ENERGY AUDIT REPORT

for

GURU NANAK KHALSA COLLEGE FOR WOMEN

MODEL TOWN,

LUDHIANA

PREFACE

Data collection for energy audit of Guru Nanak Khalsa College for Women, Model Town, Ludhiana was carried out by the team during December,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 were of primary concern. Beyond simply identifying the energy consumption pattern, this audit sought 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 analysis was carried out with software MS-Excel. The report compiles a list of possible actions to conserve and efficiently access the available scarce resources and their saving potential was also identified. We look forward towards optimization 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 interviews of consumers.

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1. INTRODUCTION

Guru Nanak Khalsa College **f**or Women, Model Town, Ludhiana is a premier Post Graduate Institute -popularly known as GNW. Guru Nanak Khalsa College for Women, Model Town, Ludhiana endeavours to cater to the needs of the most vital section of the society- the women folk. Established in the year 1969, in commemoration of the 500th birth anniversary of Guru Nanak Dev ji, it has emerged as one of the leading institutions of higher education for various academic and co-curricular activities. The college is affiliated with Panjab University, Chandigarhfor Degree and Post Graduate classes in MA (Eng.), M.Com, PGDCA and PGDMC.It imparts education in the streams of Humanities, Commerce, Business Administration (BBA), Computer Applications (BCA), Honours in English, Punjabi and Commerce upto Graduation level, Add-on Courses such as Functional English/Communicative English and Fashion Designing.

Situated in Model Town, the campus provides best facilities to the students. Its magnificent building, comprehensive infrastructure, state of the art Library, Hostel within the campus and Home Science, Fine Arts and Computer Labs along with an effective Placement Cell, offer an oasis of Learning and Opportunities galore for the students of 21st Century. The college takes pride in inculcating the spirit of education, self-confidence and progressive thinking.

1.1 OBJECTIVE OF ENERGY AUDIT EXERCISE

The objective of Energy Audit is to promote the idea of Energy Conservation in the Campus of Guru Nanak Khalsa College for Women, Model Town, Ludhiana. The purpose of the energy audit is to identify, quantify, describe and prioritize cost saving measures relating to energy use in the Hostels, Departments and Institute Central Facilities.

The work eligible for Energy Audit Study should be directed towards:

- Identification of areas of energy wastage and estimation of energy saving potential in Hostels, Departments and Institute Central Facilities.
- Suggesting cost-effective measures to improve the efficiency of energy use.
- Estimation of implementation costs and payback periods for each recommended action.
- Documenting results & vital information generated through these activities.

• Identification of possible usages of co-generation, renewable sources of energy (say Solar Energy) and recommendations for implementation, wherever possible, with cost benefit analysis.

1.2 ANALYSIS OF AREA OF USE

Identifying where energy is used is useful because it identifies which areas the audit should focus on and raises awareness of energy use and cost. The results of the analysis can be used in the review of management structures and procedures for controlling energy use.

Analysis of energy use can be done by installing sub-meters in different plant locations to pinpoint actual energy usage per area. This is a good source data for allocating energy use. The plant manager can also list all equipment used and the corresponding operating hours. With this information, spreadsheet can be created and charts useful for analysis may be generated.

Important Points to Consider When Collecting Load Data:

a. **Usage** – The usage of the equipments in terms of hours per day and days per year iscollected from key persons in Hostels, departments etc. It is important to ensure the accuracy of this data because much of the potential for energy savings lies on wise allocation of the equipment’s operating hours.
b. **Actual power consumed** – Actual power consumption is measured by Wattmeter.
c. **Supplementary Information –** Some other supplementary information are also collectedsuch as state of insulation in case of ACs or availability of natural light etc.

1.3 IDENTIFICATION OF TARGET AREAS

Opportunities for energy savings can range from the simplest, such as lighting retrofits, to the most complex such as the installation of a solar PV grid connected plant. After the preliminary identification of opportunities, more time should be spent on those which have shorter payback periods.

1.4 COST BENEFIT ANALYSIS

The identified energy conservation opportunities should be analysed in terms of the costs of implementing the project versus the benefits that can be gained. Say for example, if we wish to install a heat plate exchanger to recover waste heat, we must calculate the total cost of installation and compare that with the savings derived from recovering waste heat.

1.5 ACTION PLAN TO SET IMPLEMENTATION PRIORITY

After passing the cost benefit test, an action plan should be developed to ensure that the opportunities identified are implemented. The action plan should include all the major steps for implementing the opportunity as well as the people responsible. Furthermore, there should be a plan for monitoring the results.

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2. ENERGY AUDIT METHODOLOGY

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

1. **Data Collection** – In preliminary data collection phase, exhaustive data collection wasperformed using different tools such as observation, interviewing key persons, and measurements.
2. **Data Analysis** - Detailed analysis of data collected was done using MS-Excel. The databasegenerated by MS-Excel was used for producing graphical representations.
3. **Recommendation** – On the basis of results of data analysis and observations, some stepsfor reducing power consumption without affecting the comfort and satisfaction were recommended along with their cost analysis.

2.1 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 was performed at all the departments, academic centers, hostels, and other supporting entities such as library, computer centre etc.

Following steps were taken for data collection:

- The team went to each department, centre, hostels etc.
- Information about the general electrical appliances was collected by observation and interviewing.
- The power consumption of appliances, rated power was used (CFL for example).
- The details of usage of the appliances were collected by interviewing key persons e.g. Warden (in case of hostels), caretaker (in case of departments) etc.
- Light intensity was measured using luxmeters at the places where light intensity was either very low or very high.
- In case of Air Conditioning, insulation was checked by visual inspection.

Approximations and generalizations were done at places with lack of information.

2.2 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 observations obtained was used to obtain the power consumption pattern and also to get the information about the points where electric power is wasted.

2.3 RECOMMENDATION

Energy as well as cost analysis of different appliances were performed and recommendations were made based on the capital cost recovery time.

Following were the steps involved in this process:

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

If capital cost recovery time is less than the product life, the move can be supported. Some other recommendations were also made which are based on lighting intensity, AC insulation etc.

3. **ANALYSIS OF POWER CONSUMPTION**

With the use of MS-Excel, we have analysed the power consumption by equipment, application as well as location. Here is the summary of the analysis presented in form of charts for better understanding.

3.1 OVERALL CAMPUS

There are 41 classrooms,12 laboratories, 5 staff rooms, one auditorium, one central canteen, one hostel and supporting infrastructures like central library, and administrative block (Main Building) in Guru Nanak Khalsa College campus. The campus has a connected load and contract demand of 174.203kVA. The consumption detail for last 12 months are shown graphically below.

The first figure shows the variation of electricity bill comparison for 2019-20 (shown in red) and 2020-21(shown in blue).

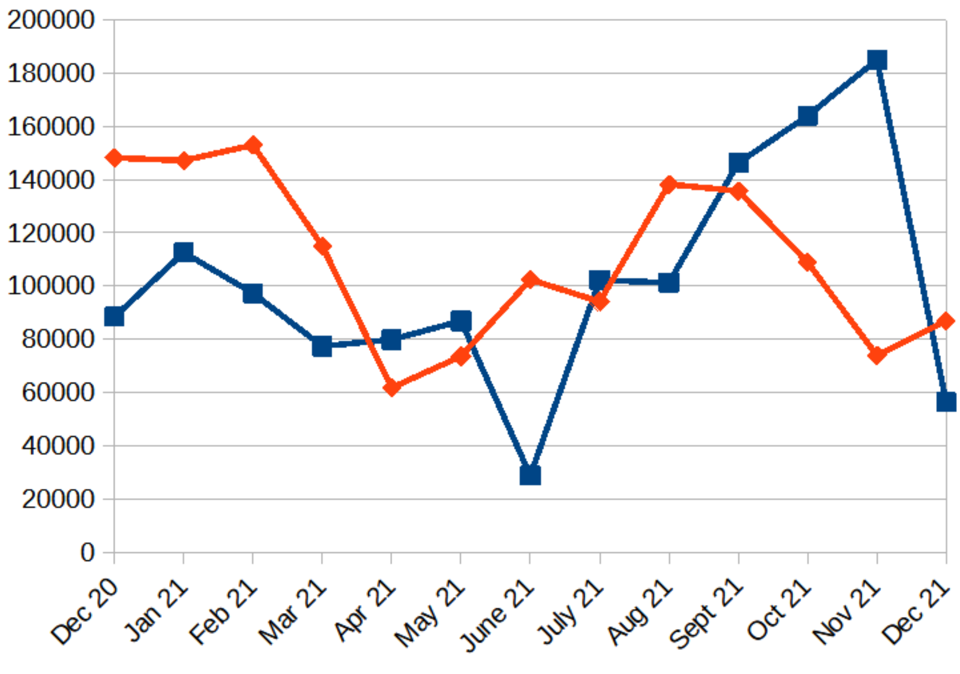


Fig 3.1 Trend line for bill amount variation

The following graph shows the trend line for maximum demand in 2021

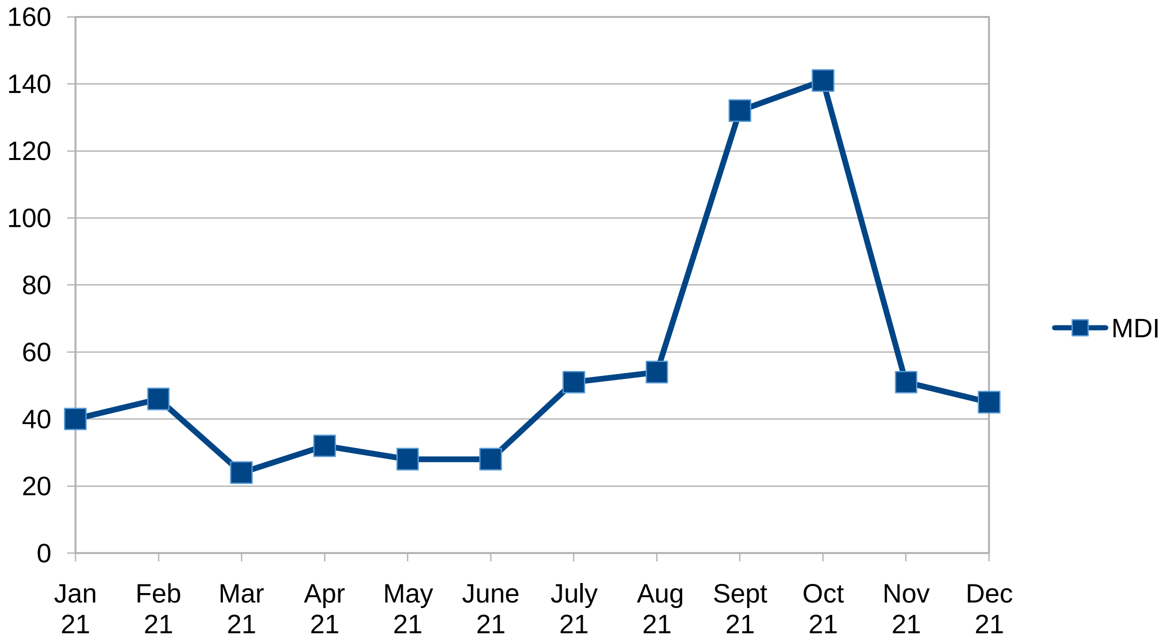


Fig 3.2 Trend line for MDI

The following figure shows the trend line for kWh consumption.

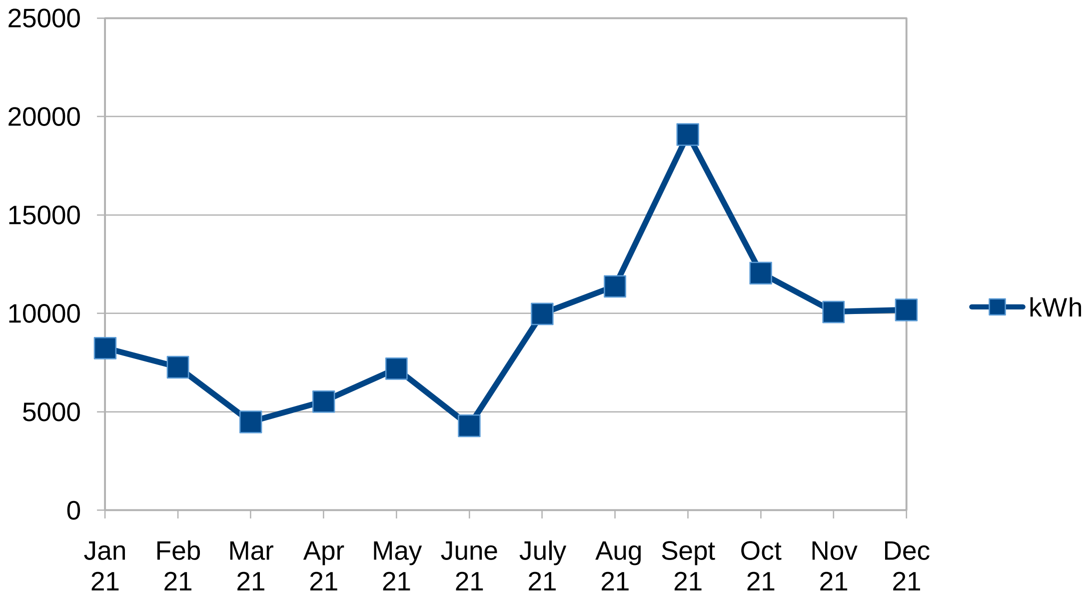


Fig 3.3 Trend line for kWh consumption

The following figure shows trend line for kVAh consumption

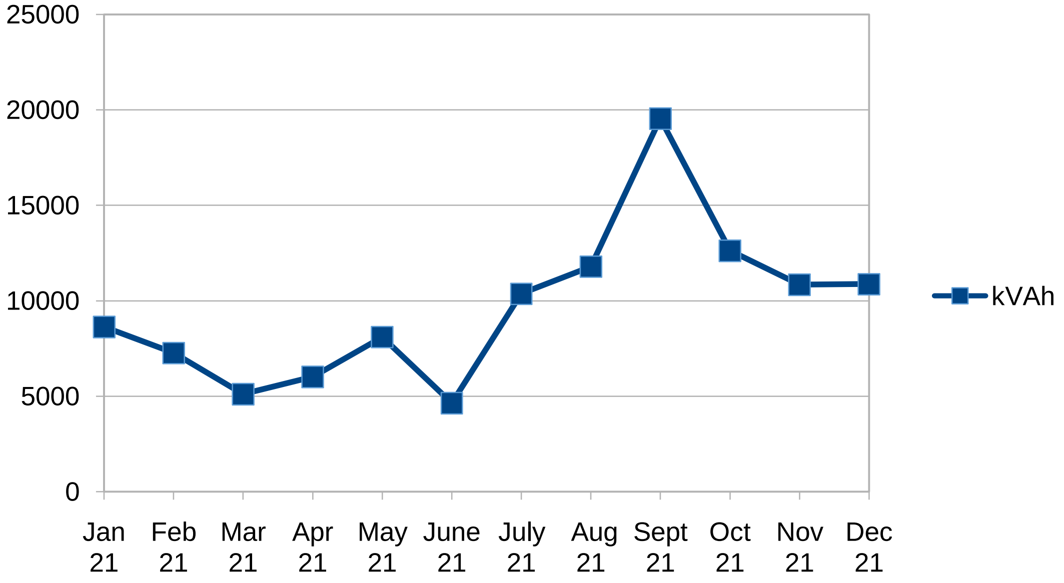


Fig 3.4 Trend line for kVAh consumption

From the above trend lines, it is seen that power consumption is peaking in month of September reflected in bills for month of October. The power factor is hovering around 0.90.

3.1.1 LOCATION WISE ANALYSIS OF CAMPUS:

The location wise distribution of power consumption in the campus has been shown in the following chart

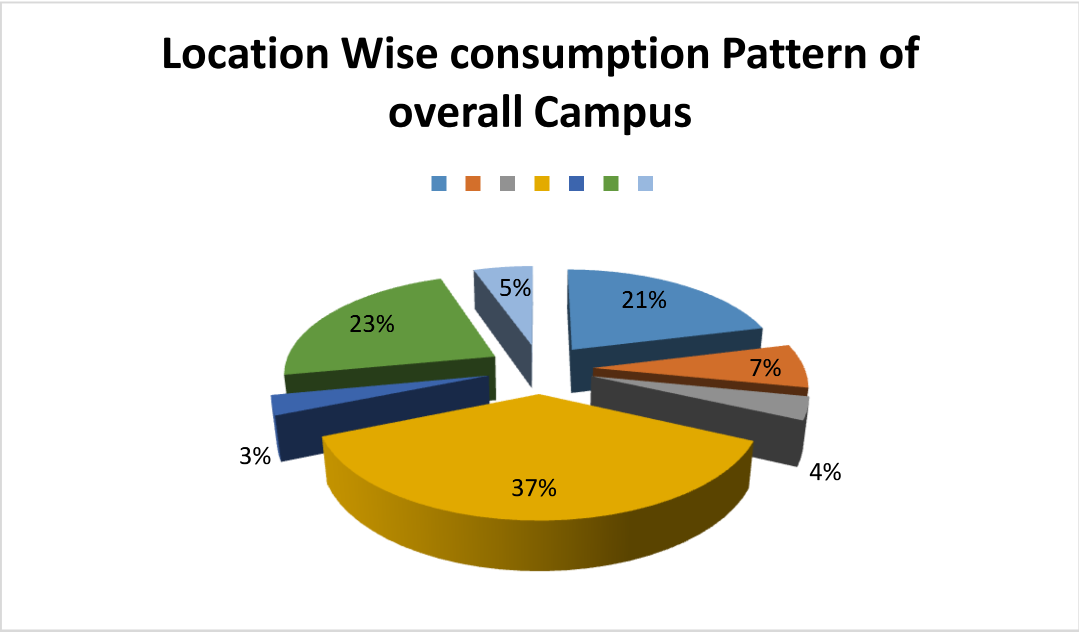


Fig 3.4 Location wise consumption pattern

As the chart suggests, major power consuming areas are central facilities (23%) and rooms in hostels (37%). After that there are laboratories (21%), classrooms (7%), toilets (5%), other offices (4%), canteen (3%).

Laboratories with 21% share in power consumption are very important area to focus for improving energy efficiency of the campus. In case of computer labs, wise use of computers and ACs is required to reduce the consumption. In other labs also, wise use of lighting and other appliances can largely reduce the consumption.

Rooms in hostels are major contributor to energy inefficiency due to poor practices. Also, for any replacement of old light fittngs, it is advised that LED tube lights should be used for lighting and star rated/BLDC fans should be used. Corridors and toilets are the areas where automation through use of sensors can be used to reduce the consumption largely.

3.**1.2 APPLICATION WISE ANALYSIS OF CAMPUS:**

Application wise analysis of overall campus has been carried out to find out the application areas with relatively higher power consumption. The results of the application wise analysis of power consumption in Guru Nanak Khalsa College for Women campus have been summarized in the following chart

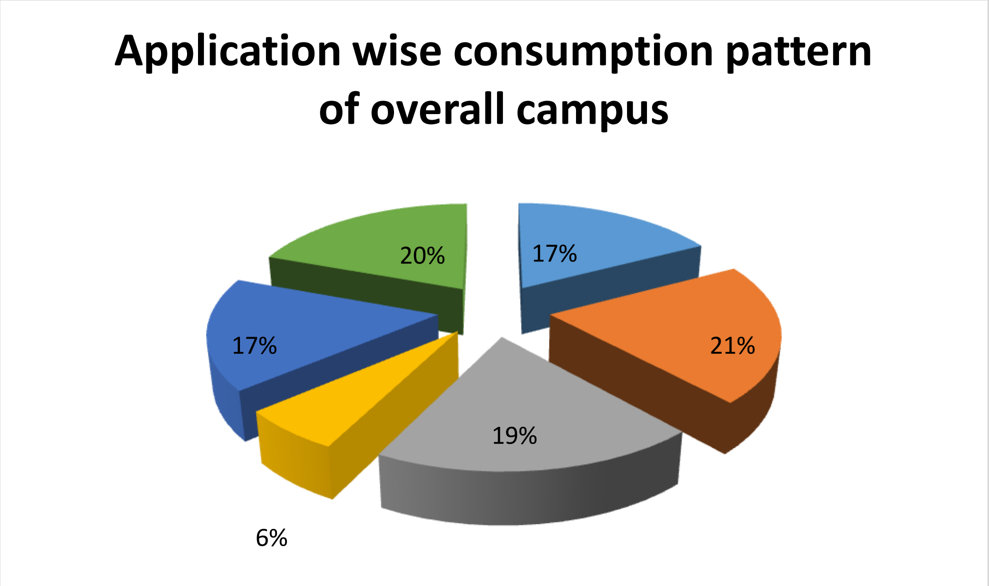


Fig 3.5 Application wise consumption pattern of overall campus

It's quite clear from the chart that maximum power is used in comfort applications (16%) such as room coolers, air conditioners, room heaters etc. To reduce the consumption in these applications, awareness about the energy conservation is very important and effective step.

Lighting with 21% of total power consumption is an application where energy efficiency can be achieved very easily by replacing old appliances by new efficient ones.

Office applications include computers, printers, scanners, Xerox machines etc. and contribute as high as 17% of total consumption. Replacing CRT monitors by LCD monitors can drastically reduce consumption of this application area.

Air circulation appliances (fans) having share of 17%, are also among major culprits in energy inefficiency.

Washing/bathing/cleaning include geysers, water coolers, water purifiers etc. accounting for 6% of total consumption.

Others include various load on power plugs which has a share of 20% of load.

3.1.3 EQUIPMENT WISE ANALYSIS OF CAMPUS:

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

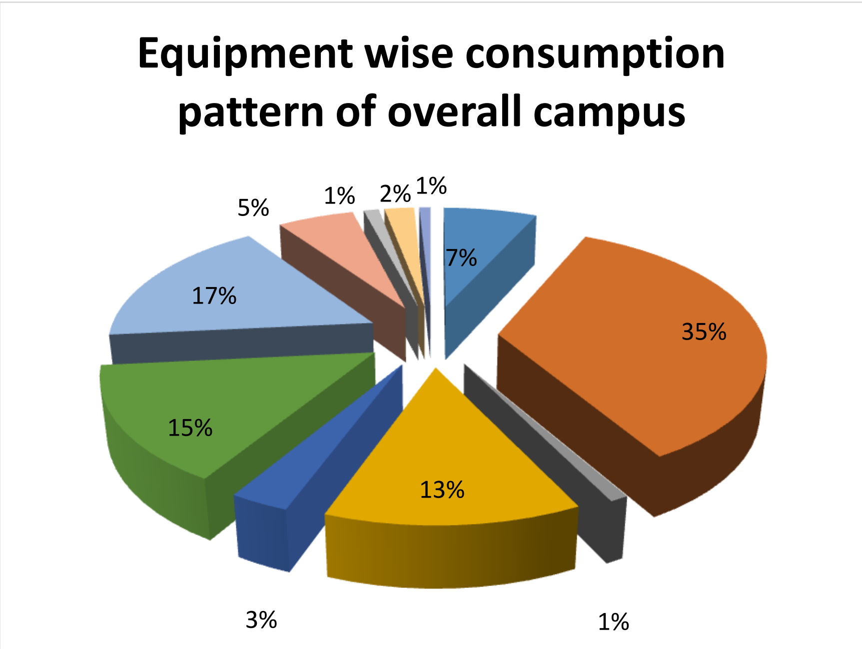


Fig 3.6 Equipment wise consumption pattern of overall campus

AC consumes 17% of total power. For lighting, dominant appliance is the conventional Ballast[Choke] tube light with 13% share and relatively efficient electronic Ballast[Choke] tube lights and T5 lamps have negligible share. CFL & LEDs have 3% share in total power consumption.

Computers also have a contribution of 15% to total power consumption.

Resistance regulated fans have 42% share (35% new fans and 7% old fans) and electronic regulated fans and efficient wall fans have negligible share in total power consumption.

Geysers with 5% share in total consumption are another significant contributor. Water coolers (2%) and refrigerators (1%) and washing machine(1%) are other significant appliances.

3.1.3.1 Classrooms

The college has 41 classrooms having142 FTLs including a very few <15 LED baton lights and 186 fans. The following pie chart shows the energy usage of fans viz a viz FTLs.

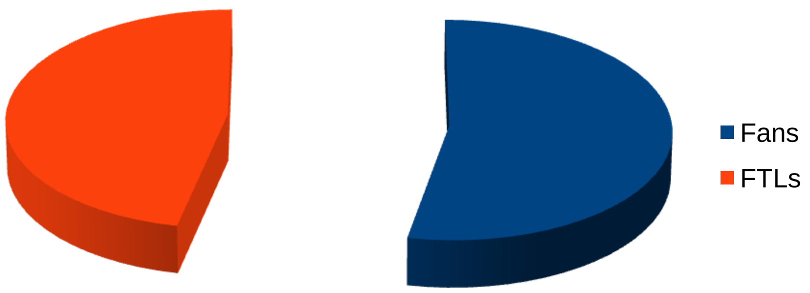


Fig 3.8 Equipment wise energy consumption in classrooms

3.1.3.2 Labortories

The institute has 14 different laboratories including the computer laboratories and one store. The total number of fans is 56 and FTLs is 150(approx.) including mirror optic fittings installed in computer labs, 5 exhaust fans, 8 wall fans, six LED lamps, one pedestal fan, 2 split ACs and 3 window ACs. The energy consumption distribution is as shown below:

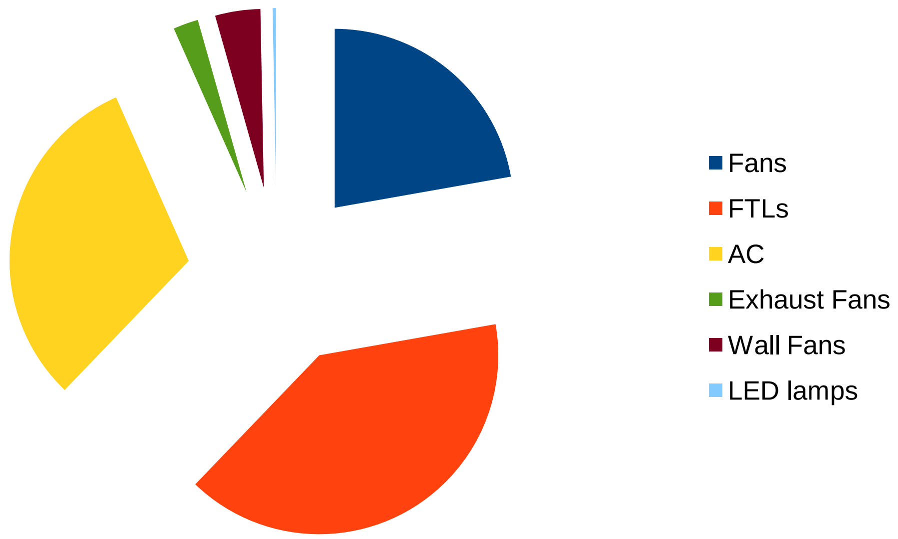


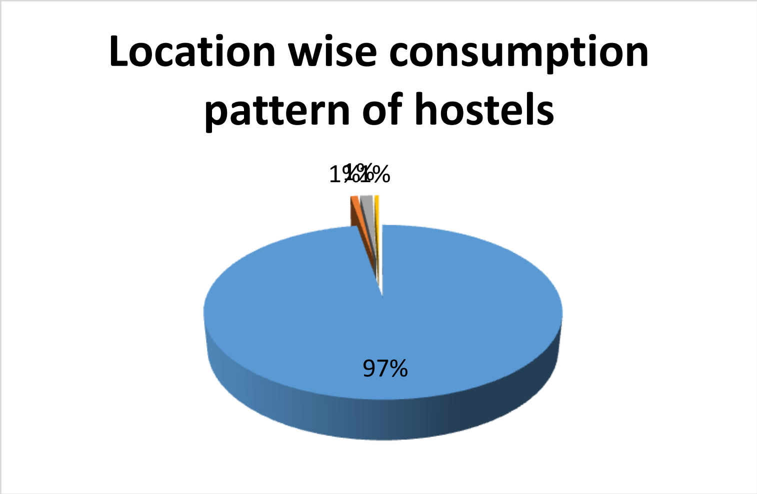
Fig 3.9 Equipment wise energy consumption in Laboratories

3.2 HOSTELS

There are in one hostel in Guru Nanak Khalsa College for Women. Most of the rooms are three seaters. In three seated rooms, two tube light and two ceiling fans have been provided. In addition, hostel has a mess.

3.2.1 LOCATION WISE ANALYSIS OF BUILDINGS:

The location wise analysis of all buildings done together suggests that maximum power consumption after rooms is in toilets. The reason is mostly poor practices. It is a general complaint of all supervisors that students DO NOT switch off the geyser after use. High consumption of mess is not a surprise as they use a number of other appliances in addition to general appliances in their kitchen.



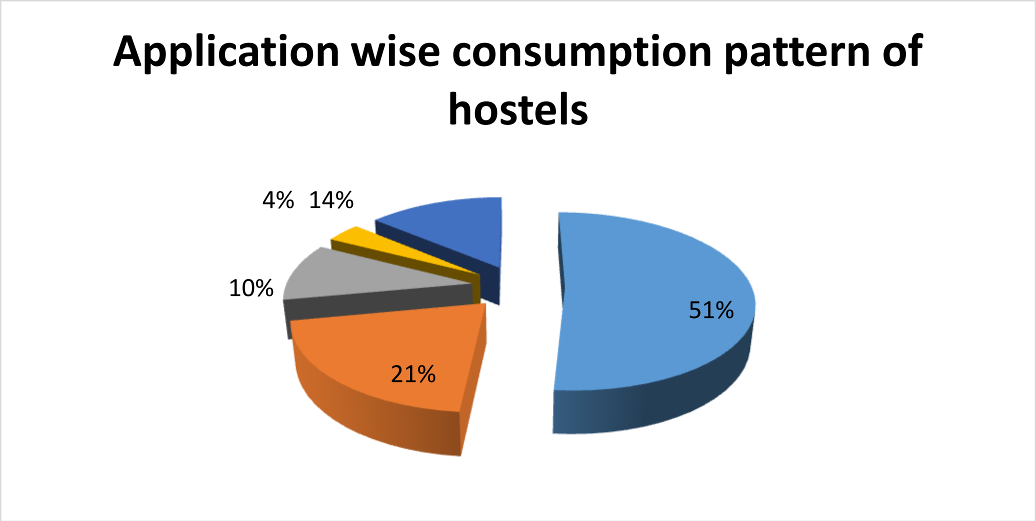
The rooms, consuming 97% of total consumption, have major role in reducing total energy consumption, just by using better practices. Some students don't switch off the lights and/or fans even when they are not in room. Most students keep their computer/laptop in standby mode all the time. Lots of power is wasted due to these poor practices.

Toilets are also a major area to focus upon, from energy conservation point of view. Power consumption here can largely be reduced by simply using geyser a little more wisely. In lighting of toilets also, there is large potential of saving by using automation so that the light is not switched on all the time.

Mess, though having smaller share in power consumption than above two, have large potential for saving electric energy. Motion sensors can be utilized to automatically switch off the lights when there is no motion in the corridors. Messes are more or less using electricity wisely and have very low potential for reducing energy consumption (except in the case, LPG replaces electricity completely for cooking purpose.)

3.2.2 APPLICATION WISE ANALYSIS OF HOSTELS

Application wise analysis helps to pinpoint the application areas to attain maximum savings with minimum efforts. Application wise analysis of hostels indicates that air circulation consumes more than 50% of the total power.

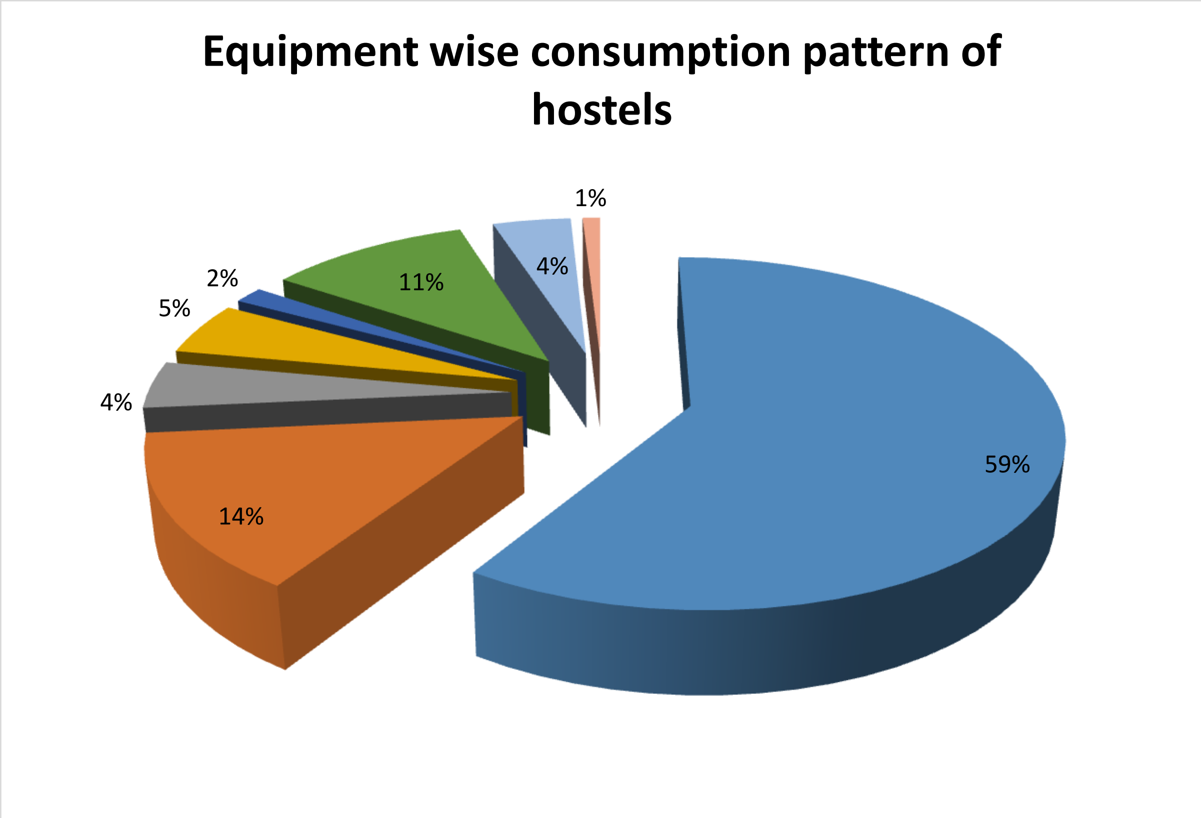


Washing/Bathing/Cleaning comprises of geysers, washing machines etc. Here energy efficiency mostly requires good practices.

Then are the air circulation comprising of fans, ACs and coolers etc. In this category, replacing old appliances by new ones can be very helpful to energy efficiency. For example, resistance regulators of fans may be replaced by efficient electronic regulators. Next is lighting which consists of tube lights, CFLs, Incandescent light bulbs, halogen lamps etc. Here also, energy efficient appliances can be used to reduce energy consumption.. Others (power plug load) are having significant consumption share and offer very small space for reducing consumption.

3.2.3 EQUIPMENT WISE ANALYSIS OF HOSTELS:

Considering the viability of representation, the appliances having power consumption less than 1% have been ignored while doing equipment wise analysis of Hostels.



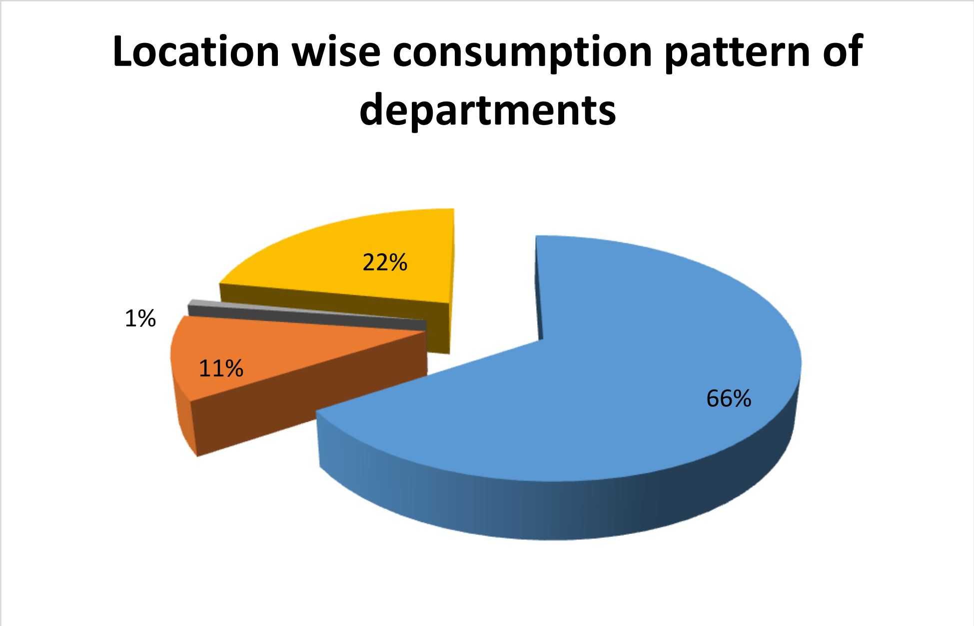
Fans and Tube lights are maximum power consuming appliances accounting for 59% and 14% of total consumption. Geysers account for 11% of total consumption. Consumption in water coolers is 4% of the total power consumption. All other devices have not that much significant consumption.

3.3 DEPARTMENTS

Guru Nanak Khalsa College for women has 5 academic departments. Each department has laboratories, classrooms, faculty rooms, and central facilities.

3.3.1 LOCATION WISE ANALYSIS OF DEPARTMENTS*:*

Location wise analysis of power consumption in departments points to a surprising fact that in spite of ignoring the special equipments installed in the laboratories and taking into account only general appliances, laboratories comprise nearly half of total power consumption of the departments. The chart below summarizes the results of location wise analysis of departments:

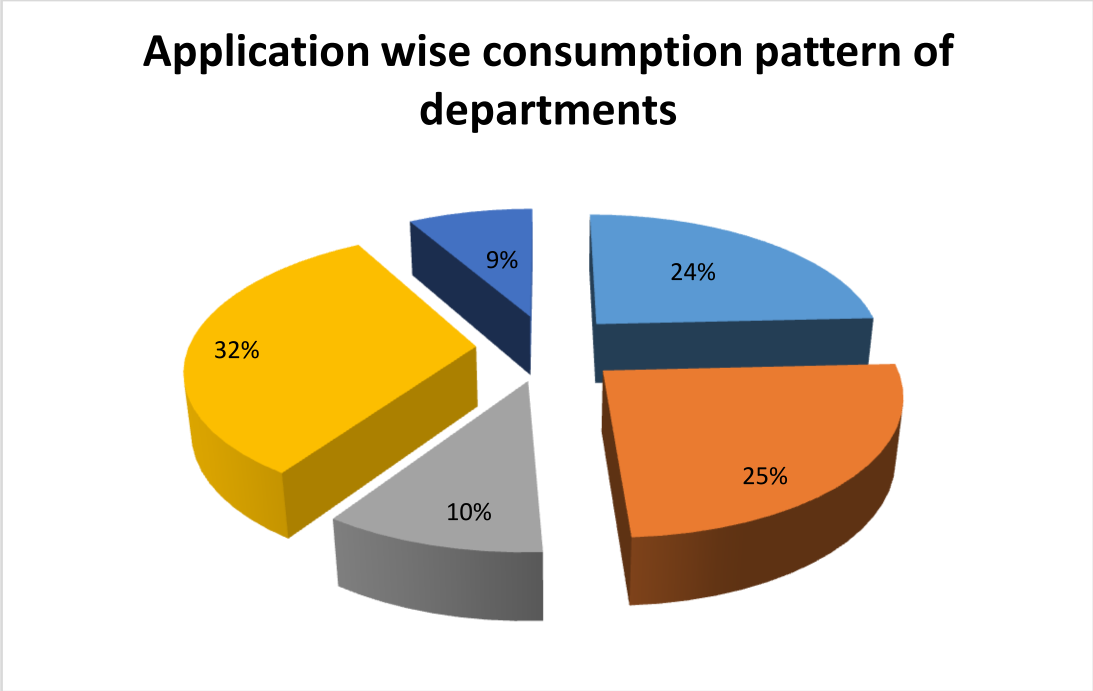


So, laboratories consume 66% of total power consumed in the departments. This is partly because laboratories are large in number and partly because all the appliances are on for the entire duration a laboratory is open. Many of the labs are air conditioned.

Staff rooms come second with 11% of total power consumption in departments. It is important to note here that since the audit has been conducted in the months of December. Classrooms consume 22%, corridors 1%.

*3.3.*2 APPLICATION WISE ANALYSIS OF DEPARTMENTS

Results of application wise analysis hint at excessive use of ACs, room coolers, room heaters etc in departments. Also the office appliances (which include computers, printers, scanners etc.) contribute largely to the total power consumption in the departments. The distribution of power consumption by different application would be clearer from the distribution pie chart given below



Comfort applications are consuming large power (25%). This clearly indicates that the ACs and heaters are not used wisely.

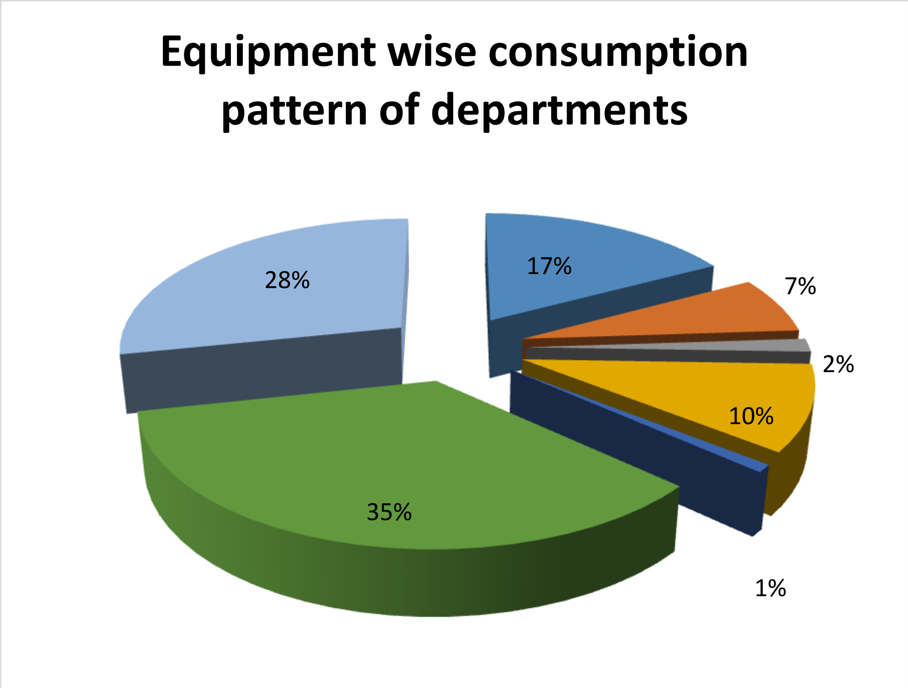
Office applications (32%) come second and its contribution is not a surprise due to large number of computers in departments.

Air Circulation (24%) is third in the list. It can be brought down further by using modern efficient appliances and automation.

Lighting have a share of 10%, and electrical accessories have 9% share in total consumption. Others are insignificant.

3.3.3 Equipment wise Analysis of Departments*:*

Following chart has been generated from the equipment wise analysis of power consumption in departments (ignoring the equipments having power consumption less than 1% of total power consumption):



AC is the second maximum power consuming appliance making up to 28% of total power consumption of the departments.

Computers account for maximum consumption of 35% of total power consumption in departments. 7% in computers with CRT monitor.

Conventional Ballast[Choke] tube lights have 10% share in total power consumption in departments, CFLs have 1%, electronic Ballast[Choke] tube lights have negligible share in total power consumed in departments.

26% of total consumption is in fans (17% in old fans and 7% in new fans).

3.4 INSTITUTE CENTRAL FACILITIES

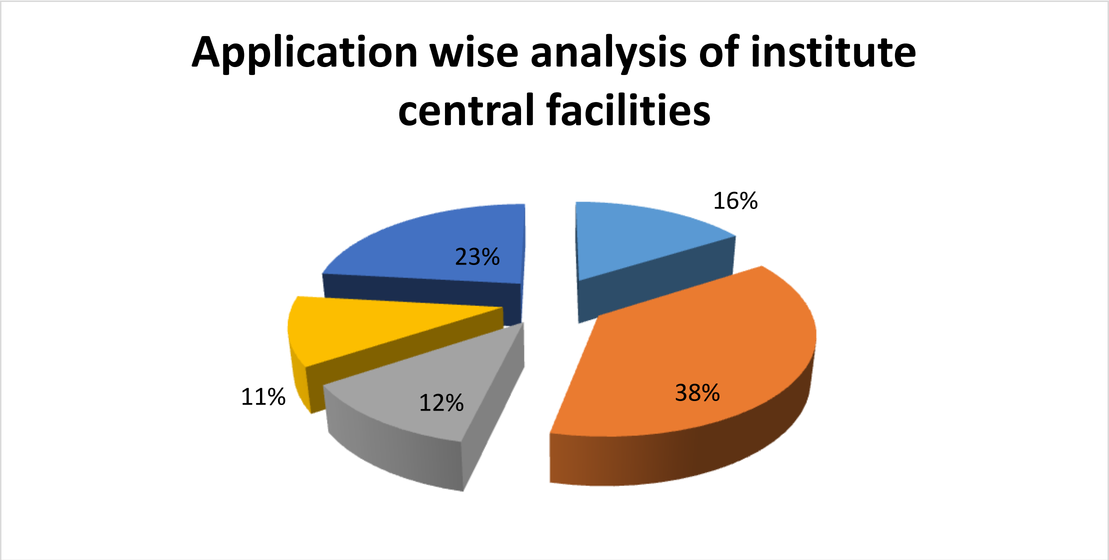
The energy audit of following units has been conducted and analyzed under Institute Central Facilities:

1. Administrative Block
2. Central Library
3. NSS & NCC rooms
4. Canteen
5. Management & Principal Office

6. Others which include Gurdwara, Sports complex, Auditorium.

3.4.1 APPLICATION WISE ANALYSIS OF INSTITUTE CENTRAL FACILITIES:

Application wise analysis of power consumption in Institute Central Facilities indicates the domination of comfort (AC, room cooler, room heater etc.) and office (computer, printer, scanner, xerox machine etc.) appliances in these units and others include Refrigerator, water cooler, coffee machine and power plug load. Following chart gives the distribution of power consumption among different application areas in Institute Central facilities:



Comfort has a maximum of 38% share in total power consumption. Most of the places in the Institute Central Facilities are air conditioned and also their usages are relatively higher.

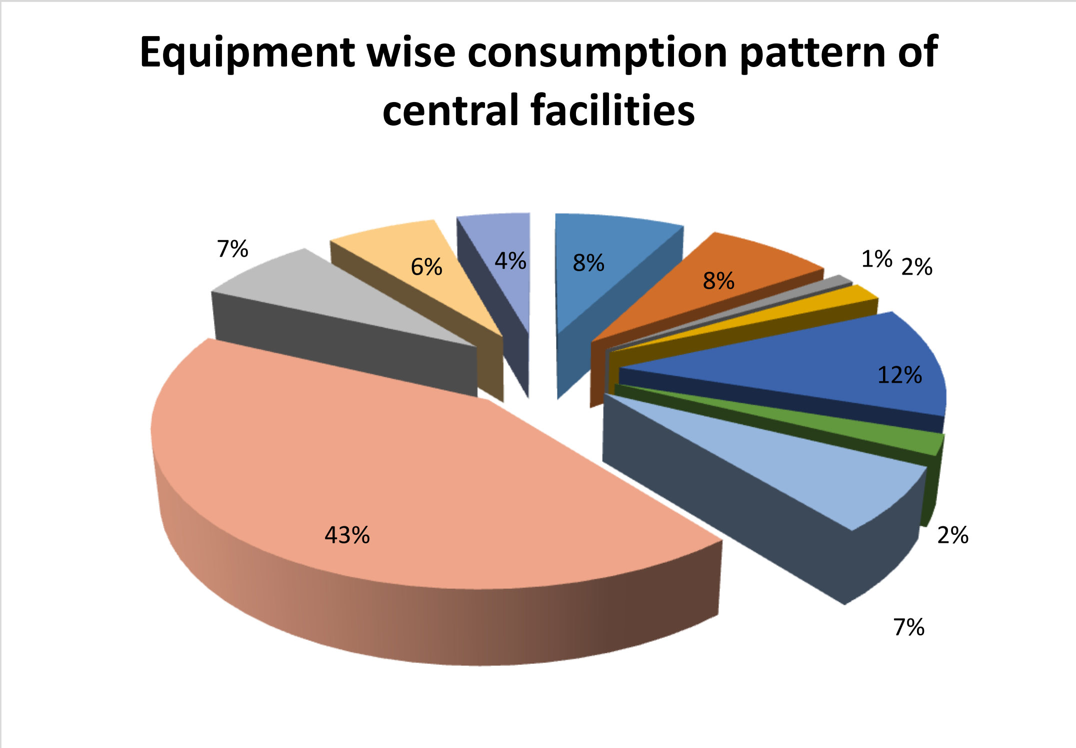
Office appliances have a share of 11% and dominant in this is the consumption of computers. During the data collection, most of the computers in Library, Computer Center as well as in offices were found to be in standby mode.

Lighting accounts for 12% of the total power consumption in Institute Central Facilities. Here dominant lighting appliance shifts from conventional tube lights & CFLs with LED. Most of the places in Institute Central Facilities use FTLs for lighting.

The per cent consumption of air circulation appliances is as low as 16% due to use of old fans. Other major loads share 23% of the total power.

3.4.2 EQUIPMENT WISE ANALYSIS OF INSTITUTE CENTRAL FACILITIES:

Equipment wise analysis of power consumption in Institute Central Facilities makes the picture clearer. Following chart summarizes the results



It is important to state here that this equipment wise analysis has been carried out by ignoring a large number of appliances having consumption less than 1% to make the analysis work simpler.

ACs are found to be consuming as much as 43% of the total power consumption in Institute Central Facilities.

Computers account for 7% of total power consumption in Institute Central facilities.

CFLs and conventional tube lights have shares of 2% and 12% respectively in the total power consumption of Institute Central facilities.

Fans account only for 19% (8% new and 8% old) power consumption.

3.5 Exterior Lighting

Sodium Vapor lamps and Solar street lights are dominant lighting source in the external lighting.

4. RECOMMENDATIONS FOR BETTER ENERGY EFFICIENCY

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

4.1 REPLACING CONVENTIONAL BALLAST[CHOKE] FTLS WITH LED batons:

Dominant light source at most places in the campus is traditional 40W FTLs with conventional Ballast[Choke] which consumes 5-7W. As per our data collection, the campus has in total 601 FTLS, out of which 541 are with conventional Ballast[Choke] FTLs and rest are LED batons. If these conventional Ballast[Choke]s are replaced by LED batons, 20-22W power can be saved per FTL.

Total No. of conventional Ballast[Choke] FTLs in Campus = 541

Average Power of conventional Ballast[Choke] FTL = 47W

Average Power of LED Baton = 20W

Power saved per FTL = (47-20)W =27W

Total Power saving = 541*27W = 14607W = 14.607kW

Average Use of FTL per year = 270*7h=1890h

Total Energy saved per year = 14.607*1890 kWh = 27607.23kWh

Saving in Rs. Per year = 27607.23*7 = Rs. 193250.61

Average Cost of Replacing each FTL = Rs. 300

Total Cost of Replacing all Conventional Ballast[Choke] FTLs =300x 541= Rs. 162300

Capital Cost Recovery time =162300/193250.61=0.84 yr

Hence, the capital cost recovery time for replacing all conventional Ballast[Choke] FTLs of the campus is around 0.84 years

4.2 REPLACING OLD FANS WITH NEW FANS

Most of the buildings in college campus are very old fans. . According to the data collected, there are a total of 465 fans. A saving of 20-40 W per fan can be obtained by replacing the old fans with new ones.

Cost Analysis of Replacing old fans with new fans

Total no. of fans in campus= 465

Average power of old fan= 75W

Average power of new fan= 28W

Power saved per fan= 47W

Total Power saving= 465*47= 21.85kW

Average use of fans per year= 200*8= 1600hrs

Total Energy saved per year =21.85*1600= 34960kWh

Saving in Rs. Per year = Rs 244720

Average Cost of Replacing per fan = Rs 2800

Total Cost of Replacing all fans = Rs 1302000

Capital Cost Recovery time = 5.32yrs

Hence, the capital cost recovery time for replacing all old fans is approx 5.32years. Since payback period is coming to be around 5 years, it is recommended that fan replacement should be done in phases.

4.4 REPLACING GEYSERS BY SOLAR WATER HEATING SYSTEM:

Geyser is the device with one of the highest consumption in hostels. It is the appliance where maximum power is wasted. Heating water by electricity is the most inefficient way to heat water. Alternatively, heating water for bathing can be accomplished by solar water heating system.

Cost Analysis of Replacing Geysers by SWHS

Cost of a domestic SWHS = Rs. 17000

Capacity of the SWHS = 100LPD

Average Capacity of Geyser = 50L

No of geysers one SWHS can be used to replace = 2

Average power of Geysers = 2kW

Average use per year = 5*180h = 900h

Energy saved per year by replacing Geysers by SWHS = 2*2*900kWh = 3600kWh

Saving in Rs. Per year = 3600*7= Rs. 25200

Capital Cost Recovery time = (17000)/(25200) = 0.67 yr

Hence, the capital cost recovery time for replacing geysers by SWHS is 0.67 years. So, the step of replacing geysers by SWHS will not only help in increasing energy efficiency, but also will reduce the cost of bathing water.

4.5 USE OF MOTION SENSORS IN CORRIDORS AND TOILETS:

Corridors and toilets have large potential of saving energy by use of automation tools. Motion sensors can be used there to automatically switch on the light when there is any movement and switch off the light when there is no movement. This can greatly reduce the total load in corridors and toilets.

Cost analysis of Installing Motion Sensors in a Typical Corridor:

Average number of tube lights in a corridor = 4

Average power of the tube lights =47W

Average number of motion sensors required = 3

Average reduction in usage per day by motion sensor = 4h

Total energy saved in corridor per year = (4*47*4*365)/1000 =274.48 kWh
Saving in Rs. Per year = 274.48*7 = Rs. 1921.36

Cost of installation per motion sensor = Rs. 250

Total cost of installing motion sensors in a corridor = 3*250 = Rs. 750

Capital Cost Recovery Time = (750/1921.36) = 0.39 yr

Hence, the capital cost recovery time for installing motion sensors in corridors is 0.39 years. Toilets are also having comparable capital cost recovery time. Hence, this is a highly recommended step to largely reduce the consumption in corridors and toilets.

4.7 BETTER PRACTICES FOR AC:

The institute has in total 43 ACs which make a very large part of total energy consumption of the campus. Most of the AC's are without star rating. Some of them are very old and consume lot more energy then the models available today.

Summarized below are some guidelines for most efficient use of ACs:

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

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

Maintenance – Proper maintenance and cleaning of ACs is required at regular intervalsto make it work at highest efficiency. Any dirt in filter may reduce efficiency of ACs very significantly.

Operating – The ACs should be switched on 15 minutes before actual use and should beswitched off before leaving the room.

4.8 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

Appliance	Number	Annual Savings (kWh)	Annual Savings (Rs.)	Capital Investment (Rs.)	Payback Period (yrs)
Ballast[Choke]	541	27607.23	193250.61	162300	0.84
Fan	465	34960	244720	1302000	5.32
Geysers	2	3600	25200	17000	0.67
Motion Sensors	3	274.48	25200	750	0.39

4.9 INSTALLATION OF SOLAR PV GRID CONNECTED PLANT

Since the institute has sufficient shadow free roof top area, it is recommended that institute installs solar PV grid connected plant of capacity 100kWp. This can be done either in CAPEX mode (Institute makes the investment) or ESCO mode in which the investment is made by vendor and charge is made through monthly bills. Keeping in view the connected laod, the maximum permissible size of Solar PV grid connected plant is 118kWp. In case the college goes in for 100kWp roof top solar PV grid connected plant with net metering, the payback period would be less than 6 years as shown in following calculations:

Cost of installation of 100kWp Grid connected Solar PV plant Rs.4800000/-

Taking 300 days of sunshine, the power produced by Solar PV plant 127500kWh

Cost per unit of electricity Rs.7/- (approx)

Annual return from plant	Rs.892500/-
Simple pay back period	5.37 years

4.10 SOME GENERAL OBSERVATIONS

The lighting arrangements are not proper in most of the rooms as the position of FTLs is not proper. Also in the Administrative room where most of the accounting part is being done has poor lighting arrangement inspite of number of luminaires installed (Old 4x20W Mirror optics, downlighters (square & round), FTLs), lux level is around 150-160lux whereas the recommended lux level is 300 lux. It is recommended that these luminaires be replaced with LED panels which consume much less power. Corridor lighting is also not proper as at most places in college FTLs and LED bulb mix is being used but the number is insufficient.

5. EQUIPMENTS AND SOFTWARE USED

We would like to list here the equipments and software used in the project to make the measurements and analyze the data.

5.1 DIGITAL LUXMETER

Digital Luxmeters are the devices used to measure luminosity level. Luminosity measurements were performed at critical points.

5.2 Energy Analyzer

We used AR5 Energy Analyzer to check power quality and consumption.

5.3 MS-Excel

Datasheets were made in MS excel. . Thereafter equipment wise analysis, application wise analysis and location wise analysis was performed. This data was then exported into excel file for graphical representation.