International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 01 | Jan 2021 www.irjet.net p-ISSN: 2395-0072

GREEN BUILDING:" A SUSTAINABLE APPORACH"

H NARENDRA KUMAR[1], SHREYAS P[2], SINCHANA S[3], RASHMITHA K B[4]

[1]H NARENDRA KUMAR, Associate Professor, Dept. of Civil Engineering, SJBIT, Karnataka, India
[2]SHREYAS P, MTech student, Dept. of Civil Engineering, RVCE, Karnataka, India
[3]SINCHANA S, M.Tech student, Dept. of Civil Engineering, SJBIT, Karnataka, India
[4]RASHMITHA K B, BE(CIVIL ENGINEERING), SJBIT, Karnataka, India

---

Abstract – *The term green building is used to refer to both the structure and the using process that are eco friendly and economical. Here in this paper we did a case study on how the green building is more economical in terms of energy and water efficiency than compared to that of the conventional buildings, for this study we have chosen SJBIT civil and mechanical block. This study also includes the green solutions for all the problems that are encountered and the cost for the installation and the amount we can save while using the more efficient ones.*

***Key Words*: SJBIT CIVIL AND MECHANICAL BLOCK, COMPARISION, GREEN SOLUTIONS, ENERGY EFFICIENCY, WATER EFFICIENCY.**

1. INTRODUCTION

Green building (also known as **green construction** or **sustainable building**) refers to both a structure and the using of processes that are environmentally responsible and resource efficient throughout a building's life cycle: from siting to design, construction, operation, maintenance, renovation and demolition.

"A **Green building** is one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier space and comfortable environment in all climates for occupants as compared to conventional buildings."

It remains cool in summer, warm in winter, fully protected from rain, gives natural pollution free air and light through doors, windows and ventilators without any artificial means.

A green building should have all safety devices. It should be provided with potable water, having proper drainage, sewerage and rain water harvesting system. The building should be provided with trees, plants and grass to provide natural greenery. Green building encompasses effort to reduce waste, toxicity, and energy, and resource consumption in buildings.

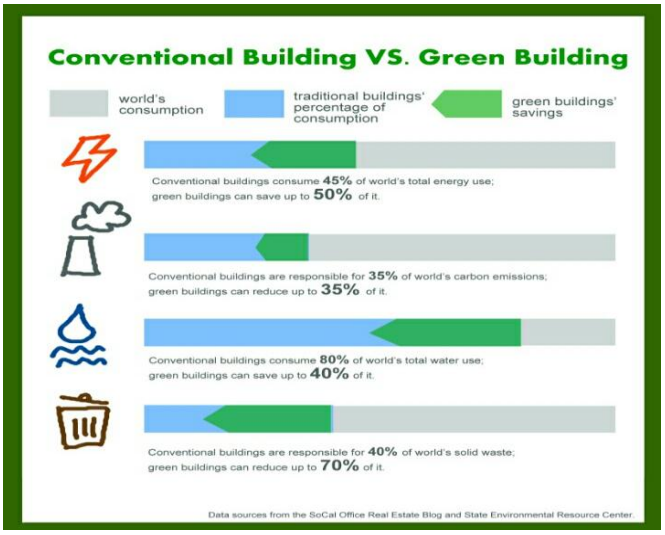
1.1 BENEFITS OF GREEN BUILDING

ENVIRONMENTAL BENEFITS: Green buildings are designed to make the best use of the natural resources, they are more eco friendly than compared to the natural buildings.

ECONOMIC BENEFITS: The overall cost of the green buildings are less than compared to that of the natural buildings as they use less resources. The property value increases in case of the green building.

SOCIAL BENEFITS: Green buildings help to maintain good health of the eco system that occupies it. It also helps to reduce the load on the infrastructure.

1.2 CONVENTIONAL BUILDINGS V/S GREEN BUILDINGS



2. EVALUATION OF RESOURCES IN SJBIT

Sir Jagadguru Balagangadharanatha Institute of Technology was established in the year 2001 with the intention of providing quality education in the field of technology and thereby serving our society. SJBIT is having five blocks, namely Admin block, Mechanical block and Civil block, EC and EEE block, MBA block, CSE and ISE block. Out of these we are considering only Mechanical block and Civil block for audits and resource evaluation.

FIG 1: SJBIT CIVIL AND MECHANICAL BLOCK

For our evaluation process we have considered water and energy as main parameters, so we will be explaining in detail about the same. Following are the places where renovation can be done to achieve green buildings criteria.

2.1 INEFFICIENT USAGE OF WATER

- Insufficient supply of water to washrooms and urinals.(water is not available throughout the day in all washrooms)
- Efficient plumbing fixtures and flow controlling devices are not used.
- Wastage of water due to leakages in taps and improper closing off after its usage.
- Rain water harvesting is not implemented.
- The waste water reuse and recycling techniques are not implemented

2.2 INEFFICIENT USAGE OF ENERGY

- Tube lights are used in classes, hallways and library which are consuming more power and even their efficiency have reduced over years.
- Improper window openings and poor ventilation openings. Older model of Air conditioning systems which are using more power and have Freon refrigerant.
- Currently no available on campus power generation units are installed.
- Wastage of electricity due to negligence by the residents to switch off electrical appliances before leaving the halls and class rooms.
- In spite of availability of Natural sunlight, it is not effectively utilized.

2.3 OBJECTIVES OF PROPOSED WORK

1. Conservation and efficient usage of water.
    - Renovation of existing plumbing fixtures with efficient ones.
    - Implementation of rain water harvesting technique.
2. Conservation and efficient usage of energy.
    - Replacement of existing electric fixtures with high efficient ones.
    - Comparison between EC and EEE block and mechanical and civil block installed solar panels.
    - Implementation of natural ventilation process.
    - Driving energy from renewable sources.

2.4 METHODOLOGY

We are carrying out study of introducing green retrofitting in any existing building and for that purpose we have selected the campus of SJB institute of technology, Bangalore. In the present project we are considering the rating system of IGBC and suggest measures to improve the green performance of the building, thereby increasing its rating on implementation.

3. WATER EFFICIENCY

Water is a precious resource, and although it flows freely from the tap, it's not infinite. Green campus lawns, clean washrooms and cafeteria plates, and even air conditioned dorms don't happen without using lots of water. As major institutions, colleges are serious users of water, and although some don't yet recognize the need to conserve water, nowadays many of them do. In fact, college campuses are home to some of the most innovative ideas for water conservation, implementing water management technology, smart conservation policies and more. Conserving water saves money in two ways by reducing the amount of water used (which households and communities pay for it), also saves the community money, by lowering the impact on water and sewage treatment facilities.

In order to evaluate any resource proper analysis of resource is to be done. Thus to get a detail picture of water and energy resources we have conducted water and energy audits which are explained in detail.

3.1. SOURCES OF WATER

1. Sri Sai Ganga water supply.
2. BWSSB water supply.

The water from Sri Sai Ganga and BWSSB water supply are collected in a common underground sump. This sump serves as supply for all blocks, SJBIT hostels and canteen.

Measurement of quantity of water

As mentioned earlier one common sump serves as supply for all the blocks in surrounding. But we need water consumption of Civil and Mechanical block exclusively. There is neither a separate pipe supply from sump nor an exclusive energy meter. Moreover all the pipes are G.I ones its very tedious to fix a flow meter to those pipes. Thus the other ways to measure quantity of water are

According to information collected from pump house operator, the water is filled to overhead tanks thrice a day on weekdays and once on weekends.
The no of overhead tanks in civil and mechanical block are:-

- 4nos - 3000L capacity
- 2nos - 2000L capacity
- 2nos - 500L capacity

Thus for one cycle of filling yields 17,000L, three such cycles gives 51,000L/day

So average consumption can be taken as 51,000 liters/day.

Estimating the quantity by knowing the population and demand.

Teaching , non-teaching and outsource	100
UG students	1500
TOTAL	1600

TABLE 1: POPULATION DETAILS OF CIVIL AND MECHANICAL BLOCK

Consider total population as 1600, According to standards the water demand for institutions is 25–60lpcd, so taking 45lpcd. Thus total water consumption is 1600*45=72000 litres/day.

Estimating the quantity of Water by considering its individual usage.
The average demands for different works are considered for computation.

1. Drinking.
The standard demand for drinking is 5 lpcd. The people in institute stay only for 6 hours (average), and the water is not available in all floors conveniently so we consider 3 lpcd as the drinking demand.

Quantity = 3*1600= 4800 litres per day

2. Floor cleaning.

The standard usage for floor cleaning is 1.5 l/sqm . The grand total floor area of Civil and Mechanical block is 11768.34 sqm(11768 sqm).
Total quantity of water is given by 1.5*11768=17652 litres per day.

3. Usage by fixtures.
The usage pattern of washrooms reaches maximum during 10:45 to 11:00 AM [Tea break] and almost reaches minimum during remaining hours. Any how the fixtures will be in use only between 8 AM to 5 PM.

Consider the population as 1400 since complete population of block will not present in a day and the usage as 15 lpcd [standard]
Quantity = 1400*15 = 21000 litres per day.

Sl.no	Description	Quantity[lpcd]
1	Drinking	4800
2	Floor mopping	17652
3	Wash rooms	21000
4	Wastage and miscellaneous	700
	Total	44152

Table 2: Water Usage per day

Hence the water consumption is obtained in three methods. The values obtained from method 1 and 3 are likely to be accurate why because they involve practical investigation and observations. Method 2 is completely based on theoretical standards. Finally we may conclude that water requirement for Civil and Mechanical block ranges 51000-44000lpd.

3.2 CONSERVATION AND EFFICIENT USAGE OF WATER

Up to half of the water consumed in a building is used in the bathroom. Thus conserving water in it achieves the major water efficiency. The major renovation in bathroom is with plumbing fixtures, as they are flow controllers.

A complete data is to be collected regarding the flow of the taps/faucets, flushes, shower heads and urinals. The flow is measured in terms of litres per minutes [LPM] for taps and showerheads whereas litres per flow [LPF] for flushes, closets and urinals. If the flow rates are more than the baseline criteria [IGBC standards] retrofitting is to be done.

Flow rates of Fixtures.

The flow rates of existing fixtures are measured in order to compare with the flow rates of renovating fixtures.

Taps.

The Flow rates of taps are measured using the basic concept of ratio of Volume to Time. The time required to fill one litre container is noted and ratio of volume and time gives the flow rate. The average values of flow rates are considered because the fixtures are old ones which are not specified with the flow rates, and the flow rate is the function of pressure head, it is going to vary with different floors heads.

a. Conventional type:-
For full flow 24 l/m, for half flow 13.5 l/m average flow can be taken as 18 l/m.
b. Aerator type
Average flow rate computed is 4.5 l/m
Urinals:-
Average flow rate is 16.5 l/m
Toilet flushes:-
Average volume of water per flush is 8 litres.
Total no taps, urinals flushes are counted and listed:-

DESCRIPTION	TAPS		URINALS	FLUSHES
	C	A		
Lower basement floor	4	2	0	0
Basement floor	12	4	4	4
Ground floor	4	2	2	2
First floor	10	3	6	4
Second floor	10	3	4	4
Third floor	10	3	4	4
Total	50	17	20	18

Table 3: Count of Water Fixtures

3.3 QUANTITATIVE SAVINGS OF WATER BY REPLACING WATER FIXTURES

For this we conducted survey for Civil and Mechanical block to know the flow rate of taps on each floors and calculates the average discharge. Then we calculated the flow rate of taps at different level by attaching aerators.

Conventional taps

Flow rate at full opening = 24 lit/min

Flow rate at half opening = 13.5 lit/min

Average flow rate = 18 lit/min

Complete discharge from all taps = 50 X 18

900lit/min

Urinals

Average flow rate = 16.5lit/m

Number of urinals = 20

Total discharge/min = 16.5 X 20

= 330lit

Aerator taps

Flow rate at full opening = 16lit/min

Flow rate at half opening = 10lit/min

Average flow rate = 13lit/min

Complete discharge from all taps = 50 X 13

= 650lit/min

Water savings after replacements = 250lit/min

Percentage savings $= \frac{water\ savings}{complete\ discharge} X\ 100$

$= \frac{250}{900} X\ 100$

$= \quad 27.78 \quad \%$

Waterless Urinals

Hence by replacing conventional urinals with waterless urinals we can save complete water usage.

Cost details of fixtures.

Cost of aerator tap = Rs.140

Cost of waterless urinals set = Rs.6565

Cost of Blue Seal liquid = Rs.2430

3.4 IMPLEMENTATION OF RAIN WATER HARVESTING

Rain water harvesting is the collection and storage of rain water for reuse onsite, rather than allowing it to runoff. These stored waters are used for various purposes such as gardening, irrigation and recharging ground water etc. There are various options available once the water is collected it can be used in 2 forms

i. Storage tanks

ii. Recharging structures

3.5 RWH AT SJBIT

Pre-requisites done at the college

- We have done the reconnaissance survey at our college.

Sl no	Sump location	Dimensions	Capacity [litres]
1.	near pump house	6.8*4*2.42	65824
2.	In quadrangle	5.3*4.35*2.2	50721

Table 4: Capacity of sumps

- Annual average rainfall of Bangalore is collected from Meteorological department.

Sl no	Year	Average rainfall(mm)
1	2008	750.7
2	2009	712.5
3	2010	1120.4
4	2011	635.2
5	2012	713.2
6	2013	782.5
7	2014	826
8	2015	1072

9	2016	951
10	2017	1115.2
Average Rainfall		868.00

Table 5: Annual Rainfall Data

3.6 COST OF INSTALLATION

SL No	DESCRIPTION	QTY	UOM	PRICE	Total
1	90mm RWH Pipe 4Kg Pn4	6	Mtrs	208	1248
2	90mm Right angled adapter	10	Nos	148	1480
3	110mm RWH Pipe 4Kg Pn4	150	Mtrs	275	41250
4	110mm Right Angled Adapter	40	Nos	176	7040
5	110mm Equal Tee	25	Nos	217	5425
6	110mm 45 Deg Bend	40	Nos	185	7400
7	110mm Coupler	20	Nos	139	2780
8	110mm x 40mm Reducer Coupler	7	Nos	152	1064
9	110mm x 90mm Reducer Coupler	6	Nos	181	1086
10	110mm x 160mm Reducer Coupler	10	Nos	276	2760
11	160mm RWH Pipe 4Kg Pn4	100	Mtrs	549	54900
12	160mm Right Angled Adapter	10	Nos	496	4960
13	160mm Equal Tee	15	Nos	578	8670
14	160mm 45 Deg Bend	15	Nos	592	8880
15	160mm Coupler	10	Nos	367	3670
16	Fastener unit [coach bolts, wooden gutta, pluggers, solvent cement]	1	Nos	4500	4500
17	L Angled hot spray galvanised antirust powder coated special clamp	175	Nos	220	38500
18	U Bolts & Nuts	175	Nos	48	8400
19	**RWH FILTER** RAINY FL- 500 Filter [First of its kind, Wall mounting, Maintenance free, Self Cleaning,]	3	Nos	20975	62925
20	**INSTALLATION** Installation Of Filter Installation Of Rainwater Pipeline By Skilled Technicians and supervised by the site Engg [In mtrs] Trenching, Core Hole & Redoing	3 260 35	Nos Mtrs Mtrs	1250 156 450	3750 40560 15750
21	Transportation	1	Nos	2500	2500
			TOTAL		**329498**
			SGST @ 9%		**29655**
			CGST @ 9%		**29655**
			GRAND TOTAL		**388808**

Table 6: Cost of Installation of RWH

3.7 BENEFITS OF RWH AT SJBIT

- The average water demand of Civil and Mechanical block is around 44000lts per day. The quantity of water collected for 25mm rainfall is 42240lts. Therefore this water meets around 70% of daily demand.
- As there is no intake of groundwater during rainy days pumping cost from bore wells will be reduced.
- There is an additional benefit of RWH i.e. ground water table can be recharged which indirectly adds to social responsibility.

3.8 SUMMARY

SL.NO	PARAMETERS	VALUES
1.	Roof area	1961 sqm
2	Average rainfall	868mm
3.	Total amount of water that can be collected at Civil and Mechanical block Method 1 Method 2	 16,89,400 lts 13,61,718lts
4.	Capacity of sump near pump house	65824lts
5.	Capacity of sump in quadrangle	50721lts
5.	Total cost of installation	3,88,808/-

Table 7: Summary of RWH

4. ENERGY EFFICIENY

Few problems facing mankind today rival the importance of using the earth's exhaustible energy resources efficiently. The fundamental economic question is: how fast should we consume our low-cost resources, which, most efficiently, should be used before our more expensive resources. A set of forecasts and evaluations of the market - determined the economically efficient paths of energy production and consumption over time is presented.

4.1 SOURCE OF ENERGY

The solitary source of energy in SJBIT campus is electricity which is supplied by BESCOM K1 station Kengeri.

4.2 Calculative comparison between fluorescent and LED tube light

The light-emitting diode (LED) Lights is environment friendly and more secure than fluorescent because it works at much lower temperatures. An incandescent bulb gives off more energy as heat rather than light, something to do with the resistance of a Tungsten filament, therefore LED is considered better than fluorescent even when the lumens per watts is the same. In our college there is total of 234 tube lights all around the building i.e. in corridors, libraries, laboratories, classrooms, staffrooms etc.

Existing tube-lights (Wipro-35watt, 6500k)

- Total tube lights of 35watt = 234
- Recorded watt consumption of each tube light= 46.5 watts
- Monthly consumption by tube lights (Actual) = 0.5 X 234 X 46.5 X 5 X 28
  =762 units/month

New LED tube-lights

- Watt consumption by LED tube-light =20 watts
- Total energy consumed by LED tube-light = 0.5 X 234 X 20 X 5 X 28
  =328 units/month
- Total energy saved = 762 - 328 = 434 units/month
- Savings in cost per month = 434 X 9 = Rs. 3900 /-
- Cost of each LED light = Rs.350 (lifetime-40,000 hrs.)
- Cost of each fluorescent tube light = Rs.80 (lifetime-15,000 hrs.)

The light emission, efficiency, lifetime and cost of products vary with the different brands, so we can't get a clear picture in terms of number of fixtures. Thus savings is indicated in terms of units of electricity.

4.3 Calculative comparison between existing and BLDC fans

Ceiling Fans are arguably the most ignored appliance when it comes to energy savings. People talk about big appliances like AC and refrigerator consuming a lot of energy. But what most people do not understand is that Ceiling Fans cumulatively consume more electricity than a refrigerator in a house. In fact, after Air Conditioners (if used), it is the second biggest contributor to electricity bills of any household.

In our own building we have 128 fans and most of them are outdated and are consuming too much power to produce less energy than what it used to consume during initial stages. According to data we collected from electrical department, currently the average consumption of fan is 39-60 watt/hr. below we have elaborated how we can save energy by replacing the existing fan (USHA company) with BLDC fans.

Existing fan

- wattage consumption of existing fans =
  39 (1speed) – 60 (5 speed) watts
- Power consumption per hour =
  0.039-0.06 ~0.05 units
- Daily electricity consumption =0.05 X 6 = 0.3 units
- Monthly consumption by all fans =
  0.6 X 128 X 0.3 X 28
  =646 units

BLDC fans

- Power consumption per hour = 0.03 units
- Daily electricity consumption =0.18 X 6 =0.18 units
- Monthly consumption by replacing
  all fans with BLDC fans = 387 units

Monthly savings that can be achieved by replacing the fans = (646 - 387) X 9= **Rs.2330**

With the above calculation, you would have already realized the cost-benefit of having a BLDC fan. Energy saving is the key forte of BLDC fans. BLDC fans would be way forward in future.

4.4 Proposal for Installing Solar Panels in SJBIT

This proposal provides an outline and estimate of costs for installing a solar energy system for our Institution at Bangalore. This estimate is based on our average monthly electricity usage and roof space available at our institution. The goal is to utilise the idle roof space to get financial savings while using solar energy.

By installing an on-grid solar energy system at our institution, we will be able to:

- Reduce our electricity bills.
- Become an independent power producer.

- Secure our self from electricity price hikes.
- Lead the way for green institution.

OUR PROPOSAL

Based your annual electricity consumption pattern we recommend a 256 kWp, On-Grid solar energy system to be installed on your roof space. This system will be on a net-metering connection synchronized with BESCOM's electricity grid. This system will generate enough power to reduce your electricity bills for the next 25 years.

Mechanical Data	
Length × Width× Height Weight	1956 mm × 992 mm × 40 mm
Weight of panel	27 kg
Frame	Anodized aluminium frame with twin wall profile
Mechanical Load Test	5400 Pa
Warranty and Certifications	
Product Warranty	10 Years
Performance	Linear power
Warranty	warranty for 27 years with 2.5% for 1st year degradation and 0.67% from year 2 to year 27

Table 8: MECHANICAL DATA

4.5 SYSTEM COST SUMMARY

	Component	**Cost**
1	SOLAR PANELS (330 W)	**Rs. 1.15 Crore + tax***
2	ON-GRID INVERTER	
3	WIRING + MOUNTING + ACDB + DCDB + EARTHING	
4	LABOUR + INSTALLATION + TRANSPORT	
	SUB TOTAL	

Table 9: System Cost Summary

4.6 SUMMARY OF SOLAR INSTALLATION

PARTICULARS	**QUANTITY**
Avg power consumption in SJBIT	84,000 units/month
One solar panel produces	330 watts
Roof area available	2190sqm
Dimension of one solar panel	992*1956mm
Total solar panel	778
Electricity produced	778*330
Total capacity of plant	256Kw
1kw produces	4 units/day
Total units produced /day	256*4 =1024 units/day
For 1 month	30720 units/month

Table 10: Summary of Solar Installation

5. DRIVING ENERGY FROM RENEWABLE SOURCES

In our campus we have two hostels [SJBIT men's hostel and ladies hostel] and both are having their own individual mess and three canteens, where daily a large amount of kitchen waste is obtained which can be utilized for better purposes. Biogas production requires Anaerobic digestion. Aim is to create an Organic Processing Facility to create biogas which will be more cost effective, eco-friendly, cut down on landfill waste, generate a high-quality renewable fuel, and reduce carbon dioxide & methane emissions. Overall by creating biogas reactors on campus in the backyard of our hostels will be beneficial.

Normally bioreactors will be constructed near the waste generating source and it should be in backyards of building so that any nuisance should be avoided. In this project we are proposing to install readily available bio reactors. Because these are easy to install, readily available, good aesthetic view, suitable for congested places [for our campus]. For that many biogas units are available in market one such system is HBT-BG-2000, a model developed by Era Hydro- Biotech Energy Private Limited.

Survey conducted by us for a period of 1 week following details are recorded

Days of week	**Waste collected in (kg)**
Monday	82
Tuesday	96
Wednesday	103
Thursday	93
Friday	87
Saturday	108
Average waste per week	**94.83**

Table 11: Data on Waste Collection

This waste can be utilized to generate biogas and also electricity. For that many biogas units are available in market one such system is Nano Biogas plant-500, a model developed by Biotech India.

1 kg of waste will produce 0.04 m3 of biogas. Hence, 1/0.04 = 25 kgs is required to produce 1 m3 of Biogas. The capacity of one unit is 20-30kg thus one unit produces approximately 1m3. We know that 1m3 of biogas is equivalent to 0.45kg of LPG.

The average waste produced by our canteen is 80~90kg so we require 4 units so that we can completely utilize the waste generated. Total amount of biogas produced by all four units is 3.2 m3(equal to 1.44kg of LPG) per day.

Fig 2: Biogas generator

5.1 SUMMARY

Sl no	Description	Value
1	Qty of waste feed, Kg/day	20 -30
2	Amount of Bio gas produced (avg.)	1m^3
3	Equivalent saving in LPG(approx.)	0.45 kg
4	Space required	6 m2
5	Water required Lit/day	20
6	Duration of gas production	Normally gas production starts after 10-14days after installation. Gas generates as per amount of feeding.
7	Resultant slurry	The resultant slurry mass produced from these Bio gas plants, is a rich fertilizer.
8	Cost	22000 per unit

Table 12: Summary of Biomass Energy Generatio6.

6. CONCLUSIONS

In this case study "Green Building: A Sustainable Approach" we have tried to incorporate the green building concepts to our college building. Green or sustainable building is the practice of creating healthier and more resource efficient model of construction, renovation, operation, maintenance experience increasingly demonstrate that when buildings are designed and operated with their lifecycles impacts in mind, they can provide great environmental, economic and social benefits.

We have conducted water audit and power audit to know the total system consumption. Based on the data collected on water and energy we have provided effective solutions to curtail the resource consumption. Likewise, for every problem identified, a detailed solution cost of implementation and return on investment is estimated.

We have suggested installing rainwater harvesting system knowing that Bangalore receives good rainfall and our college has large roof area. We gathered details needed for implementation and worked on it and presented the possible approach to install RWH. Along with it we have provided with quotation for complete installation of Rainwater harvesting system.

Based on power audit we discovered many electrical equipment are consuming more power than needed, hence we suggested to replace these electrical fixtures with efficient ones to reduce power consumption and provided with calculative comparison of amount of energy that can be saved.

Moreover, we have put efforts to utilize renewable energy as much as possible. So we thought of installing solar plant on our campus and suggested to go for on-grid system. We surveyed the roof area to know the number of panels that

can be installed, based on number of panels we came up with cost of installing the solar power plant.

Apart from these, we located rooms that don't receive good ventilation and sunlight and provided solution for the same. Also, we have suggested the ways to utilize waste generated from canteen kitchen and turn it into useful biogas energy. With help of these concepts were trying to bring a green impact on our surrounding and hope this case study act as model for other colleges and institution to bring this positive change.

REFERENCES

- "Green buildings: A step towards environmental protection",Akshey B, Swati B and Disha, iMedpub journals, waste recycle volume 3 no1:7 may29,2018,pg-4.
- "Green quotient evaluation of existing building: A case study", Sunita Bansal, S K Singh, Srijit Biswas, International journal of advanced research (2015),volume 3 Issue 1262-1269.
- "Developing Green Building Concept in India", Priyanka Rajiv Parikh, international journal of technical research and applications, Volume4, Issue 1 (January - February, 2016) pg77-80.
- "Energy use and the building envelope", Jodi SmitsAnderson, Journal of green building summer (2019) volume 4,PP 179-204.
- "how do smart buildings make a building green", Jim Sinopoli PE and RCCD, Talyor and Francis, Journal of energy engineering (2008), volume 105 issue 6.
- Code book of IGBC green existing buildings.
- https://www.igbc.in/igbc/.