The Group for Environment and Energy Engineering

IIT Kanpur Halls of Residence energy audit Project Samadhan

Group of Environment and Energy Engineering

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ABSTRACT

The following report has been prepared with a view to facilitate our understanding of the energy consumption pattern of the Halls of Residence of IIT Kanpur. The report focuses on energy efficiency measures.

Preface

An energy audit is a study of a plant or facility to determine how and where energy is used and to identify methods for energy savings. There is now a universal recognition of the fact that new technologies and much greater use of some that already exist provide the most hopeful prospects for the future. The opportunities lie in the use of existing renewable energy technologies, greater efforts at energy efficiency and the dissemination of these technologies and options.

This energy audit of the IIT-K Hostels area was carried out by the members of the GE3.This report is just one step, a mere mile marker towards our destination of achieving energy efficiency and we would like to emphasise that an energy audit is a continuous process. We have compiled a list of possible actions to conserve and efficiently utilize our scarce resources and identified their savings potential. The next step would be to prioritize their implementation.
We look forward with optimism that the institute authorities, staff and students shall ensure the maximum execution of the recommendations and the success of this work.

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Introduction

This Project is the vision to make IIT Kanpur hostels energy efficient . It is a fact that Hostels of IIT Kanpur community uses a huge amount of energy and it is also very obvious that we waste quite a sizable chunk of it.
IIT Kanpur's energy bill keeps up around INR 9-10 crore per year. This amount is huge and thus naturally attracts attention when we understand that quite a lot of energy is being wasted, which in turn would mean that huge amount of financial resources are being wasted.

Making the Hostel area energy efficient will not only help the institute reduce its expenses but also helps us fulfil our moral responsibility of not wasting this precious resource, which is scarcely available to rest of the people of the country.

This would act as a prototype project, the lessons learnt here can be put to practice in the future as we progress and move to other parts of the campus. Hostels have been chosen because they are quite familiar to us, are very accessible and have conspicuous energy wastage that can be reduced.

We are confident that the results that will come out of this exercise are bound to be of interest to everyone and can be the first step to make IIT Kanpur energetically the most efficient campus in India.

1.1 Energy Audit Objective
Primary:

- The First objective is to acquire and analyze data and finding the energy consumption pattern of these facilities.
- The second objective will be to calculate the wastage pattern based on the results of the first objective.
- The final objective is to find and implement solutions that are acceptable and feasible

Secondary:

- This would be our first exposure to this field hence experience gain would be vital.
- This project will precede many follow up projects and hence help GE3 to gain technical and management exposure required for future energy projects
- It is sure to help create a repertoire of vital contacts hence will develop interaction with alumni, faculty and students.

- It would also increase knowledge among students about streams of study other than their own which is in the spirit of the interdisciplinary approach of IIT Kanpur.

IIT Kanpur Present Energy scene

IIT Kanpur has an approximate area of 1150 acres with a student community strength of around 3800 and about 300 faculty. There is a floating population of of the order of 1000 in the campus as the Nankari residents enjoy the right of way through the campus. IIT Kanpur enjoys 24 hour electricity supply while within a few hundred feet of the institute there are 12 hour power cuts.

IIT Kanpur has a demand of 8.5 MW (NPC data). Operating power factor hovers around a good 0.98.

The Specific Energy Consumption (SEC) is defined as the energy consumption per unit of product output. The specific energy consumption considering students were calculated which forms the Hostels SEC and was taken as reference for comparison. The SEC was calculated to be 2252 kWh/person/annum (for 2007-08) for the Hostels.

2. Energy audit

2.1 Energy audit methodology

The methodology adopted for this audit was

- Formation of audit groups for specific areas and end use
- Visual inspection and data collection
- Observations on the general condition of the facility and equipment and quantification
- Identification / verification of energy consumption and other parameters by measurements
- Detailed calculations, analyses and assumptions
- Validation
- Potential energy saving opportunities
- Implementation

As a first step in this regard, 4 teams of total 6 students from the group were formed and each team was assigned a particular area or application of energy in the campus.

2.2 Grouping and strategy

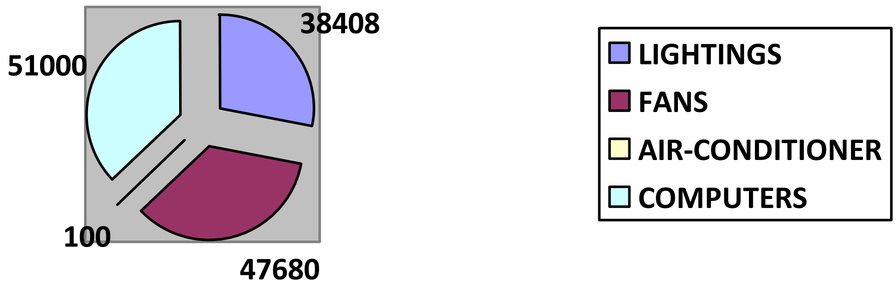
The following groups were formed with specific target areas and end uses assigned
Team 1: Lighting , Fans etc. in Hostel 1 to Hostel
Team 2: Lighting, Fans etc. in Hostel 6 to Hostel 9 & GH1
Team 3: Data logging
Team 4: Past Data Collection from IWD (internal Works Department)

The groups were allowed the use of various measuring instruments like Lux meters to assist in the auditing activity.

3. Quantification by end used

The loads were segregated based on the end use as lighting and fans, Computer/printers, water pumping. Quantification, types and necessary measurements were carried out. The details are given below:

Figure 3.1:Connected Electrical Load Distribution(In KW)



3.1 Hostels Rooms

3.1.1 Lighting and fans

The Institute has about 7571 Fluorescent tube lights. Hostels are having 4393 fans in different Hostels. The total lighting load from the above is 302 kW and the connected fan load is 352 kW.

Table 3.1: Lighting and Fan Load in Hostels

HOSTEL	NO. Of FLOUROSCENT TUBE LIGHTS(40 W)	NO. of FANS(80 W)
HALL 1	903	538
HALL 2	936	348
HALL 3	693	339
HALL 4	920	481
HALL 5	935	498
HALL 6	271	138
HALL 7	791	596
HALL 8	837	530
HALL 9	835	535
NEW GH	450	390

TOTAL	7571	4393

Computers and monitors account for 30%-40% of the energy used by office equipment. Their energy consumption is second only to office lighting. It is estimated that a power managed computer consumes less than half the energy of a computer without power management.

The total number of computers in different hostels in the campus is 3950.In which No. of desktops is around 1500 and No. of laptops is 2450.

3.3Energy usage in hostel kitchens

Energy usage in hostels messes are as given here:

Table 3.2: Details of energy consumption and food wastage in hostel kitchens

HOSTEL	CONNECTED LOAD(IN kW)	LPG USAGE PER DAY(kg)	ESTIMATED FOOD WASTAGE(IN kg)
HALL 1	42	60	125
HALL 2	42	60	125
HALL 3	42	60	125
HALL 4	30	60	100
HALL 5	30	60	125
HALL 6	14	25	30
HALL 7	40	60	100
HALL 8	29	60	100
HALL 9	29	60	100
GH-1	25	50	70
TOTAL	323	555	1000

4. Measurements performed at IIT Kanpur and IIT Bombay

4.1 Room air conditioners (Study by IIT Bombay, Energy Science Department)

A commercially available energy saver for room ACs was procured* and measurements were carried out for over 60 hrs, with and without the saver, for a typical 1.5 ton AC.

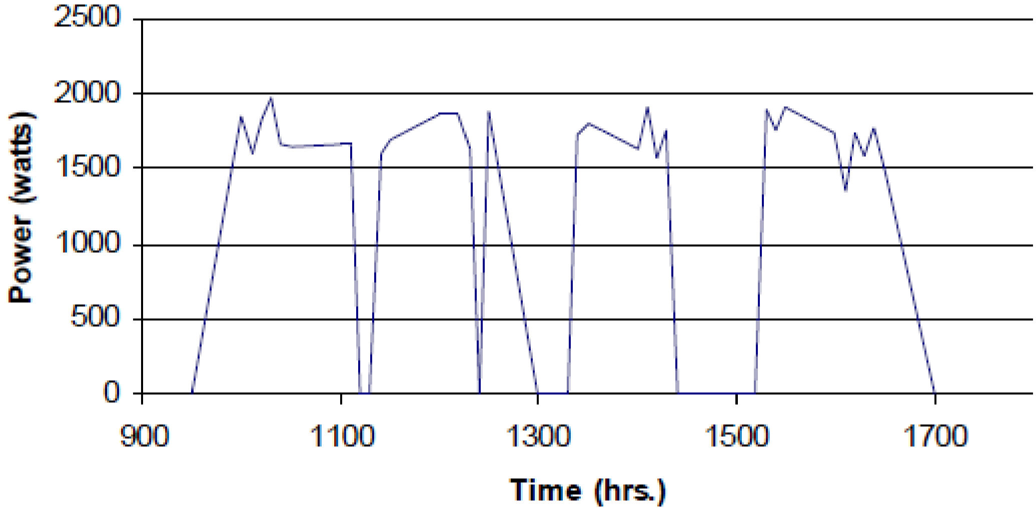


Fig.4.1: AC Load for a day without energy saver for AC's

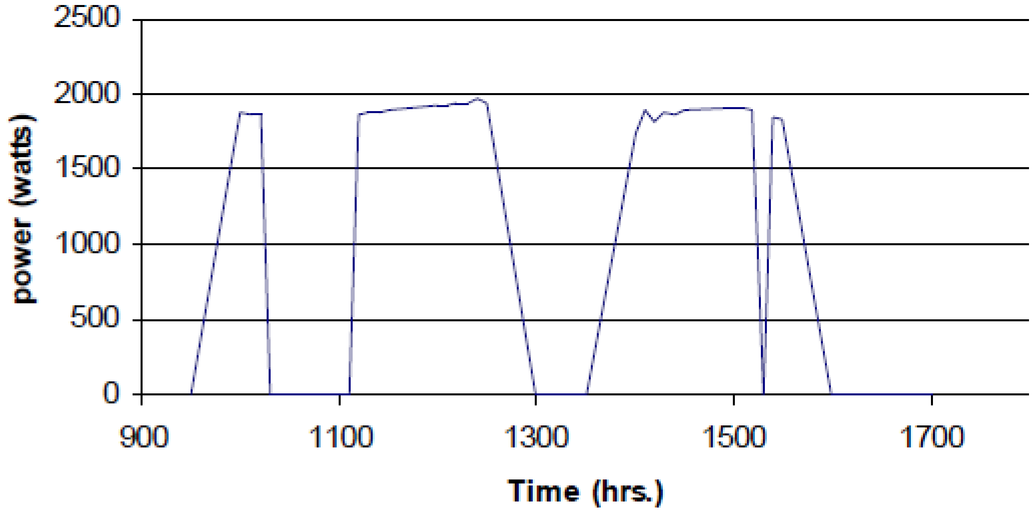


Fig.4.2: AC Load for a day with energy saver for AC's

Table 4.1: Energy savings achieved by installation of energy saver for 1.5 ton AC

Time	Energy Consumed Without saver (Wh)	Energy consumed with saver (Wh)	% Saving
1000-1110	2532	1368	46
1140-1230	1886	1086	42.4
1250-1310	372	334	10.2
1340-1430	1900	1050	44.7
1530-1650	1650	1544	41.7
Whole working day is 7.5 hrs	14880	8887	40.3

4.2 Lighting and fan loads (Study by IIT Bombay, Energy Science Department)

The energy consumption of FTLs (Fluorescent Tube Lights) which are commonly used in the campus is shown below-

Table 4.2: Measurement for lighting (done at IIT Bombay)

FTL with Electronic Ballast			
V(volts)	I(Amp)	P(Watt)	P.F
226.5	0.54	38	0.522

Table 4.3:Lux meter Reading of Hostels (at IIT Kanpur)
(All readings in lux)

Hostel	Study Room	Mess	Canteen	Bathroom	Computer Room	corridor
Hall 1	660	800	180	80	NO	20
Hall 2	440	800	180	80	400	15
Hall 3	400	750	200	80	450	25
Hall 4	270	200	300	100	NO	20
Hall5	260	200	400	100	440	20
Hall 6	400	400	300	400	NO	20
Hall 7	500	700	120	600	450	25
Hall 8	600	400	200	400	1250	25
Hall 9	620	420	200	400	1100	25
GH 1	200	600	60	90	600	20

Clearly the current lighting intensities are very high according to the ECBC standards.

5. Benchmarking

Energy benchmarking involves the development of quantitative and qualitative indicators through the collection and analysis of energy-related data and energy management practices. Benchmarking in simplistic terms is the process of comparing the performance of a given process with that of the best possible process and to try to improve the standard of the process to improve quality of the system, product, services etc. It allows organizations to develop plans on how to adopt such best practices, usually with the aim of increasing some Aspect of performance. Benchmarking may be a one-off event, but is often treated as a continuous process in which organizations continually seek to challenge their practices. Benchmarking is a method which should be used on a continual basis as best practices are always evolving. Benchmarking of energy consumption is a powerful tool for performance assessment and logical evolution of avenues for improvement. Historical data, well documented, helps to bring out energy consumption and cost trends month-wise / daily. Trend analysis of energy consumption, cost, relevant production features, specific energy consumption, help to understand effects of capacity utilization on energy use efficiency and costs on a broader scale.

The basis for benchmarking the energy consumption at IIT-K Hostels is energy consumed per student. The benchmarking parameters are as following:

- Hostel energy performance
- kWh consumed per sq.m of area
- kWh consumed per capita

5.1Hostel energy performance

The details of the annual energy consumption in various Hostels are as shown here in the following figure.

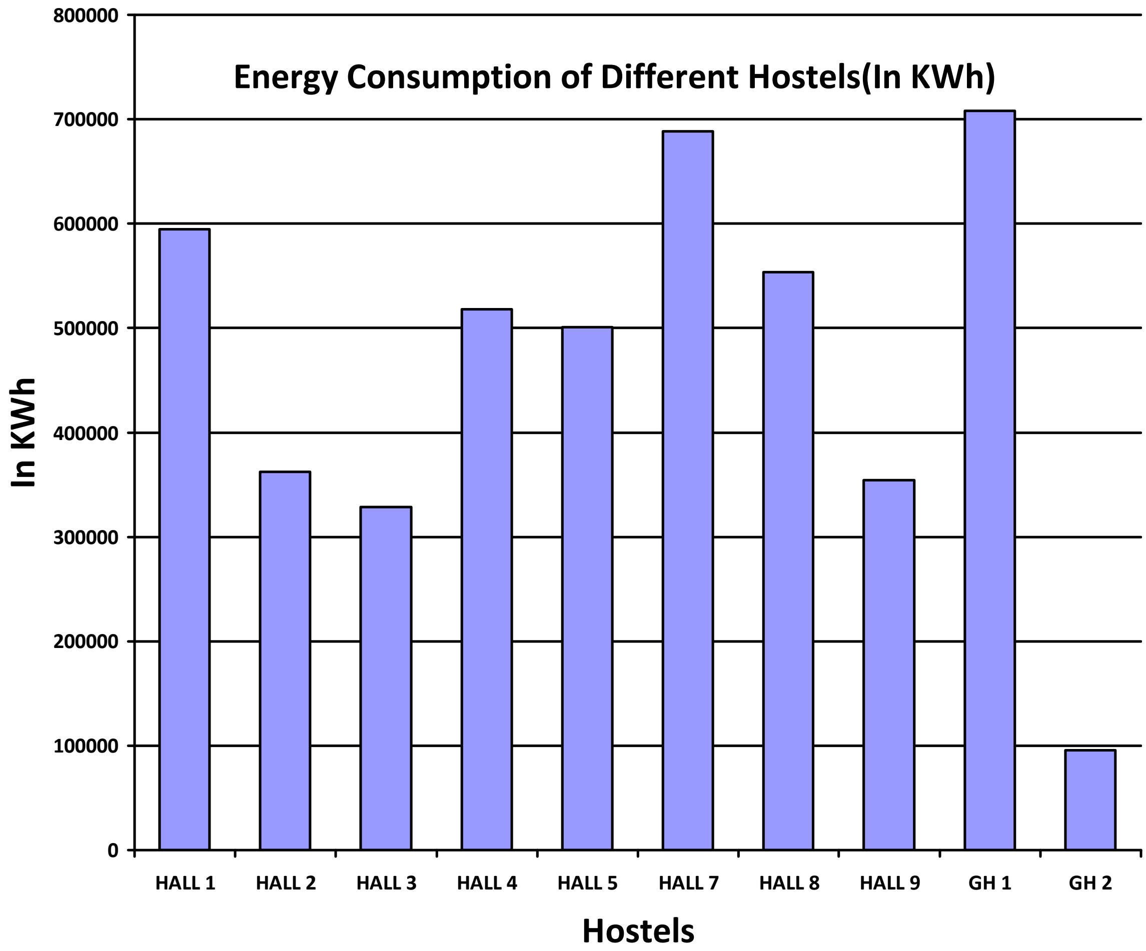


Fig. 5.1: Total annual energy consumption of different hostels in 2007

5.2 Per unit area energy consumption

The energy consumption per sq. m for each department is determined. The results are shown in following figure.

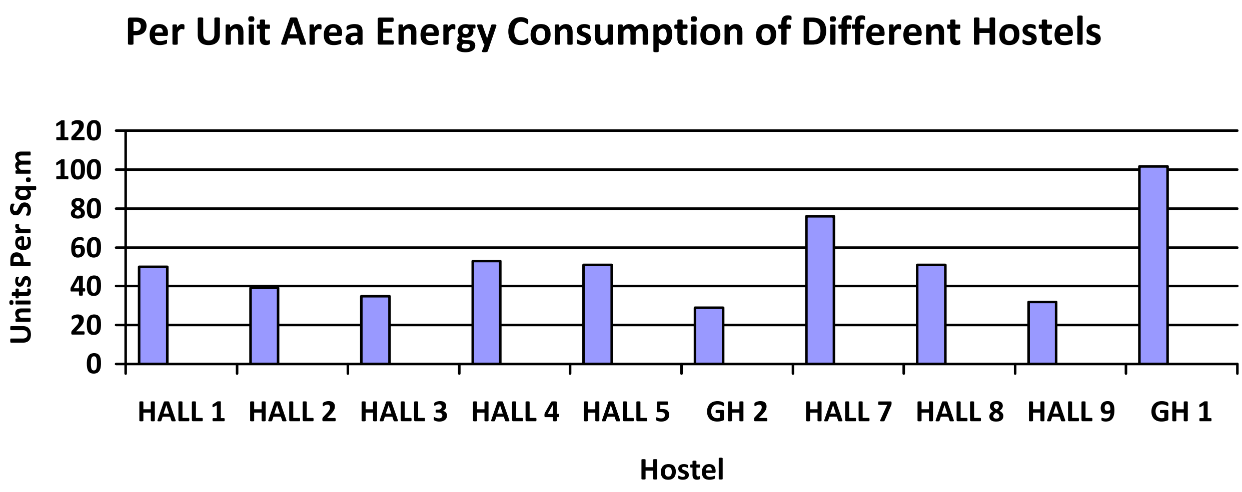


Figure 5.2 Per unit energy consumption for each 3 storied hostel. (Area used in the calculation is the plinth area.)

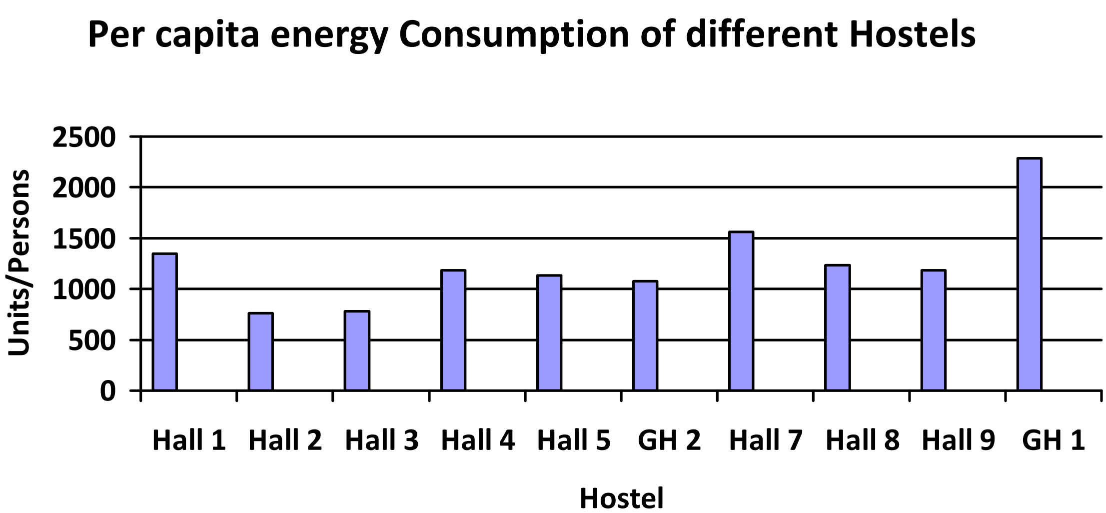


Fig 5.3: Per capita electrical energy consumption (kWh/person/yr.) for Hostel.

5.4 ECBC Standards and comparison

As per the Energy Conservation Building Code (ECBC) – 2006, published by the Bureau of Energy Efficiency (BEE), Govt. of India, the recommended Illuminance are as given below in Table 5.1

Table 5.1:Standard Illuminance Levels for different Purposes [3]

Type of Interior Or Activity	Minimum Illuminance required(In Lux)
General	200
Reading Room	200
Reading tables	200
Bathrooms	50
Computer Workspace	300
Interior Parking Area	20
Music Rooms	200
Sports halls	200
Corridors, passageways &Stairs	50
Canteens ,Cafeterias ,Dining Rooms and Mess Rooms	150
Food Preparation and Cooking	300

Recommendations

There are a number of ways in which the present situation may be improved. Following is a list of recommendations that we make that will help make IIT Kanpur an energy efficient system.

1. Installation of solar water heaters.

We calculate the parameters that will be associated with this recommendation.

Analysis for the Solar water heating systems for hostels of IIT Kanpur

<u>Sample calculation for Hall of Residence II</u>

Residents 462
Assuming an average requirement of 20 L of hot water per day
Thus daily amount of hot water used= 462x20 = 9240 L

An average flat plate collector area of 2 m^2 gives 125L of hot water per day. [1]
Thus total collector area required = 9240/125x2 = 147.84 m^2
Assuming cost of installation to be around 10,000 Rs/m^2 total capital cost comes out to be = 14,78,400Rs
Total geyser usage in the hostel for approximately 12 hrs on a typical cool day for 2.3 kW geysers installed in the hostel = 12x2.3x21= 579.6 kWh

Geysers are typically operational in IIT Kanpur for about 120 days from November to February. Thus total energy consumption = 120x579.6 = 69552 kWh
Total expense with geysers = 69552x3.5 Rs/kWh = 243432 Rs.

Thus simple payback period = 14,78,400 / 243432 = 5.25 years.

Clearly this is a comfortable payback period and it is advisable to have solar water heaters installed in this facility.

The same calculation is done for all the hostels of IITK

	Residents	hot water required	collector area m^2	Capital investment INR	no of geysers	annual saving (INR)	payback (years)
Hall-1	452	9040	144.64	1446400	21	243432	5.9417
Hall-2	459	9180	146.88	1468800	21	243432	6.033718
Hall-4	486	9720	155.52	1555200	24	278208	5.590062
Hall-5	450	9000	144	1440000	24	278208	5.175983
Hall-6	112	2240	35.84	358400	6	69552	5.152979
Hall-7	410	8200	131.2	1312000	30	347760	3.772717
Hall-8	489	9780	156.48	1564800	24	278208	5.624569
Hall-9	300	6000	96	960000	27	312984	3.067249
GH-1	310	6200	99.2	992000	21	243432	4.07506

The payback period of all the facilities is around 5-6 years which is certainly affordable considering the environmental impact of this technology.

Furthermore data clearly suggest that even while having almost the same architecture and number of students the per capita electricity consumption of Hall 2 and 3 is different and the difference clearly has a correlation with the solar heater that have been installed in Hall 3. This is further confirmed by the fact that in winter Hall 3 and Hall 2 per capita electricity consumption differences grows even further.

2. Replacement of rheostatic regulators with electronic

However studies done at IIT Bombay have shown that the electronic regulator is more energy efficient but experience suggests that resistive regulators are more durable. Though it is still mentioned here as a possible option.

3. Installation of biogas plant at IIT Kanpur

HOSTEL	CONNECTED LOAD(IN KW)	LPG USAGE PER DAY(Kg)	FOOD WASTAGE(IN Kg)
HALL 1	42	60	125
HALL 2	42	60	125
HALL 3	42	60	125
HALL 4	30	60	100
HALL 5	30	60	125
HALL 6	14	25	30
HALL 7	40	60	100
HALL 8	29	60	100
HALL 9	29	60	100
GH-1	25	50	70
TOTAL	323	555	1000

Typical waste food density is 890 Kg/m^3[2]
Total volume of waste food per day is about 890 L.
Taking example of an urban bio gas unit Nisarguna of 1000 kg capacity. [4]

Treatment capacity (tonnes per day)	Installation cost (Rs in lakhs)	O & M (Rs)	Methane generation Per cubic meter	Manure generated (tonnes per day)
1	5-6	8000	100-120	0.1

Assumptions-
Calorific value of biogas = 21MJ/m^3
Calorific value of LPG = 46.1 MJ/ kg
Energy output of biogas plant per day = 3500 MJ
This implies that LPG saved = 75.92 kg = 5.34 LPG cylinders per day
Total working days = 200 days approximately
Total annual savings = 200x5.34x350 = INR 3,73,800
Payback period = 2.15 years = 26 months approx.

4. Lighting Savings

The lighting that is currently used in most of the hostels is T8 FTL we propose them to be replaced by the more energy efficient T5 FTL. [5]

Characteristics	Conventional 40 W FTL	T5
Expected Life hrs	5000	20000
Energy input per hour	45	28

Consumption in 19 hrs per day (kWh)	.885	.532
Annual consumption 200 working days (units)	177	106.4
Annual consumption (INR) at INR 3.5 per unit	605	372
Savings INR	-----------------	233

Total savings per year considering we replace 7000 T8 FTLs with T5 we can save around INR 16, 30,000.
Total investment = 7000x770 = INR 53,90,000
Simple payback period is thus calculated to be 3.3 Years.

As clear from the standard comparison we can clearly remove some of the lights as the current levels are very high, especially in the common rooms.

5. Executive Recommendations

This section talks about the managerial aspects of the recommendation in the above section and also about other possible measures.

1. Maintenance of the Hall solar water heaters. This is a rampant problem in the installation of solar heaters, their maintenance is quite an important business and thus we propose that constant watch over system performance can be kept by the maintenance secretary. This can be integrated with the current duties of the post. Furthermore a more involved solution can be the creation of an energy and environment committee on the hall level which can keep a record of the energy consumption parameters of the hall. This can be further carry weightage in student festivals that are taken seriously by the student community. This would add much needed glamour into the activity.

2. There has to be an institute level student community that keeps track of the energy consumption parameters of the halls. This does not need to be separate, as it can derive membership from the already existing hall maintenance secretaries.

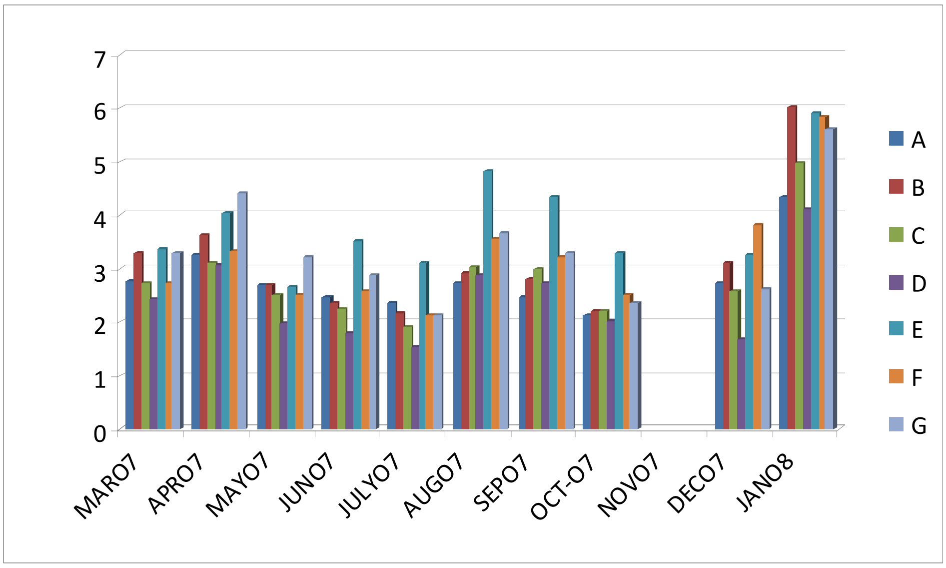
3. Energy auditing inside the campus has to be done on a regular basis and the reports should be made public. The IWD tries to keep track of the readings of various hostel meters but this reporting has to be made public to generate awareness.

Appendix

Appendix A

Charts for energy consumption pattern in various wings of halls. Units consumed per person are plotted against the month giving us a monthly behaviour.

1. GH1



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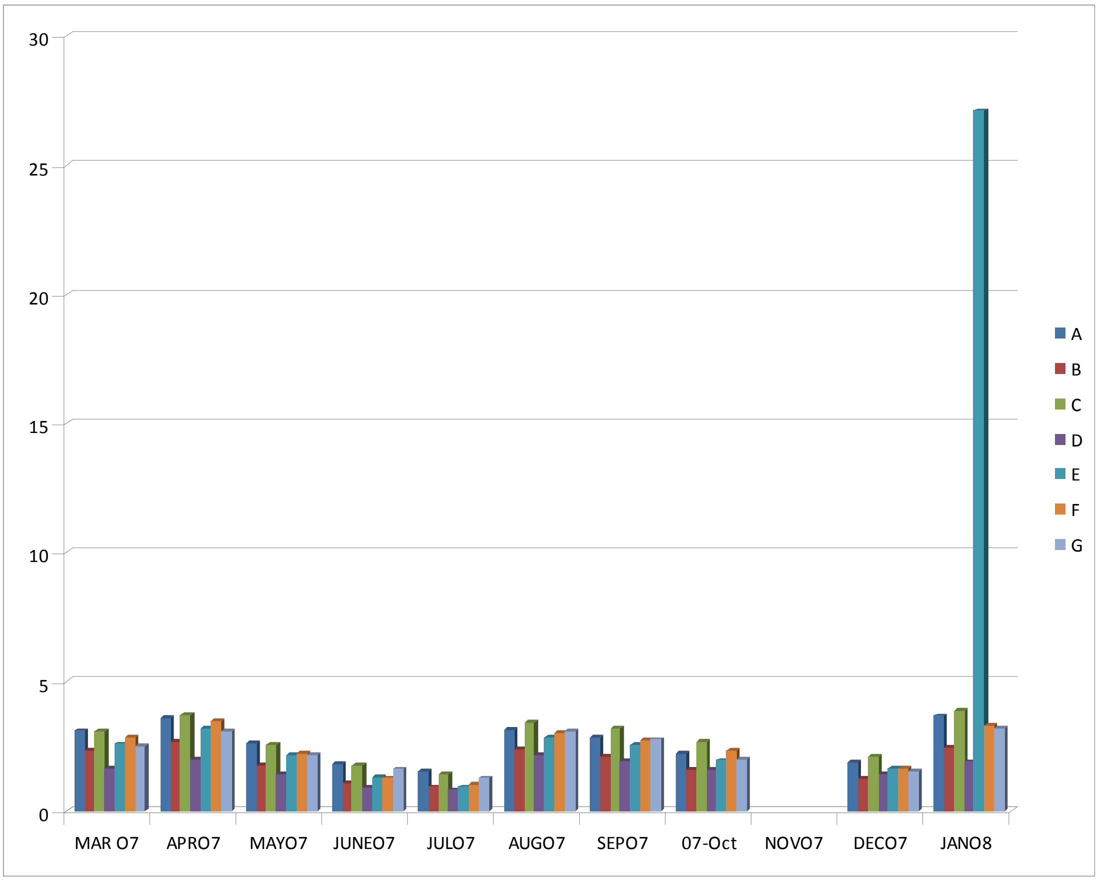
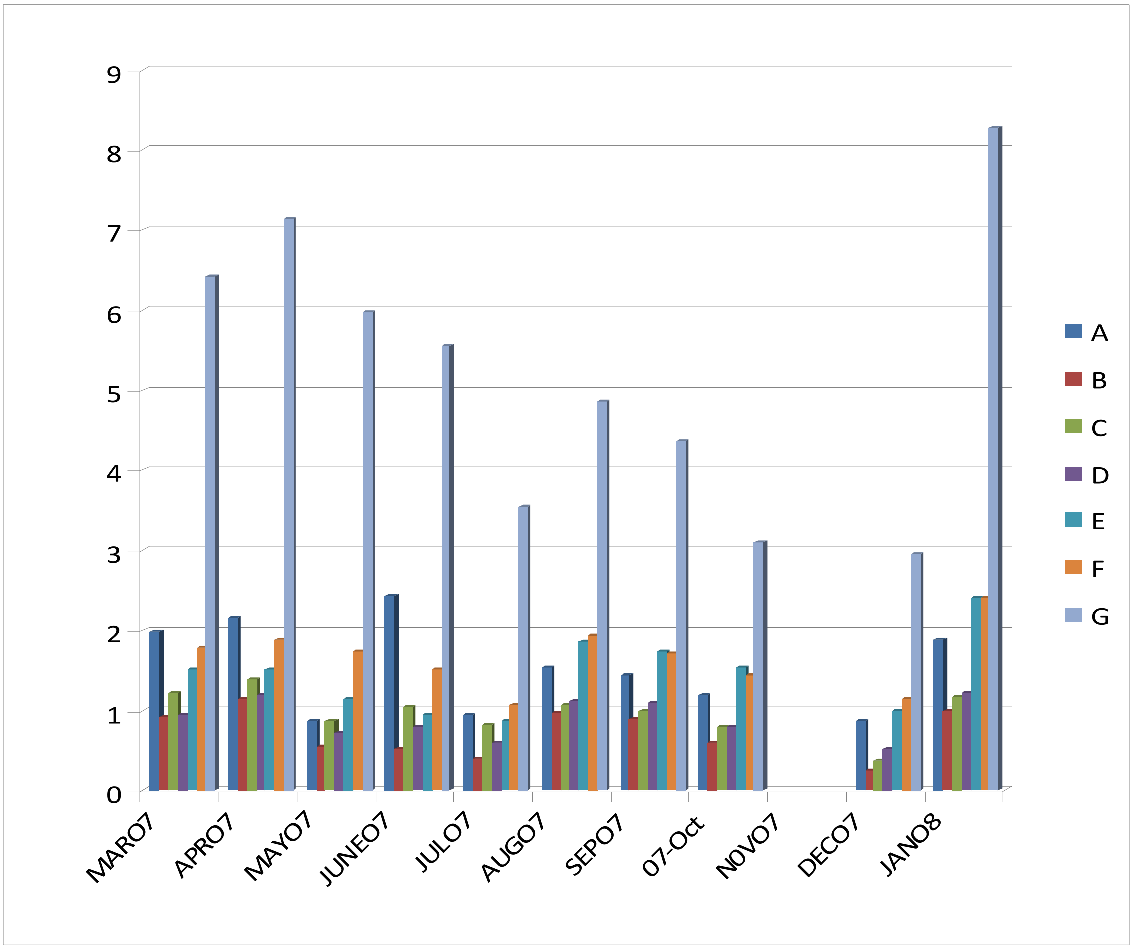
Hall1



3. Hall 2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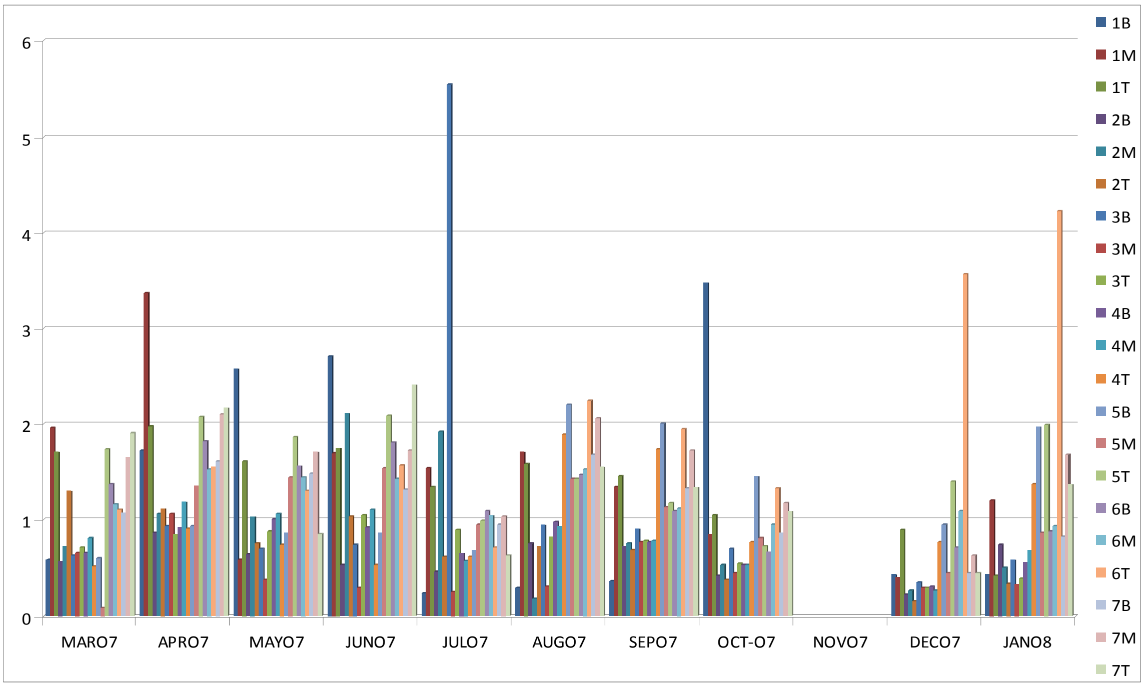
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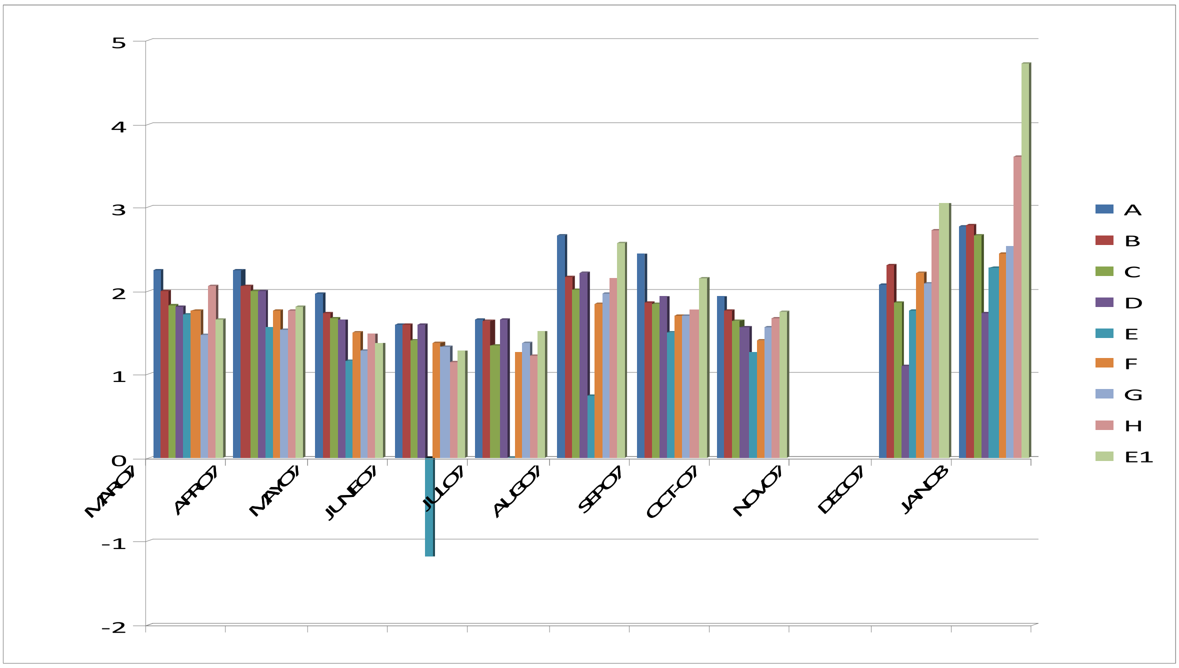
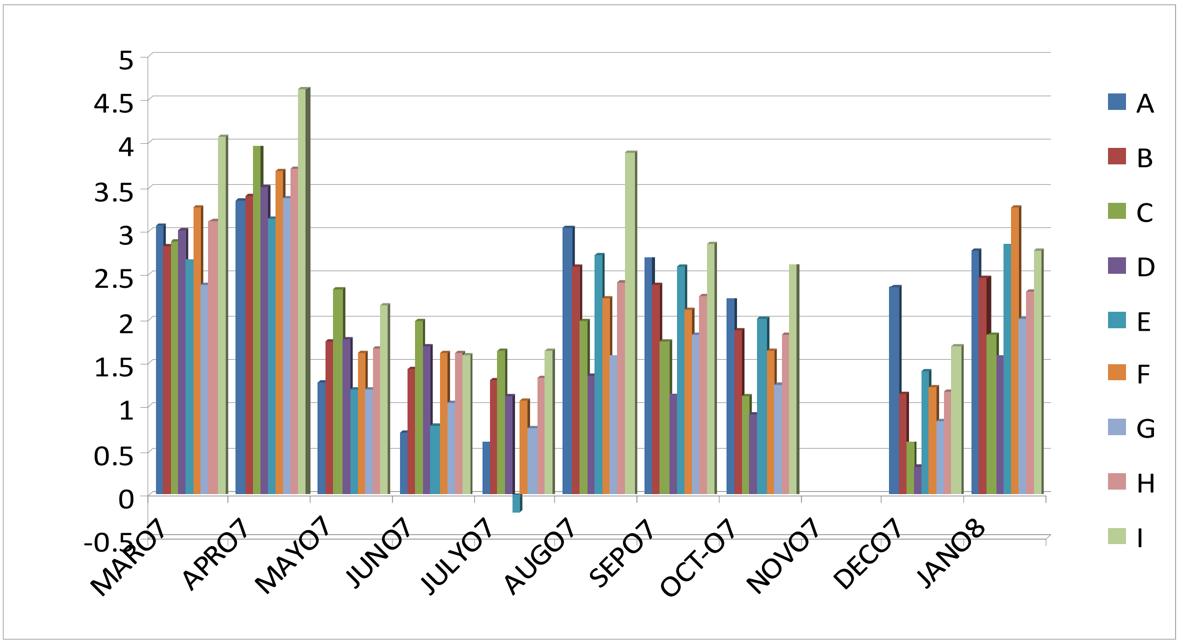
5. Hall 4 *

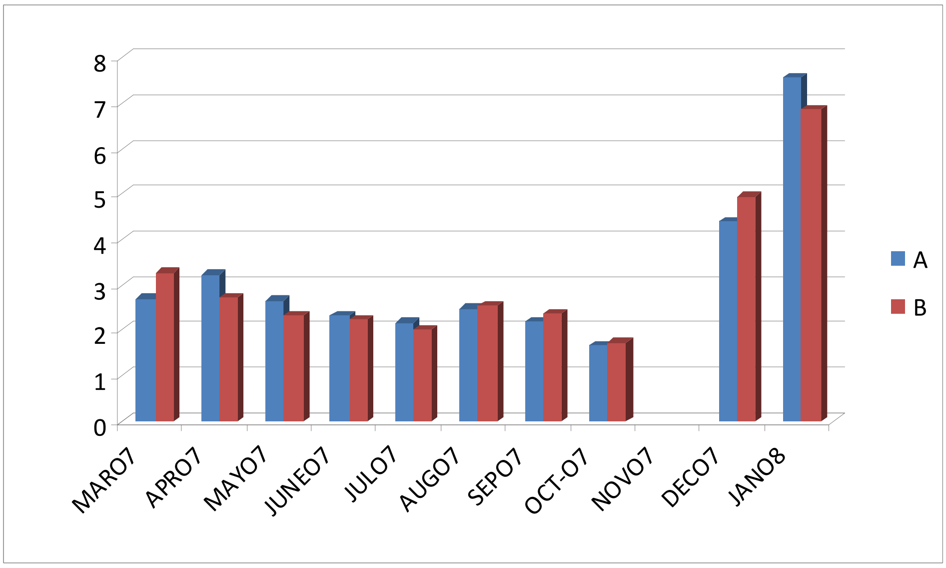


* Clearly energy consumption can not be negative it seems to be that a meter was changed and due to this discrepancy was created.

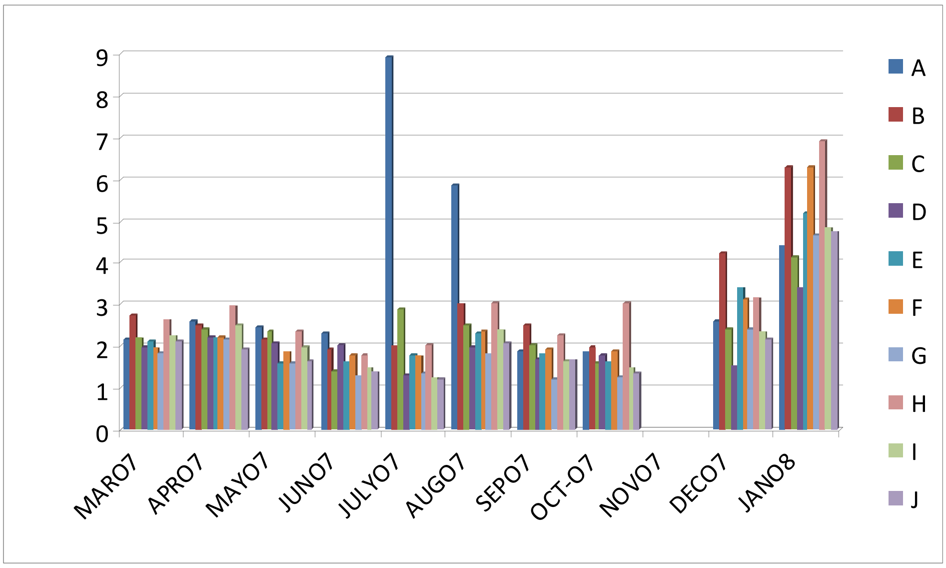
6. Hall 5



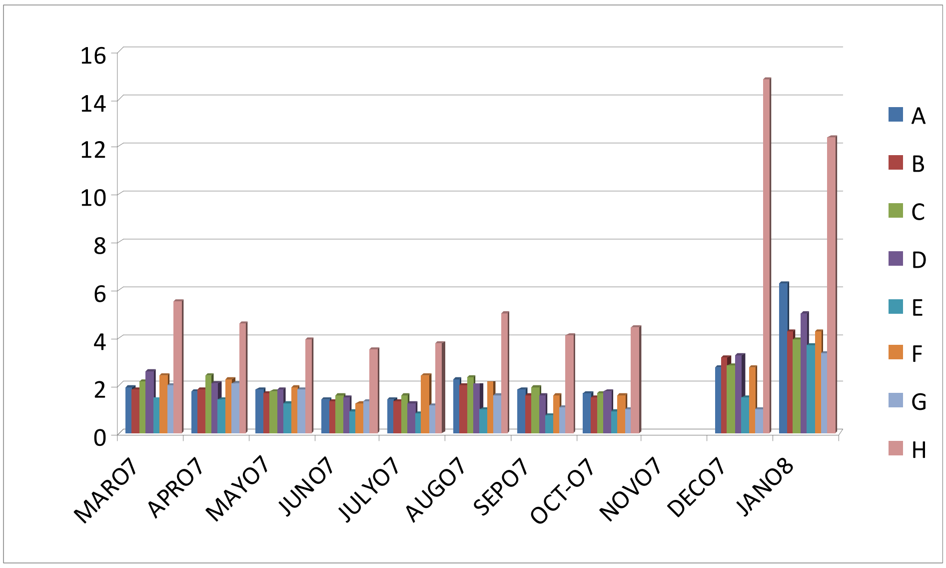
7. Hall 6



6. Hall 7



7. Hall 8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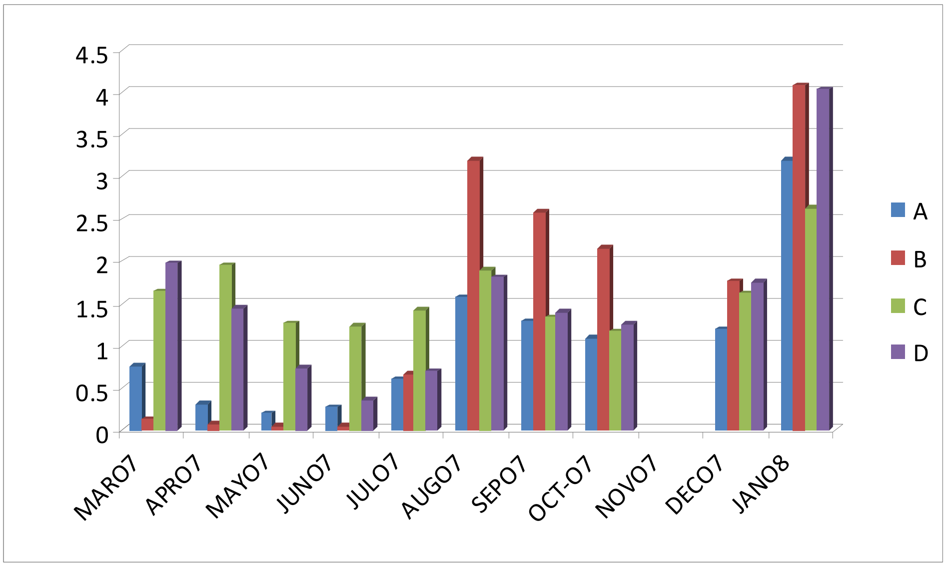
9. Hall 9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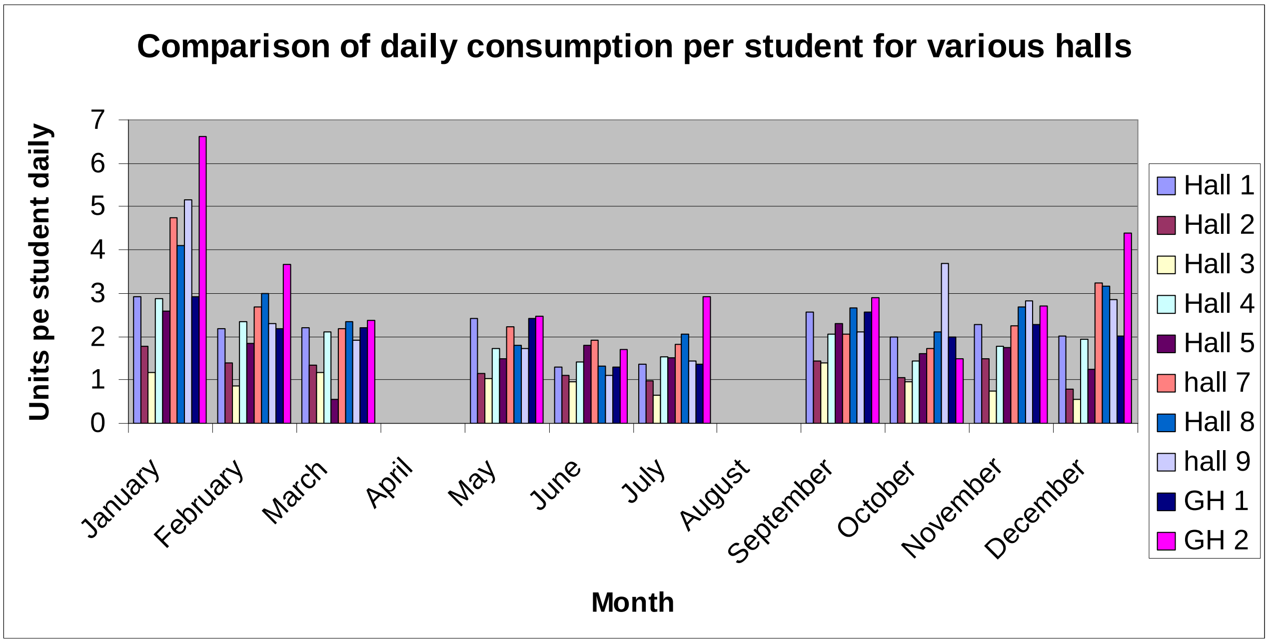
Appendix B

This Graph clearly points out the higher energy consuming halls of the campus i.e. GH2 which has significantly higher consumption than any other Hall especially in January.



Appendix C

References

[1] IIT Bombay Energy audit report, Department of Energy Science and Engineering.

[2] MATERIAL AND ENERGY BALANCES IN A LARGE-SCALE AEROBIC BIOCONVERSION CELL by Nickolas J. Themelis. Earth Engineering Center and Department of Earth and Environmental Engineering, Columbia University, New York.

[3] Energy Conservation Building Code (ECBC) – 2006, published by the Bureau of Energy Efficiency (BEE), Govt. of India

[4] SOLID WASTE MANAGEMENT*P. U. Asnani of the 3i network in which IITK is also involved.*

[5] Source: http://www.energyfreeindia.com/t5-tube-light.htm

Acknowledgements

The acknowledgements are due to all the officials at the IWD department who helped us in data collection, especially Mr. Rajiv Garg, Mr. Raghvendra, Mr. Pankaj Singh. We also thank Mr. Amitav Ray and Mr. Pawan Kumar of the National Power Corporation for helping in measurements. We also acknowledge the effort of the DESE IIT Bombay as it formed a basis on which could start our work.

We thank our faculty for their unwavering support throughout the process. We feel that this is only the tip of the iceberg, and an enormous amount of work can be done on the campus in terms of energy efficiency.