Optimising Energy Dependency of VIT University

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Abstract— An energy audit is a systematic procedure to evaluate the existing energy consumption, to identify and develop an energy management program which defines the opportunities to decrease energy costs and to improve efficiency. Improving energy efficiency and conservation are essential to achieve environmental sustainability. Our University gave us enough motivation and a golden opportunity to learn and execute 'Energy Audit' of our campus, VIT University. We started with formation of team and proceeded with data collection, investigation, survey, individual inquiry and ended up with our innovative recommendations which will definitely boost up the self dependency in energy requirements and sustainability of VIT University if implemented.

Index Terms— Energy audit, Efficiency, VIT University,

1 Introduction

THE audit is designed to determine where, when, why and how energy is being used. Information gathered from the energy audit can be used to introduce energy conservation measures or appropriate energy-saving technologies. Energy audits identify economically justified, cost-saving opportunities that result in significantly lowered energy production and consumption costs.

Energy audit basically involves data collection and review; system survey and measurements; observation and review of operating practices; and data analysis.

It helps us in determining priorities with good return on investment. Starting with monitoring, it proceeds via fixing the basics, automating and ends with monitoring. Energy Audit is comprehensive evaluations of actual facility performance of energy uses and energy managing systems. It gives us detailed view of current energy consumption, potential to save energy and ideas of prioritizing the actions.

The audit was performed by collecting more detailed information about system operations and performing a more detailed evaluation of energy conservation measures identified.

2 Organization

VIT University, established in 1956, was founded in 1984 as a self-financing institution called the Vellore Engineering College which later received the University status in 2001.VITstretches over 350 acres (1.4 km2) of land with over 50.83 lakh sq.ft. built-up space at Vellore and encompasses five constituent colleges with 19,600+ students, over 1100 faculty members and 1275 administrative and supporting staff. VIT is the proud recipient of Exnora Green Campus Award for 2004. The Vellore Institute of Technology (VIT) University, Vellore is among India's one of the pioneer institutes known for its green, clean and eco-friendly campus.

Apart from the nine schools offering graduate and research programmes, the institute has a biomass based thermal power plant that supplies electricity to a medical facility, canteens, and men's and women's hostels that accommodates two-third of the student population. 20 hostels are located in VIT campus having individual room metering service along with swimming pool and gym facility. The vegetarian and non-vegetarian dining halls in the hostels serve dining facility with the help of a unique steam cooking facility.

VIT campus' building area is expanding. At present 14 buildings, each multi-floor is the Building area statement of the University. A fully furnished and air-conditioned guest house is available at VIT, spread over 11,000 sq.ft. and with staff quarters. The Central library, built to International Standards, centrally air-conditioned, Spreads over to Ground plus Six Floors with an area of 8490 sq.m. Conference facilities of international standards are incorporated into the VIT Campus with 10 Conference Halls and 4 Auditoriums having a total capacity of 3500. The Smart Classrooms ideal for small seminars and workshops with inbuilt hi-tech equipment adds up to the fine infrastructure.

The campus is a self-sufficient enclave with black-topped, well-lit roads. Its facilities include a Canteen, Food-court, 6 Power plants, a Post Office, a Bookstore, Copier facilities, Shopping complex6, Banks and ATMs. Standby power generators are provided in the Institute, hostels and the well-maintained gardens. A cable television facility is provided on each floor of each hostel. The institute has 16 stations gymnasia for men and a 12-station gym for women students, a men's eight lane 50m×25m and women's 25m×12m swimming pool, a Health center equipped with medical equipments with first aid centers at men's and ladies' hostel functioning round the clock.

Ever since the sharp rise in the cost of energy over the past few years there has been search of ways to curb energy consumption in an effort to reduce this drain and make the energy usage more productive. To determine the most efficient and most cost effective measures that can be taken, we conduct energy audit on buildings around campus. This report contains the results of the audit conducted on the VIT University Campus by our Team Greentrix. Our audit provides a clear understanding of energy consumption in our campus buildings and facilities which can be made more efficient by:

- Continuous improvement in production efficiency
- Identifying cost saving opportunities in energy efficiency

The study encompasses capture and dissemination of tacit operational knowledge, maintenance knowledge and forced outage knowledge which is essential for progress in performance.

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3 Scope of Audit

An energy audit is a preliminary activity towards instituting energy efficiency programs in an establishment. Energy Audit attempts to balance the total energy inputs with its use and services to identify all the energy streams in the systems and quantifies energy usage's according to its discrete function. Energy Audit helps in energy cost optimization, pollution control, safety aspects and suggests the methods to improve the operating and maintenance practices of the system and the implications of alternative energy efficiency measures.

The Energy Audit aims at:

- Identifying the quality and cost of various energy equipments and the overall energy profile.
- Assessing present pattern of energy consumption in different cost centers of operations.
- Relating energy inputs and production output.
- Identifying potential areas of thermal and electrical energy economy.
- Highlighting wastage's in major areas.
- Fixing of energy saving potential targets for individual cost centers.
- Implementation of measures for energy conservation and realization of savings.

The audit also focuses on what students can do to acquire better efficiency. At the last some recommendations have been suggested to VIT administration to improve self dependency in energy consumption in VIT campus.

4 Objectives of Audit

- To highlight the energy flow and its distribution.
- To suggest some green technological ideas which can be implemented in our campus.
- To reduce the wastage of energy and energy resources by optimising process and methodology.
- To move towards sustainable future and achieve self energy dependency.
- To assess the extent to which working of energy management system is efficient, effective and economical in VIT campus.
- To find areas where improper management is going on.
- To find techniques by which existing system can be made more efficient.
- Study of limitations,if any,in the optimal use of thermal and electrical energy.
- Collection of requisite data and analysis and identification of specific areas with potential for conservation of thermal and electrical energy.
- Undertaking broad cost benefit analysis in terms of savings in energy consumption per unit of production and pay-back period.

5 Audit Criteria

The following tasks compose the audit process performed:

1. **Site Review –** Walk through the facility to understand the equipment in place and how it is operated.
2. **Monitor key performance measures –** Install data loggers on key energy consuming equipment and through the facility to directly measure how the systems are performing.
3. Prepare a list of potential Energy Conservation Measures (ECMs) – Create a list of measures that potentially would be feasible for the campus based on the site reviews and experience with similar facilities.
4. **Conduct detailed engineering studies for specific ECMs –** Some of the ECMs require detailed technical or statistical information for proper analysis. For example, light level studies were conducted in the corridor areas to help determine to what degree lighting may be cut back without unduly interfering with the normal usage of the spaces.
5. **Prepare the final list of recommended ECMs and prepare the implementation plan -** Pare down the list of ECMs for implementation, based on the financial and environmental benefits, ease of implementation and outsourcing. Also include any other notes or concerns for items to look into based on the performance monitoring and site reviews.
6. **Measurement and verification –** Implement a plan that will verify energy savings and continue monitoring over time.

6 Method of Data Collection

1. **Individual Investigation :** We went to various buildings (hostels and academics blocks) and different worksites.
2. **Collection of Data through internet:** We have collected various related informations i.e durability, efficiency, MRP etc. for energy equipments and appliances through internet.
3. **Surveying:** We have prepared several questionnaires and distributed it among students to get general idea of hours of operation of various electric equipments.
4. **Data Collected from office of Director of Estates(VIT Vellore):** We have collected various data i.e Electricity bills for year 2012, specific area details of different buildings of the campus, total amount of biodegradable waste from office of director of estates,VIT Vellore.

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TABLE 1: Electricity Bills for the Year 2012

Electricity Bills for the Year 2012											
Month	University Campus	Hostel Campus	Total	E.B.Bill	Diesel Consumption	Diesel Gen	Diesel Bill	Total Energy	Rate/ Kwh	Rate/ Kwh
	Kwh	Kwh	Kwh	Rs	Litre	Kwh	Rs	Bill Rs	EB	Diesel
Jan_12	766547	634050	1400597	8001942	6449	19382	286142.13	8288084.13	5.71	14.76
Feb_12	933511	824080	1757591	9685366	22896	92331	1015895.5	10701261.52	5.51	11
Mar_12	972128	809850	1781978	9975717	81302	271351	3607369.7	13583086.74	5.6	13.29
Apr_12	1197760	1040420	2238180	14351662	71973	209702	3193442	17545104.01	6.41	15.23
May_12	1139968	1052870	2192838	14733096	29147	910033	1293252.4	16026348.39	6.72	14.21
Jun_12	728460	274680	1003140	7355911	33250	102093	1475302.5	8831213.5	7.33	14.45
JUl_12	951075	781790	1732865	12067377	37368	122359	1658018.2	13725395.16	6.96	13.55
Aug_12	1168602	1272690	2441292	16154235	76426	245492	3410128.1	19564363.22	6.62	13.89
Sep_12	1162563	1224040	2386603	15899965	69285	219301	3506513.9	19406478.85	6.66	15.99
Oct_12	1007474	1074820	2082294	14151512	783447	248255	3495843.1	17647355.14	6.8	14.08
Nov_12	784506	835670	1620176	11300019	71741	229471	3201083.4	14501102.42	6.97	13.95
Dec_12	500657	373780	874437	7041576	32844	92338	1465499.3	8507075.28	8.05	15.87
Total	11313251	10198740	21511991	140718378	1316128	2762108	27608490	168326868.4	6.61	14.19

7 ANALYSIS (CALCULATING ENERGY CONSUMPTION OF THE CAMPUS)

7.1 Energy consumed in transportation services of VIT Vellore Campus:

Number of vehicles operated from hostel campus=3
Number of trips by each vehicle=4
Distance covered in each trip=10km
Total distance covered by 3 vehicles=3*4*10=120km
Number of vehicles operated in University campus=4
Number of trips by each vehicle=10
Distance covered in each trip=4km
Total distance covered by 3 vehicles=4*10*4=160km
Total distance covered=120+160= 280km/day
Mileage of vehicles= 3km/liter
Diesel required per annum=280/3*295 (working days) =27533.3 liters/year
Energy required= Density* Volume* Calorific Value
= 0.832*27533.3*43.400=994194.4 MJ/year=276165 kWh/year
Amount spent on diesel = 43.95*27533.3=0.121 Crores/Year

7.2 Energy Consumed for Cooking Purposes in Hostel's Mess:

LPG gas consumption- 6 cylinders/900 students/day
Total LPG consumption (15000 students) = $6 * \frac{15000}{900}$

=100 cylinders=1900kg
Amount spent on LPG= Rs. 100*1593.9/day
Amount spent on LPG in a year=100*1593.9*295 (Students in campus) =**4.7 Crores/ Year**
Total energy consumed= 1900*46.1*295 MJ/Year = **7177514 kWh/Year**

7.3 Energy (AC/DC) Consumed by Electrical Appliances and Equipments:

We have collected electricity bills of the year 2012 and estimated total energy consumption by functioning electrical appliances and equipments as follows :
Yearly Diesel Consumption: 1316128 litre/Year
Yearly Energy Consumption (Through Generator) = 1316128 KWh
Yearly Electricity Consumption: 21511991 KWh

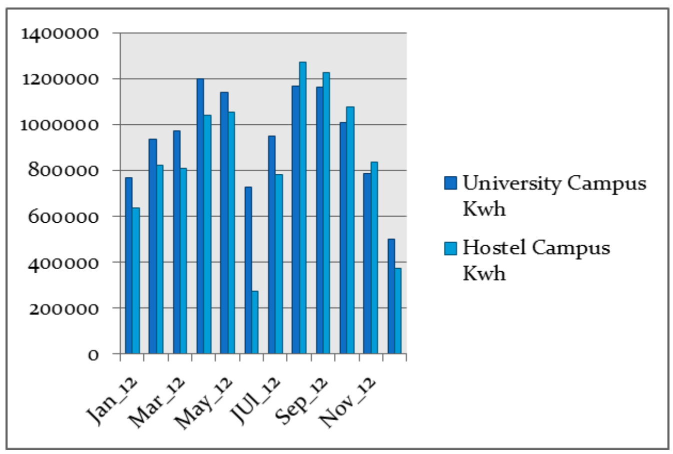

Fig. 1: Electricity consumption area-wise

- VIT has its own 8KVA substation connected from TNEB grid to convert 33KV in to 230V.
- VIT has installed capacitor banks at each of the 6 power houses to maintain power factor near to 0.99-1.00.
- VIT generates power from diesel gen-set when there is power cut at a cost of Rs 14.18/kWh as compared to Rs 6.5/kWh by TNEB grid.

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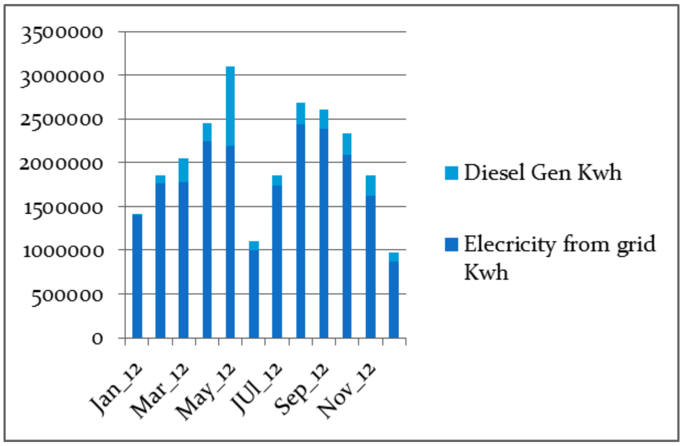

Fig. 2: Elecricity from sources

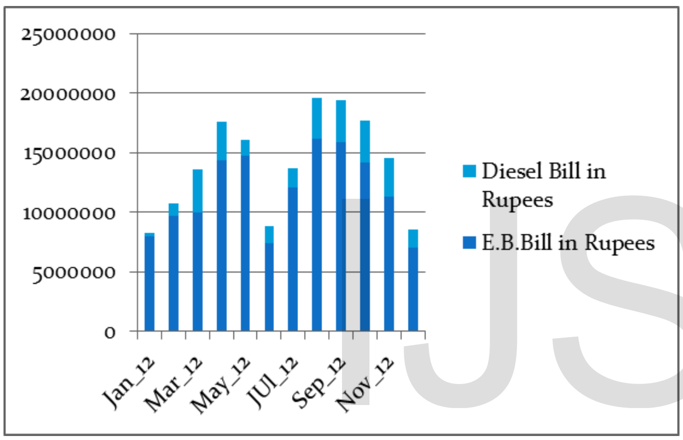

Fig. 3: Electricity bills

7 Contribution by VIT University Administration

We are thankful to our university for it's critical assistance and help in completing our assignment. VIT has provided us all the necessary information and data required in completing energy auditing assignment. It has permitted us for performing all the investigations, taking out the surveys and recording down all the specification and information required at various worksites. Also is has provided us guidance and support from academic and technical staffs. It was never possible to finish this project without indispensable support of our university.

8 Renewable Energy Application in VIT

- VIT has CO2 research and green energy technology center dedicated for research on solar energy, wind energy, small hydro power, bioenergy and fuel cell technology.
- VIT has installed many renewable energy operated plants some of the features are:
- 8.25kW Solar PV plant on CO2 research center rooftop
- 100kW (140kVA) generator driven by 80%producer gas-20% diesel engine
- Wind mill to pump water for sewage treatment plant
- B15 and B20 biodiesel blend operated bus
- Solar dish Stirling engine of 10kW capacity
- Electrical vehicle for staff transportation
- Solar PV panel operated street lights at some of the places.

9 Recommendations / Analysis

After setting up our audit panel meeting and heavy discussions, we have focused on each and every corner of energy consumption and generation. Each of the members have suggested their ideas and innovations and based on feasibility, our recommendations have been described as per following:

9.1 Scheffler Dish(CSP)-Central Concentrated Solar Steam Generation Plant:

TABLE 2: Average Global and direct radiation at VIT, Vellore from: 8am-5pm (9hrs/day)

Month	Direct Radiation (W/m2)	Global Radiation (W/m2)	Date	Day
January	384.2781	531.8981	17	17
February	444.0536	603.9007	16	47
March	477.5095	667.1116	16	75
April	412.8280	618.2313	15	105
May	342.7739	554.0629	15	135
June	156.4800	360.5772	11	162
July	148.2476	446.8067	17	198
August	158.1210	478.7230	16	228
September	295.9510	559.9014	15	258
October	400.8513	608.1172	15	288
November	390.2810	544.0623	14	318
December	379.1619	530.4342	10	344
Average	332.5447	541.9855	-	-

At Tirupathi CSP Plant:

$Installed\ area = 9.2 * 106 = 975.2\ m^2$

Mass of seam= 4,000 kg/day

Steam pressure=10 kg/cm^2

$h_{fg} = 2013.2\ kJ/kg$

$$Energy\ required\ to\ produce\ steam = mC_p(T_{out} - T_{in}) + h_{fg}m$$

$$= 4000 * 4.18(180 - 25) + 2013.2 * 4000$$
$$= 10644.4\ MJ/day$$

In VIT University:

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Solar thermal energy available per day
$= 541.9855 * 9 * 3600\ J/m^2$
$= 17.56\ MJ/m^2$
Average Daily Solar Radiation= $4.8778\ kWhr/m^2$
LPG gas consumption- 6 cylinders/900 students/day
Total LPG consumption (15000 students)= $6 * \frac{15000}{900}$

=100 cylinders=1900kg
Amount spent on LPG= Rs. 100*1593.9/day
Amount spent on LPG in a year=100*1593.9*295 (Students in campus) =4.7 cores/ year
Total energy consumed= 1900*46.1 MJ/day = 87590 MJ/day
Amount of steam required at 180ºC and 10 kg/cm^2
m (4.18(180-25)+2013.2)=87590
m=32915 kg/day
Area of collectors required to produce steam= 32915*945.2/4000 m^2=7777.8 m^2
No. of Scheffler concentrators (9.2m^2 each)= 7777.8/9.2 = 845.41~ 850
Cost of Installing the plant with 5 years maintenance= 1.1*8.22 cores =9.05 cores
Payback period= 9.05/4.7 years =2 years

9.2 Installing Bio Digester for Electricity production from sludge from sewage water treatment plant:

There are more than 15000 students living in VIT hostels. Approximately 3220 kilo liter sewage water is treated in 8 sewage water treatment plants which generate about 1000 kg dry sludge per day.

We propose to produce bio gas from the dry sludge and use the same biogas in 100% gas engine coupled with generator to produce power.

Amount of dry sludge generated= 1000kg/day
Amount of sewage=3.220 MLD
Amount of sludge produced after treatment= 1.7*10^6 ltr/12hrs
Retention time= 30days
Volume of digesters required= 102000 m^3
Average amount of biogas produced= 14419 m^3/day
Calorific value of Biogas= 6 kWh/m^3
Total energy available from biogas= 6*14419 kWh/day= $86.51\ MWh/day$
Efficiency of biogas driven engine-gen set=30%
Electricity available from biogas= 25900 kWh/day
Annual energy available=25900*365=9453500 kWh/year
Estimated savings per annum= Rs 25900*5.5*365/day =5.19 crores/year

9.3 Installation of Solar PV Panel:

VIT has unique feature to have pathways along with main road for pedestrians. In order to prevent them from bright sunshine these pathways are covered with steel sheets. Our team has come up with an idea to install solar PV panels on all the pathways which lies in north-south direction. This proposal will not require any extra land as we are going to install PV panels on shaded pathways moreover PV panels will absorb energy from sunlight and prevent more heating of steel shades which eventually help pedestrians to feel more comfortable and cool to walk down the shade. We recommend to installs PV panels directly connected to load through inverters. Battery storage is not recommended due to high battery cost.

From Appendix-I
Area of pathways in East-west direction=19355 m^2
Available roof top area=49198.856 m^2
Total area= 68553.856 m^2
From Appendix-II
Average Daily Solar Radiation $= 541.98\ W/m^2$(From 8AM: 5PM)
Average Daily Solar Radiation $= 4.8778\ kWhr/m^2$
Total energy received= 19355*4.8778 $kWhr/m^2 = 94410\ kWhr$
Total power available= $68553.856 * 541.98\ W = 37.15\ MW$
Assuming 13.5 % efficiency of solar PV panels
Power generated= 37.15*0.13 MW= $5.0\ MW$
Electricity produced =45000 kWh/day
Total electricity produced per annum= 45000*365=16425000 kWh/year
Cost saved at 5.5rupees per unit= 5.5*45000/day= $247500/day$
Total saving per annum= Rs. 247500*365/year =9.03crore/year
Total capital cost= Rs. 90000000/MW
Total installation cost= 900*5 =45.0 crore
Payback period= 45.0/9.03=4.9~ 5 years

9.4 Application of 'Presence detectors' in Toilets/Washroom:

About 15,000 students live in VIT hostels and more than 20,000 students attend classes in academic buildings. There are about 356 washrooms in VIT campus all around. Lights are kept switched on for whole night as well as some time in day also. This causes a huge wastage of electricity when no one is using washrooms.
We propose to install presence detectors in each washroom area. The detector will be kept switched off in day time and on in night time. Whenever a person will enter the washroom it will detect and switched on the lights and when no one is

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there in washroom area it will switched off the lights. This will help in saving a huge amount of electricity which is being wasted in night time when no one is utilizing it.

Installation of presence sensors in washrooms
Installation cost of each sensor= Rs. 500/-
Number of sensors to be installed= 356
Total installation cost of sensors= 356*500=Rs.178000
Total energy consumed= 2095.16 kWh/day
Energy savings due to installation of sensors= 0.3*2095.16=628.5 kWh/day
Estimated energy savings=295*628.5 =185407.5 kWh/year
Estimated savings of energy= Rs. 3457/day
Total saving in a year= 3457*295 (working days) =0.102 crores/year
Payback period= 178000/3457=52 days~ 2 months

Our Recommendation Can Be Summarized as:

1. Installation of light sensors and timers in solar powered street lights
2. Installation of light sensors in library
3. Installation of central solar vapour absorption (working on LiBr-water, absorbent-refrigerant solution) air-conditioner in library
4. Replacement of 40W tube lights by 18W CFLs in washrooms
5. Replacement of 11W night lamps by 3W LEDs
6. Installation of presence sensors in washrooms
7. Installation of solar PV panels on roof-tops and pathways
8. Installation of central concentrated solar steam generation plant using Sheffler concentrators
9. Installation of biogas plant to produce electricity from sludge from sewage water treatment plant.

10 Conclusions

After investigating and analyzing all the consumption as well as generation aspects and trends of energy in VIT University, we have concluded, synthesized and then recommended our ideas which will definitely boost up the sustainability and self dependency in energy requirement of our campus if implemented.

In brief, our recommendations can bring up following changes if implemented:

1. Reduction in energy resources wastage
2. Application of green technology
3. Sustainabile future development
4. Minimisation in pollution
5. Self dependency in energy requirement
6. Effective energy management

As per our analysis and calculations, we have structured energy consumption and generation details as follows:

TABLE 3: Energy Consumption Per Annum

Energy Consumption Per Annum		
Category	**Energy consumed**	**Amount in Crore**
Electricity form grid	21511991 kWh	14.07
Electricity form diesel gen-set	2762108 kWh	2.76
LPG for cooking	7177514 kWh	4.70
Diesel for transport	276165 kWh	0.121
Total	**31727778 kWh**	**21.65**

TABLE 4: Energy Generation Per Annum

Energy Generation per Annum		
Category	**Energy produced**	**Amount in Crore**
Concentrated Solar power	7177514 kWh	4.70
Solar PV Panel	16425000 kWh	9.03
Biogas from sewage treatment plant	9453500 kWh	5.19
Energy saved by presence sensors installation	185407.5 kWh	0.101
Total	**33241421.5 kWh**	**19.022**

At present total investment of our campus on energy consumption is Rs 216536526. If university implements my idea, energy generation will hike up to 19.02 crores. This will distinctly lead to potential saving of 19.02 crores with reduction in wastage of resources and pollution outstandingly.

Standard Data Used

1) Steam Tables
2) Heat and Mass Transfer Data Book
3) Solar Radiation Data Book
4) Pshychrometry Chart

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