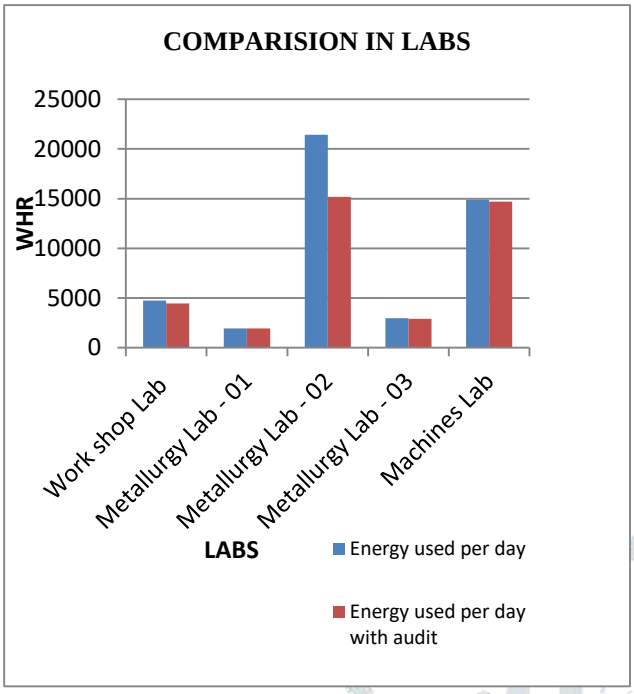

Fig. 9. Comparison of electrical energy at labs

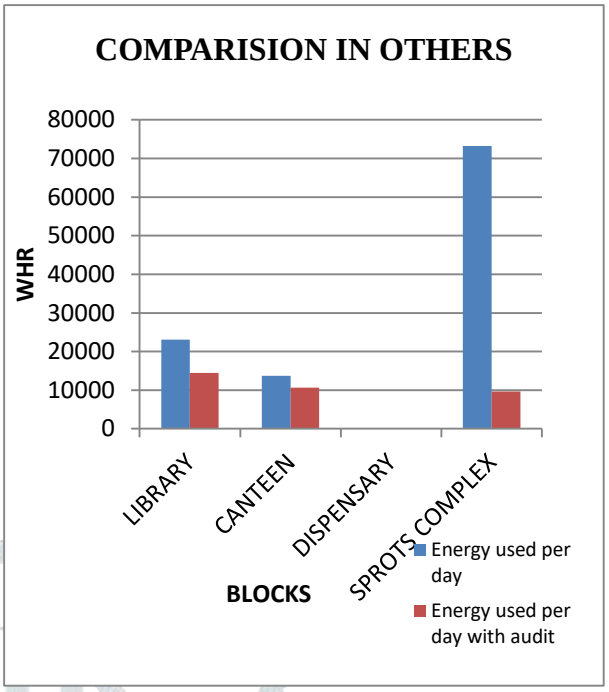

Fig 10. Comparison of day energy at other blocks

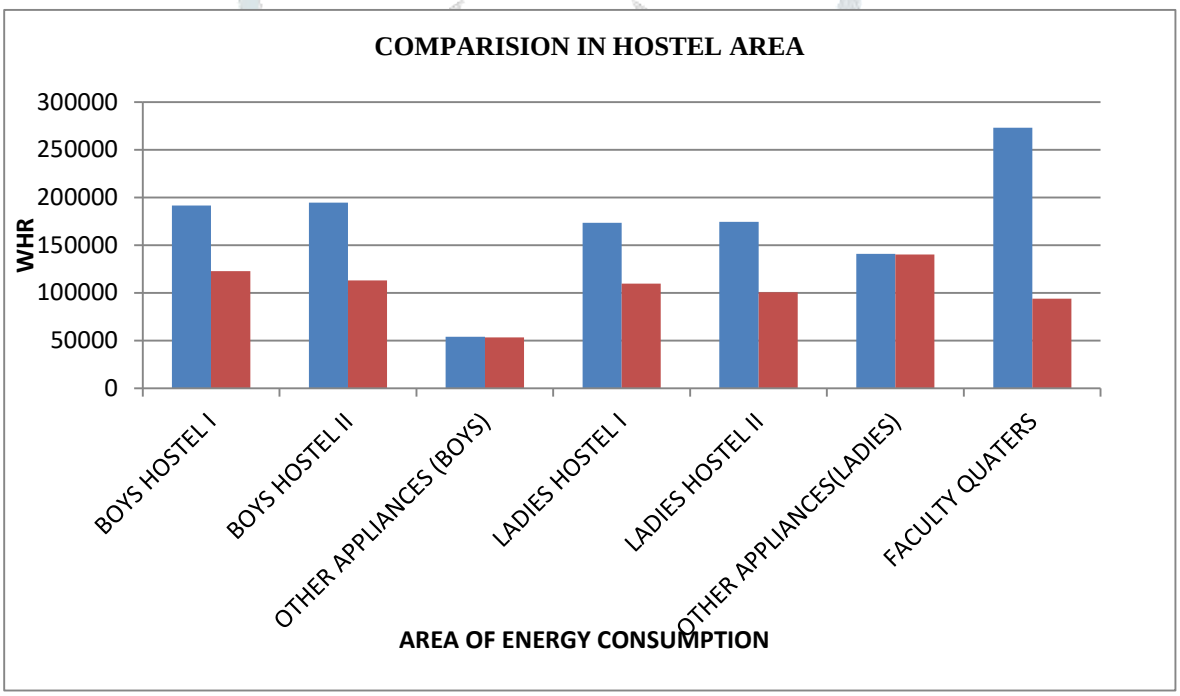

Fig. 11. Comparison of per day energy consumption at hostel area.

VI. ETAP ANALYSIS

Electrical Transient Analysis Program (ETAP) is the most powerful software which provides simulation, monitoring, analysis, control, optimization and automation of power systems. It offers best and most comprehensive solution of power systems that range from modelling to operation [11]. This software can also be used for real time management, load shedding and railway traction power. The single line diagram of the working area can be drawn in the ETAP software to do load flow analysis. This software uses Newton Raphson method to do load flow analysis.

A. ETAP Voltage Analysis: The single line diagram of the JNTUK – UCEV campus is connected on the ETAP software and places the suitable data values in each connected block. Then the load flow analysis on the ETAP software gives the voltage at each load block. This voltage output from ETAP software in fig 12.

B. ETAP Current Analysis: By connecting the single line diagram and by doing load flow analysis on ETAP software, the load current at each load of the campus is given in the fig 13. It shows the buses where the load is more on the campus.

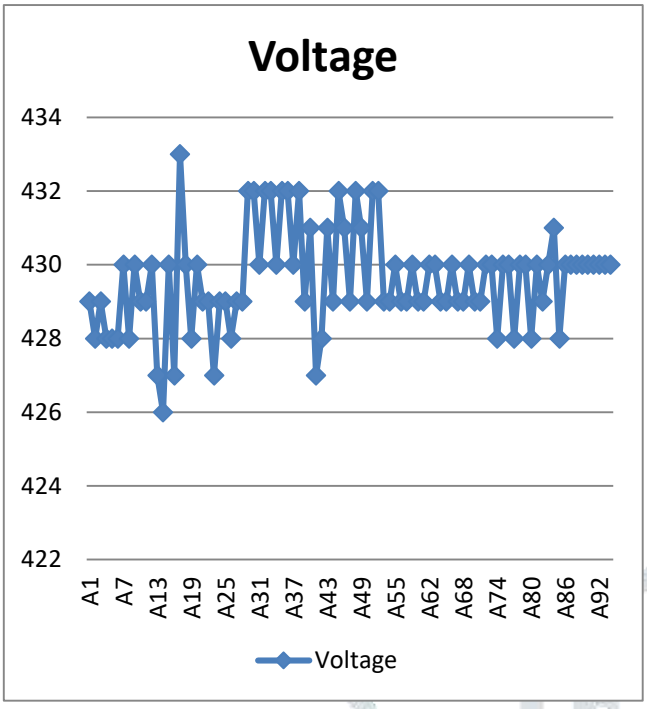

Fig. 12. ETAP load analysis without audit– Voltage.

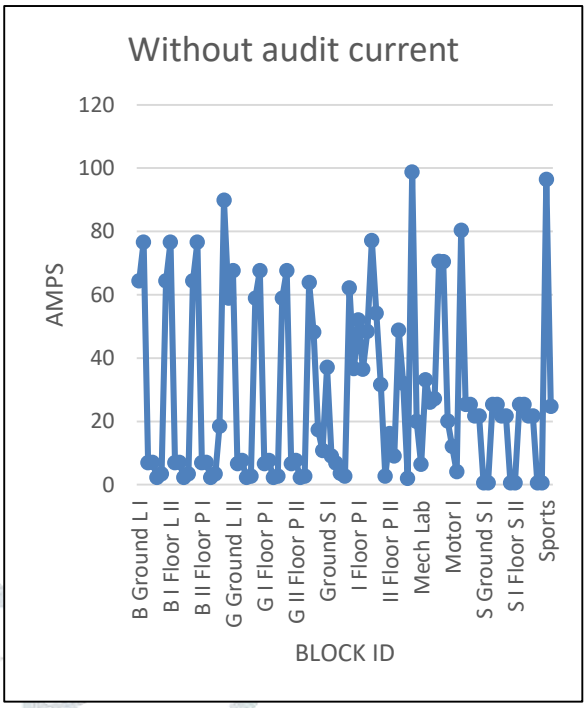

Fig. 13. ETAP load analysis without audit– Current

C. ETAP Analysis with investment:

By employing above said recommendations, and by connecting the single line diagram on ETAP software it is observed that the load on the Campus is considerably reduced. The current loading on the campus is shown in fig. 14.

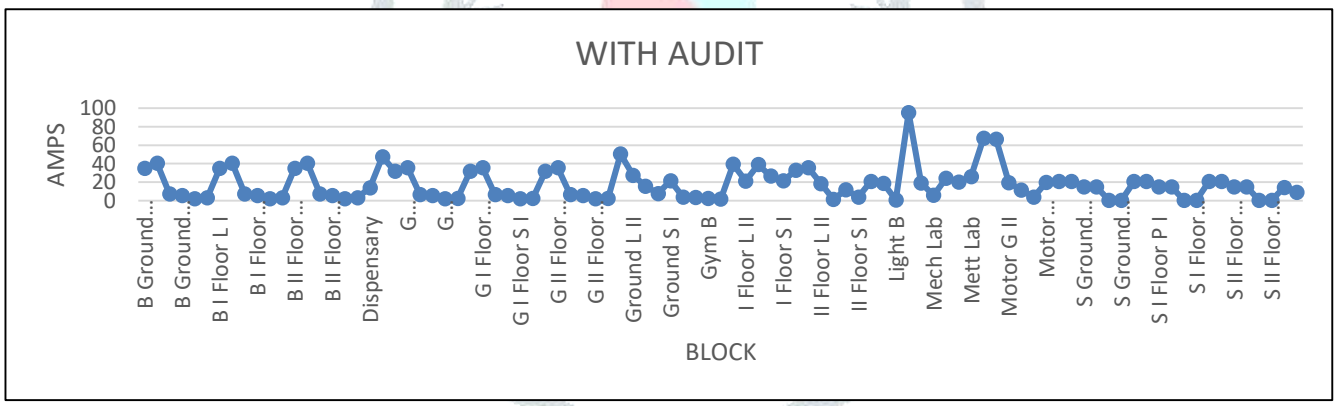

Fig. 14. ETAP load analysis with recommendations – Current profile

D. Comparative Analysis with ETAP:

Also the reduction in current loading can be observed by comparing current loading with and without audit in the following figure 16. It clearly shows the reduction in load at each block where the recommended suggestions are made[15].

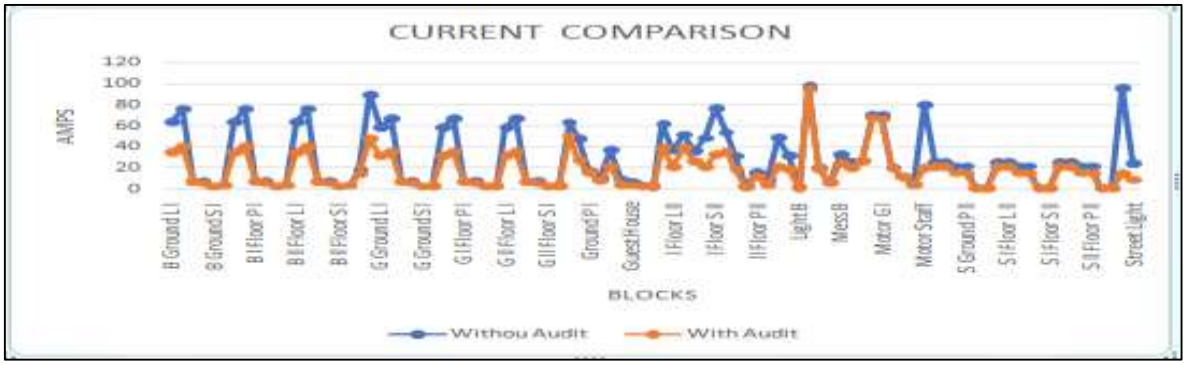

Fig 15. Comparison of current at loads with ETAP.

Also, we can analyze how the loading at low load and high load buses will be varying by comparing the respective buses loading with and without recommendations. This can be shown in the figures 16-17, which indicates the reduction in load at low load as well as high load buses.

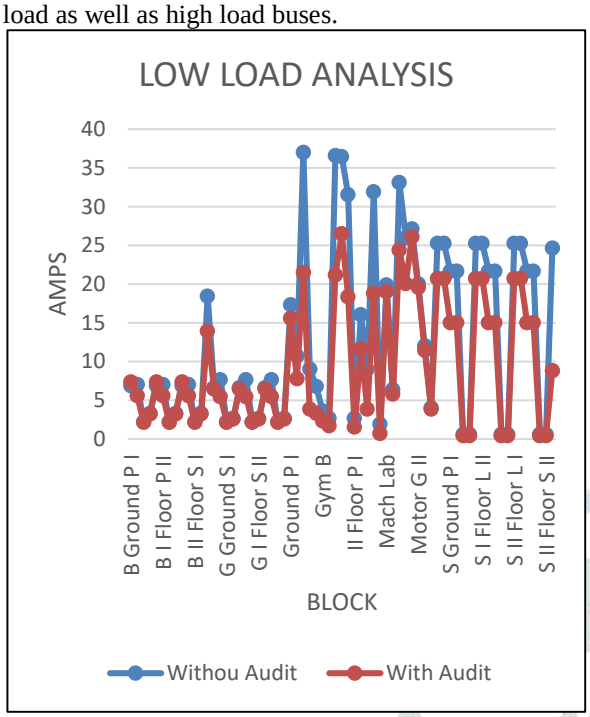

Fig 16. Low load analysis with ETAP

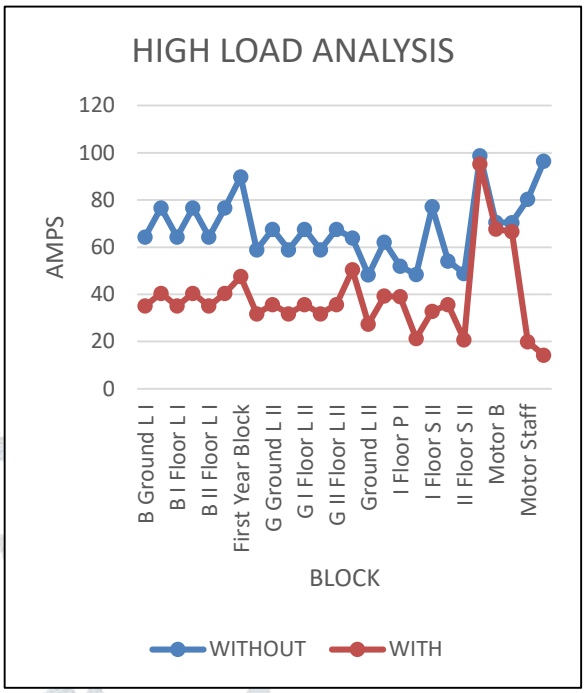

Fig 17. High load analysis using ETAP.

It is observed from the above figures that the load at the high load equipment is reduced majorly and there will be minor load reduction at low load equipment. The current drawn by different blocks have reduced so that the voltage at the load end and the power factor also has been improved.

VII. RECOMMENDATION WITH DG

After applying the above said recommendations, it is found that still 450 kW in college and 350 kW in hostel are connected to grid. If an Distributed Generator i.e., Solar Power Plant[15][16]is employed, it can make the whole campus off grid there by completely reducing the tariff which is given in table 11.

Table 11. Recommendation with DG

Solar panel capacity	200 KW
cost of 1 KWp	85000 Rs.
cost of 200 KW solar plant	17000000
Subsidy (30 %)	5100000
final investment cost	11900000
solar power generation per day	4 - 5 KW per day
no. of days	365
total energy produced	800 kWh per day
	292000 kWh per year

If all the above said recommendations including DG are employed in the campus, then we can achieve 100% tariff reduction. Also we can sell the remaining power from DG to the grid.

VIII. CONCLUSION

This paper presents the electrical energy audit of JNTUK –UCEV campus. Conservation of electrical energy is vital as it reduces the demand and power generated. The electrical energy consumption details of the campus were obtained. To conserve the electrical energy in the university campus suitable recommendations were made with and without investment. The payback period is around 7 years with all the recommendations. ETAP software is used to conduct load flow analysis on the university data. The analysis of the results with the recommendations clearly shows the reduction in electrical energy. Solar power generator is also

recommended to meet the load. If all the recommendations were made within the University campus we can achieve the 100 % reduction in tariff bill and the wastage in the electrical energy can be reduced completely**.**

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