

Sustainable Energy Assessment and Optimization for Higher Education Institute! A Pathway to Achieve SDG 7 and 12

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Abstract: -This research paper presents an energy audit conducted on Bharati Vidyapeeth College of Engineering for Women Pune having connected load of 133.8 kW. In this college major electricity consuming systems such as Computers, Smart Boards, Printers, Illumination, water pumping system, Air conditioners are analysed. The average electricity consumption per month is 9 kWh. The monthly average electricity bill is **Rs. 258911/-**. To assess its energy usage patterns, identify energy-saving opportunities, and propose strategies for reducing energy consumption and associated costs. Based on the collected data, energy-saving opportunities are identified and prioritized. Recommendations are provided for improving energy efficiency through measures such as upgrading lighting systems to LED, implementing energy management systems. Additionally, behavioural changes and awareness campaigns are suggested to engage the institute's occupants in energy conservation practices. The recommended strategies aim to decrease consumption of energy, running costs must be lower, with contributing healthy sustainable environment.

Keywords: Energy Audit, Energy Conservation, Power factor

1. Objective

- 1) Energy audit is to be conducted of HT –II consumer.
- 2) Selection of study area-Bharati Vidyapeeth College of Engineering for Women
- 3) To find major energy consumption equipment and process.
- 4) To observe and analyse current operational practices.
- 5) Scheduling of flexible loads so as to gain benefits of TOD tariff.
- 6) Giving suggestion and recommendation to all concerned people.
- 7) Improvement of energy efficiency by discussion of recommendation with top management.
- 8) To Study the present CO2 emissions
- 9) To find possibility for use of Renewable Energy

2. Introduction

Higher education institutes, such as universities and colleges, are known for their substantial energy requirements due to their size, diverse facilities, and round-the-clock activities. Energy audits provide a comprehensive assessment of energy consumption patterns, energy-saving potential, and opportunities for sustainable practices within these institutes. By identifying inefficiencies and suggesting improvements, energy audits can contribute to reducing operational costs, minimizing environmental impact, and enhancing the overall campus sustainability. The outcomes of an energy audit enable higher education institutes to make informed decisions regarding energy management, infrastructure upgrades, and policy development. By implementing the recommended energy-saving measures, institutes can significantly reduce their carbon footprint, contribute to national sustainability goals, and create a culture of energy consciousness among students, faculty, and staff.

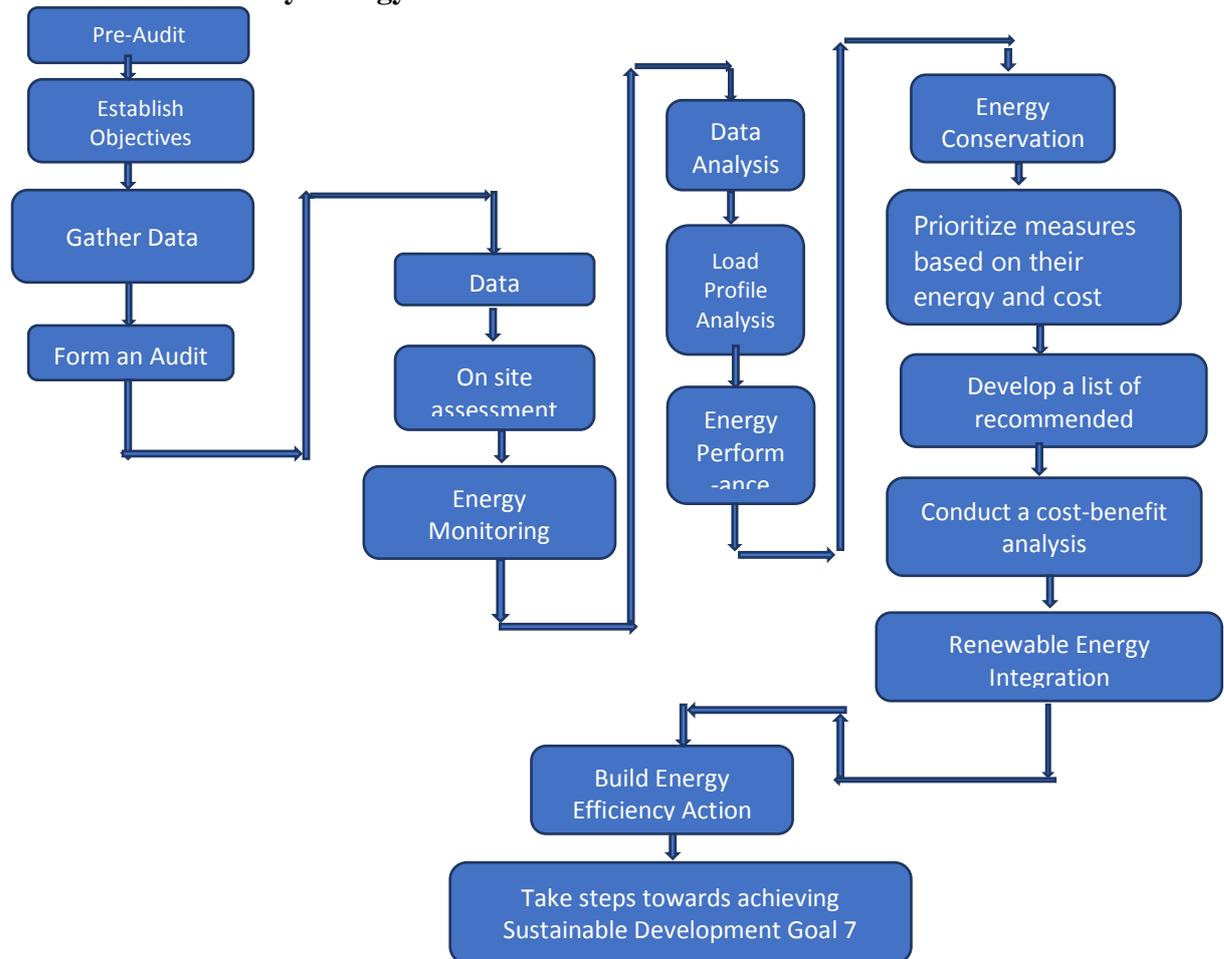
This paper presents a methodology for carrying out energy audits in higher education institutes in India. By adopting and implementing the findings of energy audits, higher education institutes in India can serve as role

models for energy-efficient and sustainable practices. Furthermore, these audits can contribute to the larger national objective of reducing energy consumption, mitigating climate change, and fostering a greener future for generations to come.

3. Literature Survey

- 3.1 **Inspection of Energy of Building: A Corporate Building Case Study in Shanghai [1]:** The Energy audit has been started by authors with reviewing energy used data in past. Previous 4 to 5 years data presented by authors on consumption of energy by referring electricity bills. This data is used for conduction of energy audit.
- 3.2 **Reconstructing the library building a case study [2]:**Data is recorded by using Data acquisition and system monitoring within the library. Data is collected and compared with respect to time software is used. Electronic ballast is used for lightening load, fluorescent tube of 26-mm is installed for energy savings. [2]
- 3.3 **Conservation of Energy in India – Problems and Solutions [3]:** Because of increasing gap between electricity demand and electrical supply Energy Conservation is coming in role to reduce this gap. Energy conservation with Cost effectiveness is done with less pay-back period and effective equipment utilization.

4. Methods use to carry Energy Audit



4.1 Pre-Audit preparation

- Establish Objectives: Clearly mention the objectives and scope of the energy inspection is to be assessed.
- Gather Data: Collect relevant information about the institute's energy consumption, utility bills, building plans, equipment specifications, and operational schedules.
- Form an Audit Team: Assemble a team of faculty.

4.2 Data Collection:

a. On-Site Assessment: Conduct a comprehensive on-site assessment which includes measuring and recording data on energy consumption, equipment performance, and lighting levels.

b. Energy Monitoring: Deploy energy meters and data loggers to capture real-time energy consumption patterns of major equipment, HVAC systems, lighting, and other energy-intensive systems.

4.3 Data Analysis:

a. Load Profile Analysis: Analyze energy consumption patterns on a daily basis to find maximum demand periods require for load management.

b. Energy Performance Indicators: Calculate energy performance indicators (EPIs) such as specific energy consumption (SEC) and energy intensity to assess the institute's energy efficiency.

c. Identify Energy Inefficiencies: Analyze collected data to identify energy inefficiencies, areas of wastage of energy, and energy-saving measures.

4.4 Energy Conservation Measures:

a. Prioritize Measures: Evaluate the potential impact, cost-effectiveness, and feasibility of energy-saving measures identified during the audit. Prioritize measures based on their energy and cost savings potential.

b. Recommendations: Develop a list of recommended measures, including equipment upgrades, operational improvements, and behavioural changes.

c. Renewable Energy Integration: find out possibility of incorporating renewable energy sources to create clean energy on campus.

4.5 Energy Efficiency Action Plan:

a. Develop an Action Plan: Prepare a comprehensive energy efficiency action plan

b. Budgeting: Estimate the financial resources required for implementing the recommended measures.

c. Prioritize and Phasing: Prioritize the recommended measures based on their urgency and potential impact. Determine a phasing strategy if necessary, considering budget limitations and implementation complexities.

4.6 Implementation and Monitoring:

a. Execute the Action Plan: Implement the recommended energy-saving measures according to the established timeline and responsibilities.

b. Monitoring and Verification: Establish a monitoring system to track energy consumption, performance, and savings after the implementation of the measures. Compare the actual results with the projected savings.

5 Instruments used for Energy Inspection are:

1.Lux meter 2.Anemometer 3. Portable Power Analyzer 4.CO2 Meter 5. Digital Temperature Indicator

6. Conduction of Energy Audit as per above Methodology

6.1 Pre-Audit Preparation [7]:

This is the first phase of energy audit .it is initial data gathering process. In this determine saving energy, collection of data which require for more detailed energy audit

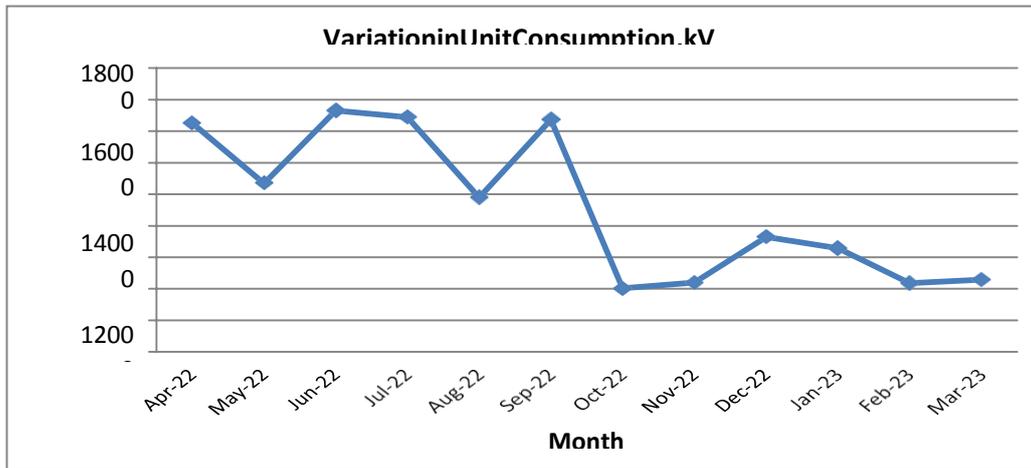
6.1.1HistoricalData Collection [8-9]

Monthly consumption for last few months electricity bill amountisasfollows.

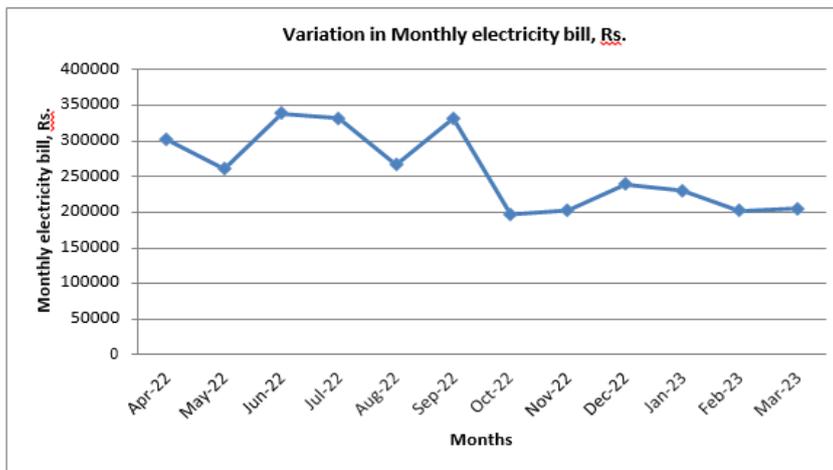
Sr.No	Month	kVAh	Amount
1	March-23	4583	205282
2	Feb-23	4351	201792
3	Jan-23	6573	230262
4	Dec-22	7286	238828
5	Nov-22	4397	202461
6	Oct-22	4031	197052
7	Sep-22	14731	331950
8	Aug-22	9795	266537
9	July-22	14890	332007
10	June-22	15304	338063

11	May-22	10691	260792
12	April-22	14512	301911
13	Total	111144	3106937
14	Average	9262	258911.4
15	Max	15304	338063
16	Min	4031	197052

MonthlyUnits Wise Consumption:



Variation of Monthly Electricity Bill:



6.2 Data collection

6.2.1 On-site assessment

- For Women’s college the built-up area of is 82817.53 Sq. ft. The building of college is a four storied, well illuminated.
- Total students are around 1039 including Undergraduate and Post Graduate students.
- There are 3 main departments in the Women’s College. Each Departments have separate well equipped practical laboratories.
- There is a separate Central library. So, Illumination load of library is very high. 24 hrs. Internet facility is available.
- Other facilities such as library, internet, digital library, well equipped lecture halls with LCD projection
-

6.2.2 Study of load which is connected:

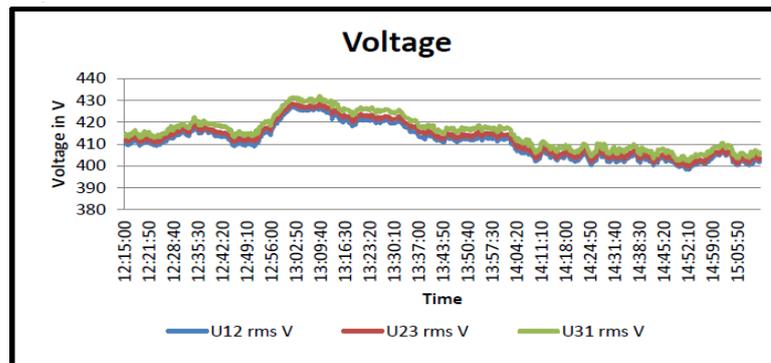
Sr. No.	Connected load	Load/Unit	Quantity	Load in kW
1	Tube lights	40	477	19.1
2	Tube LED	18	124	2.2
3	Street lights	30	3	0.1
4	Fans	66	316	20.9
5	Air-conditioner	1500	6	9.0
6	Refrigerator	1500	2	3.0
7	PC	150	342	51.3
8	Printers	200	67	13.4
9	Smart Boards	220	04	0.9
10	Water Pump	3500	4	14.0
			Total	133.8

6.3 Energy monitoring:

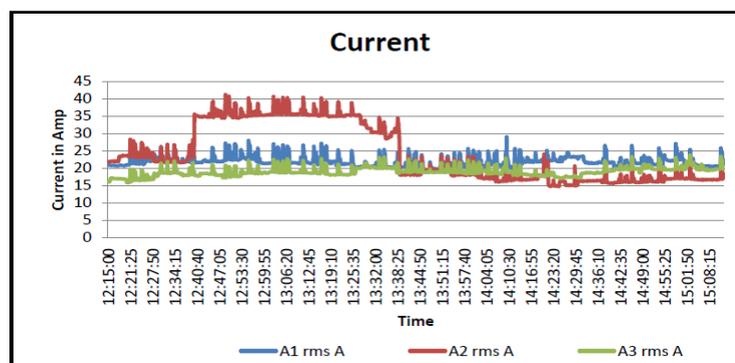
Details of measurements with Portable Power Analyser at the distribution centre and meter room of Bharati Vidyapeeth's College of Engineering for Women [10].

With Power Analyser current, voltage, Power, and Power Factor are measured. Now we present the variation in various Electrical parameters as under.

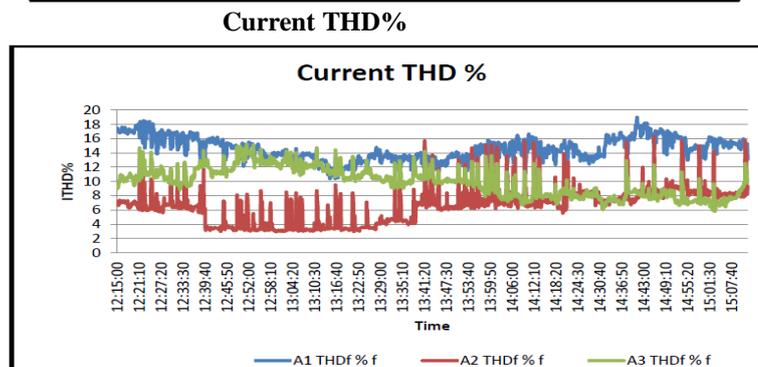
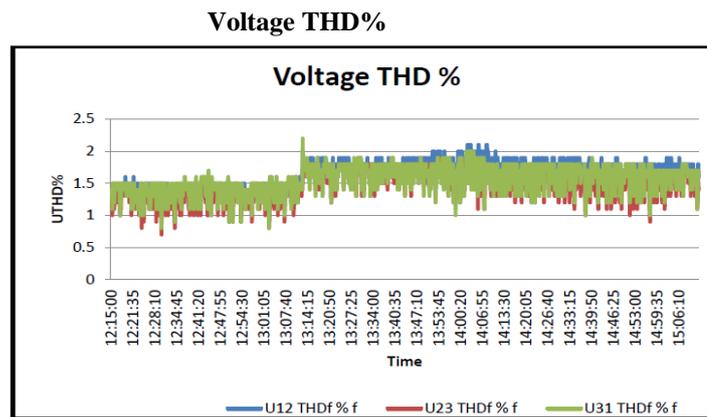
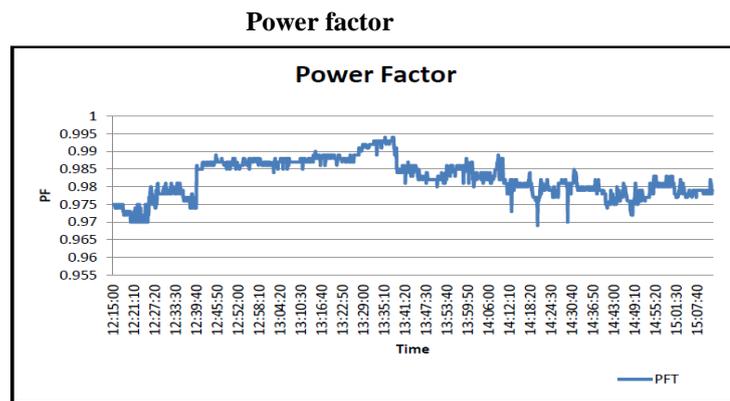
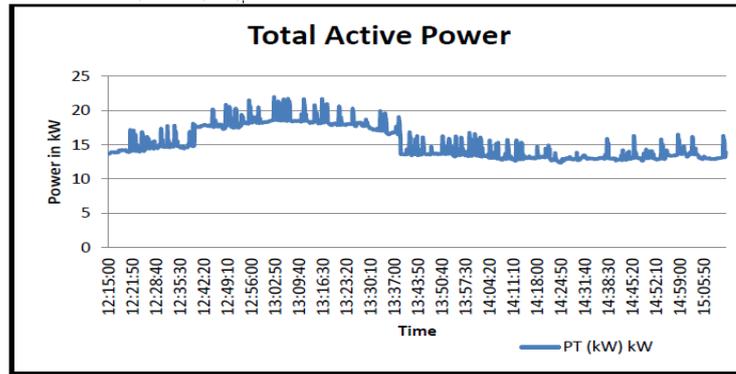
Voltage: Average voltage is around 413.0V of transformer



Current: Average current is around 21.62A



Power (kW)



7. Data Analysis:
Harmonic Analysis [11]:

Electrical Parameter	Minimum	Maximum	Average	Ideal Values
Voltage	391	435	413	420
Current	16.80	26.44	21.62	-
Active Power	13.20	23.40	18.32	-
Power Factor	0.972	0.992	0.982	1
Voltage THD %	0.8	2.3	1.55	5%
Current THD %	3.6	19	11.3	20%

7.1 Saving Calculation on replacement of LED Lights [12]

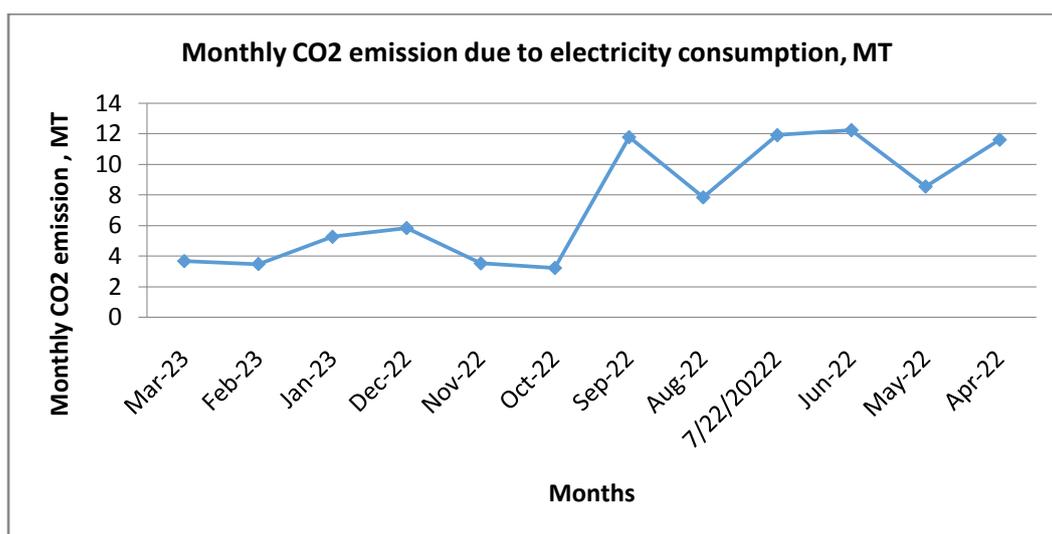
Saving on Replacement of Tube Lights with Energy LED Lights		
Total no. of Tube Lights	Nos.	477
Avg. running hours per day	Hrs.	8
Avg. working days per year	Nos.	240
Avg. Power consumption of Tube Lights	W	28
Total electricity consumed by Tube Lights per year	kWh	256335.20
Avg. Power consumption of LED Lights	W	18
Total electricity consumed by LED lights	kWh	164857.20
Total electricity saving per year	kWh	9147.8
Rate of electricity	INR	12
Total monetary saving per year	INR	109773.6
Investment	INR	95400
Simple payback period	Months	10.42

7.2 Basis for computation of CO₂ Emissions [5]:

1 Unit (kWh) of Electrical Energy releases **0.8 Kg of CO₂** into atmosphere. Electrical energy uses by college for operating various electrical equipment.

Month wise CO₂ Emissions: 170019005146

Sr. No	Month	Electrical Energy Consumed, kVAh	CO ₂ Emissions due to Electricity, MT
1	March-23	4583	3.67
2	Feb-23	4351	3.48
3	Jan-23	6573	5.26
4	Dec-22	7286	5.83
5	Nov-22	4397	3.52
6	Oct-22	4031	3.22
7	Sep-22	14731	11.78
8	Aug-22	9795	7.84
9	July-22	14890	11.91
10	June-22	15304	12.24
11	May-22	10691	8.55
12	April-22	14512	11.61
	Total	111144	88.92
	Average	9262	7.41
	Max	15304	12.24
	Min	4031	3.22



Therefore, the CO2 emissions is calculated as under:

No.	Parameter	Value	Unit
1	Emissions of CO2	88.92	MT/annum
2	Area of College	82817.53	Sq. ft.
3	/sq. ft.CO2 emissions	1.07	Kg of CO ₂ per annum/sq. ft.

8. Energy Conservation Measures:

Following Energy Conservation Opportunities and actions on the basis of energy audit are suggested to implement in the campus on the basis of funds availability and institute preferences.

- Energy efficient tubes and fans can be replaced. Already the phasing out of old tubes has been undertaken during regular maintenance practices.
- Installation of 50 kW solar roof top system as ample space available on the roof of the college building. As sanctioned load is 291kW, the solar roof top of 50 kW capacity with net meter can be installed in the college campus to meet the requirement of electricity.
- Installation of Solar powered light for hoarding.
- Installation of 05 Nos. solar mobile phone charging stations in the college campus.
- Water management system must be in place. Overhead tanks can be with float control and Time of the day (TOD) can be implemented for water pumping for filling the overhead water tank.
- Installation of Biogas plant for canteen.
- Automatic switches with occupancy sensors in common areas, classrooms
- Large number of ventilation and exhaust systems may be placed in seminar hall to reduce the carbon dioxide level among the participating students, scholars and staff members.
- It was observed that sufficient space is there on the college terrace. It can be possible to install a Solar Photovoltaic roof top with net meter of capacity **50 kWp**. We calculate the saving potential as under

Sr.No	Particulars	Value	Unit
1	Solar PV Pack Installed Capacity	50	kWp
2	working period per day	6	Hrs./Day
3	Units generated Daily	300	kWh/Day
4	Annual days of working	280	Day/annum

5	Annually Electrical Energy saving	84000	kWh/annum
6	Annually CO ₂ saving	67.2	MT/Annum
7	Current Energy Charges	10	Rs/kWh
8	Annual Gain	840000	Rs/Annum
9	Required Investment	22,50000	Rs lump sum
10	Payback period	2.67	Years

8.1 Existing APFC panel –

APFC Panel of 100kVAR capacity installed at main distribution with steps 15kVAR five steps and fixed 25kVAR steps at Bharati Vidyapeeth's College of Engineering for Women, Pune. This APFC is working in proper way and maintain average power factor about more than 0.98 which is indicated in monthly electricity bill.

8.2. Renewable Energy Integration:

8.2.1 Installation of 50 kWp Solar PV Power Plant:

Solar roof top power plant having capacity 50 kWp is installed on College of Engineering building, at college campus which meets the requirement of electricity demand of the that building. The Solar roof top plant is successfully installed, and it is in operation to meet the requirement of electricity of institute campus building.

8.2.2 Solar powered light for hoarding:

This system can be used to power the huge hoardings in the college campus.

In order to achieve that with solar, we consider the following system:

1. Highly Efficient Solar Panel
2. Charge Controllers with MPPT Technology –electricity production by solar is increases up to 30% compared to conventional charge controllers
3. LED Projection Light- electricity consumption is 10-times less than conventional bulbs, has a 50,000-hour warranty.

Features:

- Auto on off
- 4 Days Battery Back Up
- Robust housing
- Weatherproof

With the help of this, systems that provide 6 hours of lighting each night with 4 -lamp system to light up boards up to 15'x30', and a 8-lamp system to light larger boards up to 20'x40',with payback of the system will come around 2.5 years.

9. Conclusion:

Study has clearly established the need of continuous monitoring and centre of consumption. Energy audit gives a “actual photo” of energy is currently being used in the facility. By energy Inspection we are able to find the energy cost savings and it is possible by changing the way of energy used in a building. We carried out very elaborate measurements for the various areas like lightning load, Air conditioner, water pump etc. We analysed very critically the effectiveness of energy consumption in each area. By doing energy audit in Bharati Vidyapeeth College of Engineering for Women we are able to effectively manage and reduce areas of consumption creating losses. This energy audit provides a major role in reducing the losses in electrical energy consumption in higher education institutes and a step towards achieving SDG 7 &12.

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