ACCESSING ENERGY EFFICIENCY AT UNIVERSITY CAMPUS: CASE STUDY MAHARISHI MARKANDESHWAR UNIVERSITY, SADOPUR, AMBALA, HARYANA

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Abstract— The study of the building energy demand has become a subject of importance, due to the numerous increases in interest in energy property. University campuses represent specific team of various buildings, with vital energy consumption [1]. They comprise various buildings, representing small-scale city for itself. Therefore, they supply a wonderful work to characterize and perceive energy consumption of a bunch of "mixed-use" buildings. Appropriate building information for Maharishi Markandeshwar University, Sadopur is made, and on the market information on heating and power use square measure collected and arranged.

Adverse impacts on the atmosphere from energy generation became a serious concern today. Study of energy consumption for establishments resembling MM University to make sure the property of energy usage, and additionally to cut back its prices is of prime importance. This study results in a preliminary audit for the mm University campus to get info resembling the electrical appliances, ambient temperature, and built-up space and to grasp the link of those factors with energy consumption. Analysis founds that the amount and kinds of electrical appliances, population, and activities within the campus impacted the energy consumption of MM University directly. There is no clear correlation in energy consumption between the built-up area and ambient temperature. An investigation of the diurnal and seasonal energy consumption of the field was also applied.

In the 21st Century Energy Efficiency is not a fixed treatment of design which bond architects to a firm geometry. It encompasses a variety of techniques to suit the nature of project and behavior of a user.

Key Words— Energy Audit Framework, Energy Efficiency Analysis, Sustainable Design Approach

1.1 INTRODUCTION

The study of the building energy demand has become a subject of importance, as a result of the many increases in interest in energy sustainability. Considering the constant increase of fuel costs, threats of worldwide warming, implications of carbon emissions from ancient fuels, there is a growing interest in rising energy efficiency. One among the foremost vital components in making certain a building's efficiency is energy management and observance. Energy observance is an energy efficiency technique supported the quality management axiom stating that "you cannot improve what you can not measure". It implies the need for measurements and information organization [2].

According to the circumstances, it may be attainable to work out the energy performance of a building through a calculation model ranging from building well-known options (forward approach) or to assess the energy use from energy meters (inverse approach). Scientists and engineers square measured recently moving from hard energy demand toward analyzing the energy consumption of buildings. A number of the necessary queries square measure to work out that parameters ought to be monitored, outline the optimum range and position of meters, opt for an appropriate frequency of assembling knowledge (annually, monthly, daily, hourly or sub-hourly). It's essential to spot the main influencing factors so as to scale back the number of monitored parameters. So as to attain energy efficiency in buildings, making an appropriate database is important.

In order to watch and manage energy consumption, adequate aggregation data is primer issue. Weekly or monthly knowledge isn't nearly pretty much as good the info that comes simply and mechanically from the modern approach [3]. Interval metering systems that mechanically live and record energy consumption at short and regular intervals such as each 15-minutes provide precise knowledge. There's merely no manner that weekly or monthly meter readings will show what quantity energy is employed at completely different hours of the day, or on completely different days of the week. So a lot of elaborated energy use reading makes it abundant easier to search out the routine waste within the building.

1.2 Scope of Energy Efficient Building

India is functioning in direction of skyrocketing building efficiency. In 2009, the Government approved the National Mission for increased Energy efficiency. Ministry of Power and also the Bureau of Energy potency (BEE) has adopted the Energy Conservation codification (ECBC) and in 2007 minimum building commonplace is established [4]. ECBC is nowadays voluntary and also the Ministry of Urban Development and BEE can work with state and governments to contemplate these codes necessary in approaching years. The Ministry of environment and Forests additionally take the project on environmental impact assessment. The Indian Government provides and is growing the scope of economic incentives for approaching economical buildings. The Ministry of new and Renewable Energy's certified green rating for integrated surroundings assessments (GRIHA) for buildings and developers get money prize of Rs. 2.5 lakhs for a three energy star rating building, and Rs. 5.0 lakhs for a four energy star and municipal firms might rise up to Rs. fifty lakhs for five energy star rating [5].

1.3 Group of Buildings in University Campuses

Considering that university campuses represent a cluster of numerous buildings, a recent analysis of building stock is studied. As there's increasing interest during this field of study, it had been essential to collect and analyze results and conclusions created by scientists. Authors came to conclusions that may be applied to school campuses, or provide an inspiration for similar analysis. S. P. Corgnati. introduced energy index that may be used for energy analysis and prediction of energy use[6]. Chen, S. identified the importance of Breakdown of energy use and projected the simplest way of resolving problems in lack of knowledge or sub-meters for finish users [7]. It showed that alternative scientists and engineers even have some similar problems with missing or faulty knowledge which it's a crucial topic of analysis that ought to be explored.
A form was set up for the collection of the building data and of the amounts of energy consumption, and it is divided into three main sections:
•General data (which include identifying data, climatic data and the main features of the building)
•Monthly energy data (includes a table of conventional quantities, measured quantities and corrected conventional quantities)
•A diagram comparing predicted and measured specific heat supply

With the aim to own vital statistical data, climatic, users and energy data were collected for an amount of a minimum of 3 heating seasons and on a monthly basis. So as to form information uniform and comparable, they introduced an energy index, derived from the collected information and named it typical specific energy offer for area heating.

In order to characterize the building stock in terms of energy consumption, for the last three heating seasons, the following data were collected:
•Seasonal and monthly billed fuel consumption for space heating;
•Seasonal and monthly supplied thermal energy for space heating;
•Seasonal and monthly operating periods of the heating plant.

Moreover, the seasonal and monthly actual degree-days of the analyzed sites were additionally evaluated. A preliminary analysis of the info was disbursed, aimed to light the most correlations among the info and also the applied mathematics values of the sample. The results showed smart correlation line between the annual billed fuel consumption and also the gross heated volume. Also, the linear correlation between average monthly specific billed fuel consumption and monthly degree-day was verified. one in all their conclusions is that actions aimed toward reducing the energy consumptions of the sample ought to be self-addressed first of all too few buildings with giant volumes to own a right away impact on the consumption decreases.

2.0 Energy Efficiency Measures for Buildings

On average new buildings will scale back energy consumption between 20-50% it's calculable that new buildings will scale back energy consumption on a median between 20-50% by incorporating applicable styleinterventions within the building.Energy consumption during a building is reduced whereas maintaining or rising the extent of comfort in buildings [8]. They will be classified as:

I. Reducing heating demand;
II. Reducing cooling demand (need for air conditioning);
III. Reducing the energy requirements for ventilation;
IV. Reducing energy use for lighting;
V. Reducing energy used for heating water;
VI. Reducing electricity consumption of office equipment and appliances;

3.0 CASE STUDY, MM University Campus Sadopur, Ambala

This analysis has the aim to research energy use at MMU campus Sadopur (Figure 1). The campus consists of four buildings, with the whole space of roughly 125656.94 SQM. Depending on their purpose, building types area unit office, instructional, laboratory workshop and sports facilities. It includes the faculties of study and Technology, Natural Sciences and Technology, and information Technology, arithmetic and technology. the primary building (Academic Block-A – Main building), that is additionally MMU`s 1st building, was in-built 2009, whereas the newest one (Architectural Building) was in-built 2014. The largest building, hostel block covers about 2902 m2 and is that the largest building in campus. Out of threetutorial buildings, there area unit three libraries and one is that the central library. The university`s student athletic association features a sports center at this campus. Due to totally different building use and year of construction, varied materials, insulation, and space underneath windows were used.

Figure-01, Location Map of MM University, Sadopur, Ambala ;(Image Source: by Author)

Figure-02, Google Map of MM University, Sadopur, Ambala

Building and Energy Management System (BEMS) and web-based Energy Monitoring System (Energy Remote Monitoring

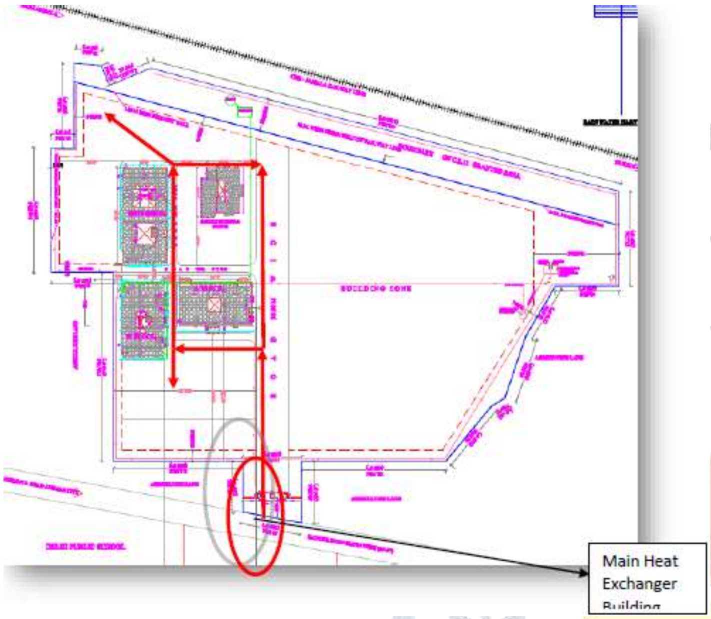

Figure-03, Building and Energy Management System ;(Image Source: by Author)

As campus has only one main meter there is no risk for missing data from some meters or submeters. District heating net in University campus is shown in above Figure-03. Supply is organized in form of an interconnected ring, while the main heat exchanger is installed in small building at entrance.

3.1 Meters in MMU Sadopur campus

There is only one meter installed in MMU campus Sadopur. The bills for heating and lighting for campus are defined by this main meter, that is installed by Uttar Haryana Bijli Vitran Nigam Limited, and it is named **Main electricity meter.** The MMU did not install its own, control main meter, to control and calculate the individual building loads. It's difficult to have correct load for particular activity especially for construction activities which are charged by administration on contract basis (An amount for particular electricity uses etc.)

3.2 Creating Building Database

Information incorporates a key role within the correct analysis of energy use. The form of information and data provided, depending on the aim of research. If a lot of parameters area unit collected and used, energy use model can higher predict energy use in buildings.For making buildings information for Sadopur campus, totally different sources of data are used:

- Information concerning HVAC systems in buildings was found by counting
- Data for building envelope, transmission coefficients, heated volume, etc. were found in Energy efficiencycertificates and codes
- Building service staff provided tables containing helpful info concerning the amount of systems, capacities of heat exchangers, etc.

Table-01 ; Annual Electricity Consumption in University Campus MMU Sadopur

Sr.No.	Year	Month	Units(KWH)	M.F.	Units Consumed	Rate	Amount
1	2014	Jul	12975	3	38925	6.35	247173.8
2		Aug	20647	3	61941	6.35	393325.4
3		Sep	83328	3	249984	6.35	1587398
4		Oct					
5		Nov					
6		Dec					
7	2015	Jan	23526	3	70578	6.35	448170.3
8		Feb	18369	3	55107	6.35	349929.5
9		Mar					
10		Apr	18117	3	54352	6.35	345135.2
11		May	21406	3	64220	6.35	407797
12		Jun	13169	3	39508	6.35	250875.8
Total			211537		634615		4029805
Avg.Monthly			17628.0833		52884.58333		335817.1

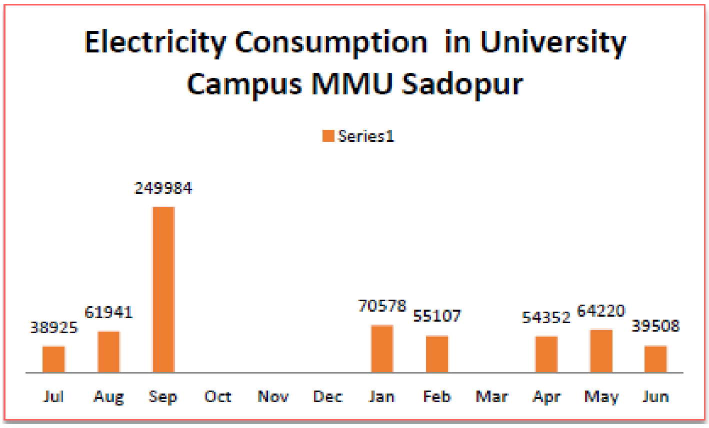

Figure-04, Building and Energy Management System; (Image Source: by Author)

Energy efficiency certificates provided helpful data concerning building envelope, surfaces, volume, walls, windows, doors, and additionally concerning systems (district heating share in total heating consumption, anefficiency of systems, cooling and ventilation requirements', etc)

Majority of data was within the English language that failed to need time beyond regulation to adequately translate and perceive provided information.

<u>1.47 unit/sqm consumption</u>

Figure-05, Problem Illustration Figure-A ;(Image Source: by Author)

Figure-06, Problem Illustration Figure-B ;(Image Source: by Author)

Figure-07, Problem Illustration Figure-C ;(Image Source: By Author)

Figure-08, Problem Illustration Figure-D ;(Image Source: By Author)

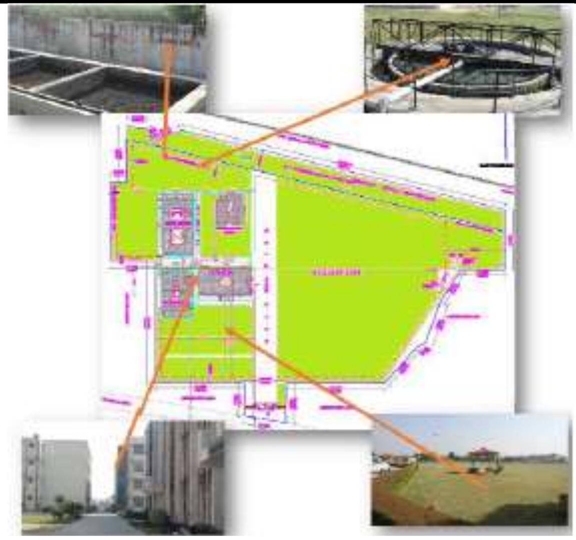

Figure-09, Site Plan and Location of Sewerage Treatment Plant ;(Image Source: By Author)

Table -02: Categorisation of Energy Consumption in Laboratories

Energy Categories	Electricity-related Activities	Electricity-related Activities
Ventilation Related	General supply	Boilers (Total energy minus space heating energy – see below)
	General extract	
	Fume cupboard extract	
	Special area ventilation	
	Electrical heating re ventilation (pumps)	
	Electrical cooling re ventilation (chillers,pumps)	
Space Heating (conventional space and water heating)	Electrical heaters – not present in any of the labs audited	Boilers (based on Carbon Trust benchmark figure per sq.m)
Equipment and Small Power	Scientific equipment, IT equipment other than servers, split DX air conditioning units etc.	
	Central services – gases, compressed air etc.	

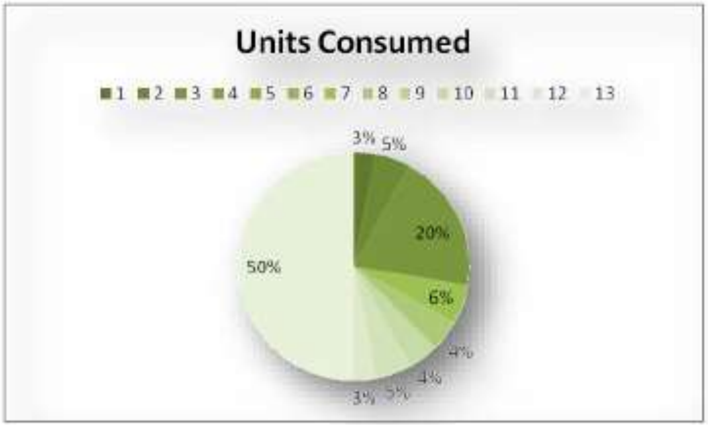

Figure-10, Monthly Consumption Variation Chart ;(Image Source: by Author)

3.3 RESULTS

Electricity consumption breakdown viewed through total consumption by building. The entire variety of every electrical appliance was increased with the desired power consumption and average operative hours to get the entire power consumed by the appliances. The table shows the proportion of consumption by everybuilding.

Table-03, Areas Require Artificial Lighting at Day Time

Sr.No.	Building Name	Area Detected for Artificial Light During Day(SQM)	No.of Floors	Total Area (SQM)	Annual Energy Consumption@ 1.47 Unit/Sqm
1	Architectural Block	307	4	1228	1805
2	B-Block	300	4	1200	1764
3	Hostel Block	164	4	656	964
4	A-Block	85	4	340	500
Total		3424		5033	

Cost saving @ 6.35 Rupees/Unit = 5033X6.35 = 31959 INR.

Table-04, Recommended Energy Conservation Opportunities Energy Use, and Demand, and Savings

Sr.No.	Energy Conservation Opportunity	Est. Annual Energy Savings (kWh)	Est. Annual Electric Cost Savings	Simple Payback (years)
1	Block-A	500	3175	Immediate
2	Block-B	1764	11201	Immediate
3	Hostel Block	964	6121	Immediate
4	Architectural Block	1805	11461	Immediate
	Total of Individual ECOs	5033	31959	Immediate

3.4 Building Built-Up Area and Temperature versus Electricity Consumption

A comparison of the link between the full building built-up space in MM University campus and ambient temperature versus the total electricity consumption was carried out.

There is no clear correlation between the total built-up area of buildings and also the total electricity consumption in building at MM University campus as shown within the table. Although the built-up area of hostel block is the total larger than Block-A, Block-B and Architectural block, the total energy consumption of this building is very low. On the other hand, the total energy consumption of Block-A is exceptionally high even if the total built-up area of the building is very small. This suggests that the total built-up area of the buildings at campus doesn't have an effect on its consumption.

There is no apparent correlation yet between ambient temperature and also the total consumption as discovered.
The total built-up space and ambient temperature had no apparent impact on the electricity consumption of campus. Different vital factors are activities and population within the building as well as electrical appliances used in the building.

3.5 Lighting and Ventilation of Rooms

Habitable rooms shall have opening directly to the external air or into a open verandah not more than 2.40 mt. in width. In case light and ventilation to habitable space area are through an internal courtyard, the minimum dimensions of such courtyard shall not be less than 3.0 m. x 3.0 m. for buildings up to 12.50 m. in height[9].

3.6 Ventilation Shaft

For water closets and bathrooms, if not opening on the exterior or interior open spaces, shall open on the ventilation shaft, the size, of which shall not be less than the values given below:

3.7 Rainwater Harvesting Potential at MM University, Sadopur Campus

Rainfall: the conventional annual rain of the district is 1076 mm, and is unevenly distributed over the area. The typical rainy days are forty four. The south-west monsoon sets in from last week of June and withdraws at the top of the end, conducive regarding eighty one of normal annual rain. July and August are the wettest months. Rest one hundred and ninetieth rainfall is received throughout a non-monsoon period within the wake of western disturbances and thunderstorms. Generally, rain in the district will increase from southwest to northeast. Mean most temperature is forty.8o C (May & June) and mean minimum is six.8o C (January) of the district [10].

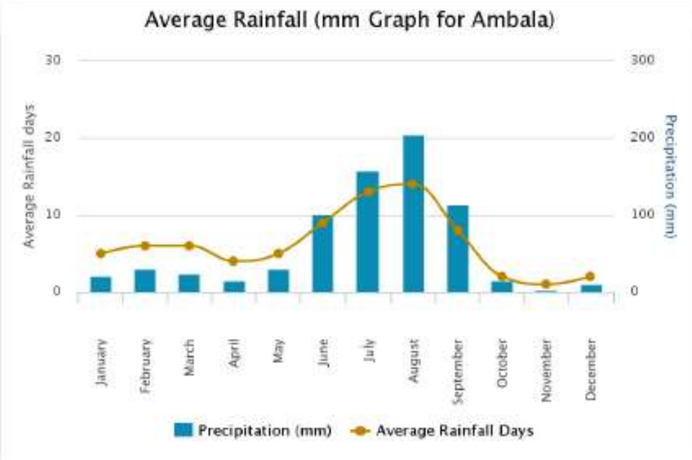

Figure-11, Average Rainfall (mm graph for Ambala) ;(Image Source: by Author)

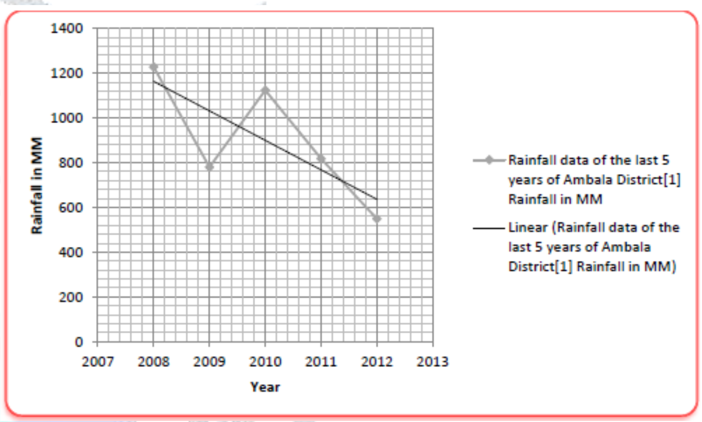

Figure-12, Rainfall data of the last 5 years of Ambala District ;(Image Source: by Author)

Right now there are no active measures to harvest rain water at MM University, Sadopur. Facility to harvest rainwater and recharge groundwater at the campus should be beneficial for energy efficiency at all. Initial calculations showed that 26837467.84 Gallon rainwater can be harvest at the University campus.

Table:07 Proposed Rainwater Harvesting Potential at MMU Sadopur ,Ambala

Type of Catchment	Coefficient	Area (SFT)	Rain Fall Depth (INCH/YEAR)	Harvested Water(GAL)
Roof Catchments				
Tiles	0.85	83850	47.16	3361211
Ground Surface Coverings				
Concrete	0.7	145828.6	47.16	4814093
Brick Pavement	0.55	16608.75	47.16	430797.8
Rocky Natural Catchments	0.35	1104530	47.16	18231366
Total				26837468

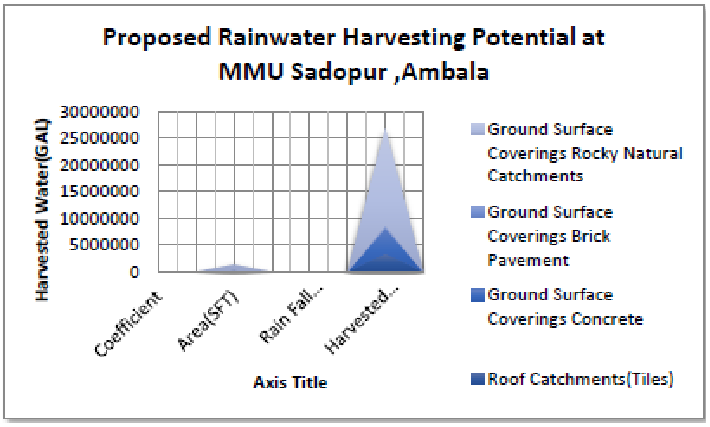

Figure-13, Proposed Rainwater Harvesting Potential at MMU Sadopur, Ambala ;(Image Source: by Author)

The fresh water harvesting structures built in the campus have minimum maintenance activities and recurring prices. The assorted annual maintenance activities include:

1. Removing grasses and weeds and general cleanup in and around the surface water harvesting structure.
2. Spray of bleaching powder around the structure to avert any unwanted bio-contaminants getting into in conjunction with the primary runoff water.
3. Closing the outlet pipe caps before the onset of rains thus keep away keep the primary fresh water from moving into the recharge well. This water is allowed to evaporate keep away a number of it seeps down through Hell bottom.
4. Checking the water for bacteria e-coli before recharging.
5. Cleanup out the chlorophyte that type throughout the monsoons within the recharge trench. This mustbe physically removed and bleach additional. Cleanup out the netlon mesh wrapped around the recharge well casing now so in order that there are not any obstructions to the entry of water into the well.
6. Removing and commutation the sand within the filter compartment each third year with new sand of mixed size.
7. Flushing the recharging bore well each fifth year to get rid of internal impeding in order that adequate recharge rates are maintained.
8. Flushing out the roof water harvesting site of the first fresh water flow by closing the valves provided at the bottom levels of the buildings.
9. Cleanup totally and flushing out the storage tank through an outlet pipe provided. The bleaching powder ought to be sprayed throughout the lowest of the storage tank soon when the cleanup.
10. Gap the water opening valves in order that the roof water comes into the vessel. At constant time the outlet valves permitting tank water into the bore wells ought to even be opened totally.
11. Periodically locking and inspecting the tank to make sure the security and different connected aspects of the structure

Table-08 ,Building database for University campus MMU Sadopur

Sr.No.	Building	Existing Outside Walls Area (Excluding opening)	Existing Outside Glazed Area	Roof Area	Floor Area	Windows,Doors and Glass Area
		SQM	SQM	SQM	SQM	SQM
1	Block-A	2140.6	1434.68	2158	9386.6	1856
2	Block-B	2663.79	1411.38	2221	9858.6	1800
3	Hostel Block	4531.48	1249.96	2099	11459	2626.8
4	Arch. Block	1668.33	1173.54	1286	5309.1	1853.6
5	Time Office & Check Post	40	30	36	36	20
	Total	11044.2	5299.56	7800	36049	8156.4

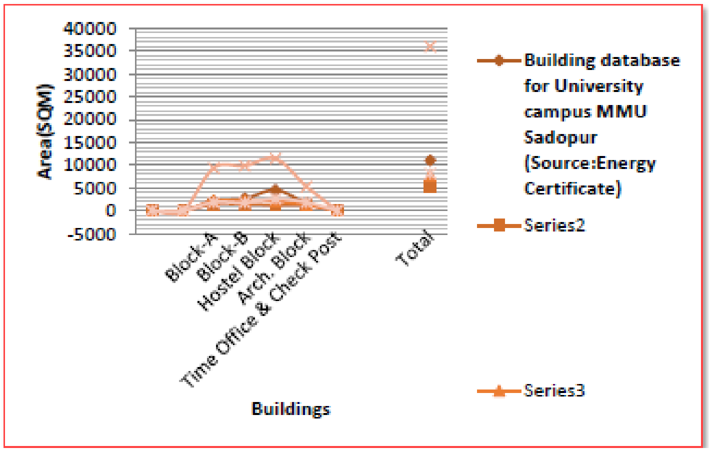

Figure-14, Graphical Representation of Building Database for University campus MMU Sadopur ;(Image Source: by Author)

3.8 Solar Power Harvesting Potential

Factors that have an effect on roof space required the amount of rooftop space needed for solar PV power plants have been the topic of interest. Ground-mounted power plants are sometimes located in lands aloof from cities and therefore are available economically. Hence, the world needed per MW is that if interest, however not of great concern. But for rooftop solar power plants area could be a vital constraint for each residential and industrial rooftop solar power plants.

The extent of roof area needed by a solar PV plant depends on two factors[11]

Shade-free roof area
Panel-efficiency

3.8.1 Calculation of the Total Power Output by Solar Panels

Do remember that solar panels are usually installed at an angle to the earth surface and this may change the results somewhat. Imagine a solar panel has a conversion efficiency of 100% i.e. it converts all the solar energy into electrical energy then all you would need is a 1 m^2 solar panel to produce 1000 Watts of electrical energy[12].

Let's assume that you want to install X solar panels rated at 100 Watts each and having a conversion efficiency of 18%. The total power output of the solar system can be calculated as:
Total Power Output = Total Area x Solar Irradiance x Conversion Efficiency
Total Power Output = (Roof Area + Sun exposed wall Area) x Solar Irradiance x Conversion Efficiency
Total Power Output = (7800+1973) X 1000 X 18 = 175914000

4.0 Concluding Remarks

An energy audit framework was created supported a preliminary audit with walk-through to assess the energy consumption of MM University, Sadopur. The rule was primarily supported the ECBC and BEE, with a couple of modifications created to suit the condition of the campus. The consumption pattern of university campus is often divided into seasonal and diurnal variations. Consumption throughout weekdays is beyond the weekends. Fluctuations were seen throughout the day as a result of differing kinds of electrical appliances was used. Peak hour of MM University campus (9 a.m. to 4:30 p.m.) consumes the next quantity of energy compared with the off-season hour (4:30 p.m. to 9 a.m.). Comparison between the tuition-free week (No workshops and extra labs), semester breaks and study week showed a distinction in energy consumption.

It was conjointly found that the electricity consumption of MM University is affected by the population at the campus, activities conducted and conjointly the categories of electrical appliances used. Once higher population is available within the campus, energy consumption tends to be higher. Moreover, complicateduseful buildings consume additional electricity because of use of varied appliances. Computers consume additional energy as a result of computers need higher power as compared to different appliances such aslighting and printers. Temperature and building built-up area showed no correlation with the energy consumption in mm University field as a result of consumption of a building is ruled by different additionalvital factors such as the utilization and population within the building additionally as electrical appliances used.

Extension of this research leads in two directions as a conceptualization of proposed Energy Efficient Techniques, Refurbishment of Existing Buildings, Proposed Module Conceptualization for New Buildings and Result and Analysis. The study may have the aim to analyze energy efficiency by the adoption of various building envelope measure, material selection, and orientation and design methodologies. Areas lacking daylight and ventilation can be identified and remedies can be suggested to minimize energy consumption throughout the buildings.

References

[1]. Dober, R.P. (1991), Campus Design, Publisher: Wiley; 1 edition, ISBN-13: 978-0471542582
[2] https://www.eex.gov.au/sites/g/files/net1896/f/files/2014/06/ESMG.pdf , Energy Savings Measuremnt Guides.
[3]Krigger , J.T., Dorsi , C., (May 1, 2009) Residential Energy: Cost Savings and Comfort for Existing Buildings, Publisher: Saturn Resource Management; 5th edition (May 1, 2009), ISBN-13: 978-1880120095
[4] https://epdf.tips/leed-practices-certification-and-accreditation-handbook.html , LEED® Practices, Certification, and Accreditation Handbook, Accessed on [05 August 2018]
[5] www.grihaindia.org/files/Manual_VolI.pdf ,GRIHA Manual
[6] Advances in research and applications of energy-related occupant behavior in buildings, Energy and Buildings, ISSN: 0378-7788, Vol: 116, Page: 694-702, Publication Year: 2016
[7] Real-time, appliance-level electricity use feedback system: How to engage users? , Energy and Buildings, ISSN: 0378-7788, Vol: 70, Page: 455-462, Publication Year: 2014
[8] www.undp.org/.../energy_efficiency_improvements_in_commercial_buildings, UNDP/GEF EE Improvements in Buildings
[9] General building Requirements mohua.gov.in/upload/uploadfiles/files/Chap-4.pdf
[10] http://cgwb.gov.in/District_Profile/Haryana/Ambala.pdf , Ground Water Information Booklet Ambala District Haryana
[11]http://www.cercind.gov.in/2011/WhatsNew/PERFORMANCE%20OF%20SOLAR%20POWER%20PLANTS.pdf , Performance of Solar Power Plants in India
[12]Chaichan, M.T., Kazem ,H.,A., Generating Electricity Using Photovoltaic Solar Plants in Iraq , Hardcover: 211 pages ,Publisher: Springer; 1st ed. 2018 edition (April 24, 2018) ,ISBN-13: 978-3319750309
[13] Proceedings of 8th International Symposium on Heating, Ventilation and Air-conditioning, Volume-01 Indoor and Outdoor Environment (Springer Publication)

[14] www.scirp.org/journal/PaperDownload.aspx?paperID=59912
[15]http://www.researchgate.net/publication/245197026_A_method_for_heating_consumption_assessment_in_existing_buildings_A_field_survey_concerning_120_Italian_schools
[16] Energy and Power Engineering, 2015, 7, 465-476 Published Online September 2015 in SciRes. http://www.scirp.org/journal/epe http://dx.doi.org/10.4236/epe.2015.710045
[17] www.worldenergyoutlook.org/media/weowebsite/2009/WEO2009.pdf
[18] http://www.carbse.org/ Centre of Advanced Research in Building Science and Energy
[19] Renewable and Sustainable Energy Reviews, Reducing energy demand: A review of issues, challenges and approaches, ISSN: 1364-0321, Vol: 47, Page: 74-82