ENERGY AUDIT

REPORT 2022

Bejoy Narayan Mahavidyalaya

Members of the Energy Audit Committee of Bejoy Narayan Mahavidyalaya:

1. Dr. GOUTAM BIT (Principal)
2. Dr. Kausik Ghosh (Assistant Professor), Dept. of Zoology
3. Sri Samir Kr. Majumder (Associate Lab. Instructor), Dept. of Zoology
4. Dr. Semanti Basu (Assistant Professor), Dept. of Chemistry
5. Dr. Parasuram Kamilya (Associate Professor), Dept. of Botany

Members of the Energy Audit Team of Nandi Resources Generation Technology Pvt. Ltd.

1. Dr. Paritosh Nandi
2. Mr Sunil Ghosh
3. Ms Pia Banerjee

Energy Audit key steps:

• Planning completed	28th August, 2022
• Field work completed	12th September, 2022
• Draft report completed and sent for management response	16th October, 2022
• Management response received	11th November, 2022
• Final report completed	13th November, 2022
• Report presented to the Management	14th November, 2022

Certificate by Auditor

This is to certify that Energy Audit activity of Bejoy Narayan Mahavidyalaya for the period of September 2022 to October 2022 was assigned to us. During this period following activities have been audited by us:

- Fundamentals of Energy Audit
- Load hour Calculations
- Measurement of Installed Capacity
- Energy Conservations
- Rain Water Harvesting
- Potential of harnessing Renewable Energy sources
- Wastes Recycling
- Efforts for carbon neutrality
- E-wastes Managements

Nandi Resources Generation Technology Pvt. Ltd.
Director

Dr. Paritosh Nandi
Director

Certificate by Principal

Our Energy Audit Committee along with Certified Energy Auditor from Nandi Resources Generation Technology Pvt. Ltd. appointed by us has done a commendable work in framing out Energy Policy in our college. We strive to comply with Energy Conservation Act 2001 and other relevant standards, such as ISO 14001, Energy Audit Framework etc.

I hereby accept all the recommendations and observations mentioned in the Energy Audit Report and undertake to implement the same.

Principal
Bejoy Narayan Mahavidyalaya

PRELUDE

Energy Audit team of Bejoy Narayan Mahavidyalaya conducted energy audit of the college in September 2022 in consultation with Kolkata based Nandi Resources Generation Technology Private Limited. The company is promoted by Certified Energy Auditor by Ministry Power, Government of India. The objective of the Energy Audit is to ensure that the carbon and water foot prints are optimised in line with the environmental sustainability as mandated by National Accreditation Council. The objectives of the audit were to evaluate the adequacy of the management control framework of Environment Sustainability as well as the degree to which the Departments are in compliance with the applicable regulations, policies and standards. In order to assess on the carbon footprint issue, a detailed energy audit was conducted 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. Considerations of efficiency, accountability, transparency and ethics are important in both the public and private sector. However, it is arguable that they are more so in the public sector and government, as their primary purpose is to promote the public good. Public assets of the whole society, including natural and social goods, are entrusted to the state and, therefore, the need to protect them in the long term is more pressing than for businesses which have a more limited responsibility to their shareholders. Governments are responsible for the outcomes for society in general, as well as their own direct policy or organisational impacts on them. For these reasons, existing sustainability reporting frameworks for the private sector are not adequate to the needs of the public sector or national government. There are certainly lessons to be learnt, but these are not one-way. Sustainability reporting in any sector should also draw on the planning, monitoring and reporting frameworks to understand where and how elements of sustainability are already addressed, perhaps under a different name and, hence, where the gaps may be. Measurement of sustainability planning, action and reporting have grown greatly in recent years. Environmental sustainability has received the most attention as there is growing evidence of an urgent need for change in this area. But there is also general consensus that environmental sustainability cannot be achieved except in tandem with social and economic change. The measurement of environmental sustainability in isolation, then, does not seem sufficient. Greater attention needs to be paid to understanding how other elements of sustainability could also be measured, in order to ensure they also receive action and attention. This measurement could be, but does not necessarily need to be, in financial terms.

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1. Introduction

Bejoy Narayan Mahavidyalaya, a Government-Sponsored and UGC recognized institution (Cycle-I in 2007 and Cycle-II in 2015), is specifically devoted to the enlightenment and empowerment of rural boys and girls in an agriculture-based rural area in the district of Hooghly in West Bengal. Our Institution has contributed its best towards improving the teaching- learning process, enhancing student support services, and infrastructure development as far as practicable and feasible. The vision of the Mahavidyalaya is to become one of the best educational institutions in the State catering to the rural people's need of higher education, and run along the ideals of man-making education propounded by Swami Vivekananada. The mission of the college is 'Tanme manah Siva samkalpamastu' (May that mind of mine be auspicious resolution).

1.1 About the college

BEJOY NARAYAN MAHAVIDYALAYA, a Government-Sponsored and UGC recognized co-educational college (Preparing for 3rd Cycle NAAC assessment), is noted for its prestigious position as a premier academic institution affiliated to the University of Burdwan. Located in an agriculture- based rural area in the district of Hooghly in West Bengal, this college is proud of its seventy two years of contribution to the field of education, offering its students a wide range of subjects, which is backed by adequate infrastructural facilities and well managed student-support system. The vision of the Mahavidyalaya is to empower its students in social, moral and intellectual terms, and in the process to become one of the best educational institutions in the State catering to the rural people's need for higher education. The mission of the college is 'Tanme manah siva samkalpamastu' (May the mind of mine be an auspicious resolution).

The college was established in the year 1950. At present, the student strength is around 3570 who are mentored by 94 faculty members (including SACTs). The college offers honors courses in 13 subjects and have also introduced Santali language, Alchiki in the recent years.

The mission of the institution is as follows:

1. To develop self-esteem and accountability among the students of the Mahavidyalaya.
2. To promote research-oriented teaching-learning activity.
3. To promote ICT (Information Communications Technology) based teaching to complement the conventional teaching with chalk and duster.
4. To introduce courses and consultancies that would be beneficial to the students mostly coming from rural areas.
5. To collaborate with all the stakeholders of the institution for an all-round effort towards enhancement and sustenance of quality.

1.2 Objective of Energy Audit

Energy Audit is aimed at obtaining a detailed idea about the various end use energy consumption activities and identifying, enumerating and evaluating the possible energy savings opportunities. The Energy audit practically involves use of renewable sources, conservation of the energy, rain water harvesting program, and efforts of carbon neutrality, plantation of trees, E-waste management and hazardous waste management. The target of Energy Audit is to achieve savings in the electrical energy consumption to the extent of 20%. For the college this Energy Audit assumes all the more significance due to the fact that its combined electricity bill was of (Rs 416744.00 / (Rupees Four Lac Sixteen thousand seven hundred forty four only) from December 2021 to November 2022. The Energy Audit was also aimed at giving the students a feel of the practical problems and difficulties in carrying out audit activities.

The objective of the Energy Audit is emphatically embodied in the vision statement of the college which states that the College aspires to be a futuristic and achieving a near- carbon neutral college in West Bengal by using ICT and other sustainable technologies, providing a well-resourced, strongly academic, holistic education to boys and girls in such a way that it will create an environment where the mind is without fear, the head is held high and knowledge is free.

1.3 Green Building: A global development

Energy Building is a structure that is efficient in resources throughout its life cycle which are designed to lessen down the overall impact of the built environment on the natural environment and human health. They are also known as high performance building or sustainable building.

Green Building's main objective:-

- Energy Efficiency
- Structure Efficiency
- Water Efficiency
- Material Efficiency
- Waste and Reduction

Shortly a Green Building is that which uses less water, conserve natural resources, produces less water, uses eco-friendly ways, optimization of energy efficiency and by doing all these providing healthier space for living for the occupants in comparison with conventional building.

GBC or Green Building Council is an umbrella organization for all the developing, existing and growing GBCs around the world. GBC is a non-governmental, non-profit, national organization that is a part of global network recognized by the World Green Building Council. GBC's goal is to form buildings, towns and cities which are sensitive to environment, economically feasible, culturally just and socially just. Around the world at least 19 nations has established GBCs, 7 recognized as growing members and many more is in the process of development. The 19 established councils are:-

- Argentina Green Building Council
- Green Building Council of Australia
- Green Building Council Brazil
- Peru Green Building Council
- Canada Green Building Council
- Dutch Green Building Council
- Emirates Green Building Council
- France Green Building Council
- German Sustainable Building Council
- Indian Green Building Council
- Italy Green Building Council
- Japan Green Building Consortium
- Korea Green Building Council
- Mexico Green Building Council

- New Zealand Green Building Council
- Pakistan Green Building Council
- Green Building Council of South Africa
- Sweden Green Building Council
- Taiwan Green Building Council
- Romania Green Building Council
- United Kingdom Green Building Council
- U.S. Green Building Council
- Vietnam Green Building Council

1.4 Bejoy Narayan Mahavidyalaya Energy Scenario

The energy consumption on campus is mainly in the form of electricity, apart from the use of LPG as cooking fuel in the college canteen. The college campus has a connected electrical load of 42.77 kVA. The Electricity meter details along with contract demand and connected load for the year 2022 is given in Fig.1.

Building	Consumer ID.	Meter No.	Connected Load (kVA)	Demand (kVA)
BNMV	163138861	SF066099	42.7	

Fig 1: BNMV Campus Meter details with demand and connected load

- The college has one 30 kVA DG set for emergency purpose and it consumes yearly 275 litres of diesel which approximately costs Rupees Twenty Four Thousand Only.

1.5 Specific Energy Consumption (SEC)

The Specific Energy Consumption (SEC) is defined as the energy consumption per unit of product output. The specific energy consumption considering students, faculty and staff members were calculated which forms the college SEC and was taken as reference for comparison. The SEC was calculated to be annual energy cost /person (for 2022) for the academic area and Rs. 120.29 per person per annum.

1.6 Segmentation

This energy audit report has segmented the energy consumption patterns both by building/ offices and by end use activities (lighting, cooling and pumping etc.). The details are provided in the subsequent chapters.

2. Energy Audit

2.1 Energy Audit Methodology

The methodology adopted for this audit was

- 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 and analyses
- Validation
- Potential energy saving opportunities
- Recommendation

2.1.1 Data Collection

For suggesting any corrective measures to reduce power consumption, it is first necessary to know the power consumption pattern in detail. For this, the exhaustive data collection exercise was performed at all the departments, controller of section and other supporting entities such as library, computer lab etc.

Following steps were taken for data collection:

- The audit team went to each department, laboratories, library etc.
- Information about the general electrical appliances was collected from its manual or nameplate sticker.
- Load hour calculation was done by interview of the Head of the Departments and the very experienced staff who have been working for decade or so.
- The power consumption of appliances was measured using power analyzer when there is nothing visible from the nameplate.
- Light intensity was measured using Lux meter at the college classrooms, computer lab, library and the other departmental laboratories.
- External electrical insulation was measured with Infrared Thermometer.
- Air-conditioners and their insulation were checked with visual inspection.
- Quality of power is measured with Power Analyzer.

2.2 Primary Data Building-Wise

Room Name/No	Floor	Instrument	Nos	Rating (kW)	Total Load (kW)	Avg. Usage time (hr)	Unit (kWh)
Room No 43	Gr. Floor	Tube Light	2	40	0.08	3	0.24
		CFL Light	4	15	0.06	3	0.18
		LED Light	4	18	0.072	3	0.216
Chemistry		LED Light	1	18	0.018	3	0.054
Deptt.		LED Tube Light	1	20	0.02	3	0.06

		Exhaust Fan	4	75	0.3	3	0.9
	Beside the room	LED Light	2	9	0.018	3	0.054
					0		0
Room No 44		Tube Light	2	40	0.08	2.5	0.2
		Ceiling Fan	4	80	0.32	2.5	0.8
		Bulb	1	60	0.06	2.5	0.15
		LED Light	3	15	0.045	2.5	0.1125
	Beside	LED Light	1	9	0.009	11	0.099
Room No 45		Tube Light	3	40	0.12	3	0.36
		Ceiling Fan	5	80	0.4	3	1.2
		CFL Light	1	15	0.015	3	0.045
	Beside	LED Light	2	9	0.018	11	0.198
Room No 46		Tube Light	3	40	0.12	3	0.36
		Ceiling Fan	3	80	0.24	3	0.72
		CFL Light	3	15	0.045	1	0.045
		LED Light	8	9	0.072	11	0.792
		LED Tube Light	1	20	0.02	4	0.08
		Hot Air Oven	1	250	0.25	1	0.25
		Motor	1	750	0.75	0.15	0.1125
		Rocker Machine	1	300	0.3	0.15	0.045
		Digital Potentiometer	2	60	0.12	0.5	0.06
		Digital Calorimeter	2	60	0.12	0.5	0.06
		Visible Spectro	1	60	0.06	0.05	0.003
		Electronic Balance	1	60	0.06	1	0.06
		Exhaust Fan	1	75	0.075	3	0.225
		Fridge	1	100	0.1	24	2.4
Room No 47	GR	LED Tube Light	8	20	0.16	3	0.48
		Ceiling Fan	4	80	0.32	3	0.96
		LED Desktop	4	60	0.24	1.2	0.288
		LED Light			0		0

		Xerox Machine	1	500	0.5	0.2	0.1
		Xerox Machine	1	250	0.25	0.1	0.025
LAB 4	GR	LED Light	3	15	0.045	5	0.225
		Electronic Balance	1	60	0.06	0.25	0.015
		Digital Potentiometer	1	60	0.06	0.25	0.015
		Ice	1	250	0.25	0.16	0.04
		UPS	4	250	1	0.75	0.75
	Beside	LED Tube Light	1	9	0.009	3	0.027
Room 48 Chemistry Lecture Hall		LED Tube Light	5	40	0.2	3	0.6
							0
		Ceiling Fan	7	80	0.56	2.5	1.4
		LED Tube Light	2	20	0.04	4	0.16
	Beside	LED Light	3	9	0.027	4	0.108
Room 49 Lab-3	Ground	LED Light	10	15	0.15	3	0.45
							0
		Pump	1	1500	1.5	0.15	0.225
		Exhaust Fan	1	75	0.075	3	0.225
	Beside	LED Light	1	9	0.009	9	0.081
Room No 50 Professors' Room	Gr	Ceiling Fan	1	80	0.08	2	0.16
		Tube Light	1	40	0.04	2	0.08
		LED Light			0		0
		Laptop	5	65	0.325	1	0.325
		Fridge	1	100	0.1	24	2.4
Room No 51 Preparation Room	Gr	Ceiling Fan	1	80	0.08	3	0.24
							0
		Tube Light	1	40	0.04	1	0.04
		LED Light	6	9	0.054	5	0.27
Honours Lab 2	Gr						0
							0

		LED Light	10	15	0.15	3	0.45
		Exhaust Fan	2	100	0.2	3	0.6
	Beside	LED Light	1	9	0.009	11	0.099
Honours Lab 1		LED Light	7	15	0.105 0 0	3	0.315 0 0
		Exhaust Fan	1	100	0.1	3	0.3
Store Room	Ground	Ceiling Fan	1	80	0.08	2	0.16
		Tube Light	1	40	0.04	0.5	0.02
		LED Light	7	15	0.105	2	0.21
	Beside	LED Light	1	9	0.009	11	0.099
Class Room	Ground	Ceiling Fan	3	80	0.24	3	0.72
Physics Deptt		Tube Light	3	40	0.12	3	0.36
		CFL Light	4	15	0.06	3	0.18
Teachers Staff Room Physics Deptt	Ground	Ceiling Fan	1	80	0.08 0	3	0.24 0
		Tube Light	1	40	0.04	5	0.2
		LED Tube Light	2	22	0.044	3	0.132
		LED Desktop	2	60	0.12	3	0.36
		UPS	2	450	0.9	3	2.7
Non-teaching Staff Room & Store Room	Gr	Ceiling Fan	1	80	0.08	2.5	0.2
		Table Fan	1	100	0.1	2	0.2
Physics		Tube Light	4	40	0.16	3.5	0.56
		CFL Light	1	15	0.015	4	0.06
		Bulb	1	100	0.1	2	0.2
		Fridge	1	100	0.1	24	2.4
M N Saha Lab		Ceiling Fan	2	80	0.16	3	0.48
		Table Fan	1	100	0.1	0.5	0.05
		Tube Light	5	40	0.2	2	0.4
		CFL Light	1	15	0.015	2	0.03
Faraday Lab		Ceiling Fan	4	80	0.32	2.5	0.8

Ground Floor Physics		Tube Light	6	40	0.24	4	0.96
		CFL Light	1	15	0.015	4	0.06
Computer Lab Physics		Table Fan	2	100	0.2	1.5	0.3
					0		0
		Tube Light	1	40	0.04	1.5	0.06
		CFL Light	1	20	0.02	1.5	0.03
		LED Desktop	4	60	0.24	1.5	0.36
		LED Tubelight	1	20	0.02	1.5	0.03
		UPS	4	450	1.8	1.5	2.7
JC Bose Lab Physics		Ceiling Fan	4	60	0.24	3	0.72
					0		0
					0		0
		Tube Light	4	40	0.16	3	0.48
		LED Tube Light	1	20	0.02	3	0.06
Toilet Teachers Physics		Exhaust fan	1	75	0.075	3	0.225
		LED Light	1	6	0.006	3	0.018
		LED Light	1	9	0.009	3	0.027
Main Building Gate		Tube Light	4	40	0.16	4	0.64
	1st Floor	Ceiling Fan	8	80	0.64	3	1.92
					0.64	4	2.56
		Tube Light	6	40	0.24	4	0.96
					0		0
		LED Tube Light	3	20	0.06	4	0.24
		Wall Fan	1	40	0.04	0.1	0.004
3QC	1st	Ceiling Fan	2	80	0.16	2	0.32
		Tube Light	2	40	0.08	2	0.16
		LED Light	3	32	0.096	2	0.192
		LED Desktop	1	60	0.06	2	0.12
		Printer	1	250	0.25	2	0.5
		AC	1	1.5	0.0015	2	0.003
Office- F4	1st Floor	Ceiling Fan	5	80	0.4	3	1.2
		Tube Light	2	40	0.08	4	0.32
		LED Tube Light	5	20	0.1	4	0.4

		Wall Fan	2	40	0.08	2	0.16
Office Exam F5	1st	Ceiling Fan	1	80	0.08	2	0.16
		Tube Light	2	40	0.08	4	0.32
		LED Tube Light	1	20	0.02	4	0.08
		Stand Fan	1	250	0.25	0.1	0.025
F-6	1st	Ceiling Fan	2	80	0.16	0.001	0.00016
		Tube Light	4	40	0.16	0.2	0.032
		LED Light	1	20	0.02	0.2	0.004
F-7	1st	Ceiling Fan	5	80	0.4	3	1.2
		Tube Light	6	40	0.24	3	0.72
		LED Tube Light	4	20	0.08	3	0.24
		CFL	1	32	0.032	1	0.032
		CFL	1	18	0.018	1	0.018
		LED Desktop	3	60	0.18	3	0.54
		Printer	3	250	0.75	1	0.75
		AC	2	1500	3	2	6
		Fridge	1	100	0.1	3	0.3
		Wall Fan	3	60	0.18	1	0.18
		Exhaust Fan	1	75	0.075	2	0.15
F-8	1st Floor	Ceiling Fan	2	80	0.16	1.75	0.28
		Tube Light	5	40	0.2	1	0.2
		CFL Light	1	18	0.018	1	0.018
		AC	1	1500	1.5	2	3
Principal's Room	1st	Ceiling Fan	5	65	0.325	3	0.975
		LED Desktop	1	60	0.06	3	0.18
		LED Light	1	9	0.009	3	0.027
		LED Light	2	20	0.04	3	0.12
		CFL	7	15	0.105	3	0.315
		Printer	1	250	0.25	1	0.25
		AC	1	1500	1.5	2	3
		Exhaust Fan	1	75	0.075	3	0.225
		CCTV	1	3	0.003	24	0.072
F-10		Ceiling Fan	3	80	0.24	2	0.48

Zoology		Tube Light	3	40	0.12	2	0.24
		LED Tube Light	2	20	0.04	2	0.08
		LED Bulb	4	12	0.048	3	0.144
		Fridge	1	150	0.15	24	3.6
F-11 Zoology		Ceiling Fan	2	80	0.16	1	0.16
		Tube Light	6	40	0.24	1	0.24
		LED Tube Light	1	20	0.02	1	0.02
		LED Bulb	1	9	0.009	1	0.009
Zoology Store Room		Ceiling Fan	1	80	0.08	2	0.16
		LED Tube Light	3	20	0.06	2	0.12
		Exhaust Fan	1	75	0.075	0.8	0.06
F-17		Ceiling Fan	2	80	0.16	1	0.16
		Tube Light	5	40	0.2	1	0.2
		LED Tube Light	1	20	0.02		0
		LED Bulb	1	9	0.009		0
		Fridge	1	100	0.1	24	2.4
		Exhaust Fan	1	75	0.075		0
		Water Filter	1	150	0.15	0.06	0.009
F-18		Ceiling Fan	4	80	0.32	3	0.96
		Tube Light	8	40	0.32	3	0.96
		LED Bulb	2	9	0.018	3	0.054
		Exhaust Fan	2	75	0.15	0.5	0.075
F-19 Staff	1st	Ceiling Fan	1	80	0.08	3	0.24
		Tube Light	1	40	0.04	3	0.12
		LED Tube Light	2	40	0.08	3	0.24
		LED Desktop	1	60	0.06	0.08	0.0048
		Printer	1	250	0.25	0.08	0.02
LS-2	1st	Ceiling Fan	6	80	0.48	3	1.44
		Tube Light	5	40	0.2	3	0.6
		LED Tube Light	8	40	0.32	0.1	0.032
		LED Bulb	2	9	0.018	0.1	0.0018
		Fridge	1	100	0.1	24	2.4
Seminar Room	1st	Ceiling Fan	22	80	1.76		0

		Tube Light	12	40	0.48		0
		LED Tube Light	1	20	0.02		0
		Amplifier	1	500	0.5	0.01	0.005
		Small Amplifier	7	40	0.28	0.05	0.014
F-27		Ceiling Fan	3	80	0.24	3	0.72
		Tube Light	3	40	0.12	3	0.36
		LED Tube Light	3	20	0.06	3	0.18
F-28		Ceiling Fan	11	80	0.88	3	2.64
		Tube Light	8	40	0.32	3	0.96
		LED Tube Light	3	20	0.06	3	0.18
Student Union Room		Ceiling Fan	6	80	0.48	2	0.96
		CFL Light	2	20	0.04	2	0.08
		LED Tube Light	3	20	0.06	2	0.12
Boys Common Room		Ceiling Fan	2	80	0.16	0.01	0.0016
		Tube Light	1	40	0.04	0.02	0.0008
Meditation Room	2nd	Ceiling Fan	6	80	0.48	0.5	0.24
		Tube Light	3	40	0.12	0.75	0.09
		CFL Light	12	20	0.24	0.75	0.18
		AC	1	2000	2	0.75	1.5
G-38		Ceiling Fan	3	80	0.24	0.06	0.0144
		LED Tubelight	4	20	0.08	0.06	0.0048
G-35		Ceiling Fan	2	80	0.16	0.04	0.0064
		Tube Light	4	20	0.08	0.04	0.0032
G-62		Tube Light	10	40	0.4	4.5	1.8
		Amplifier	4	40	0.16	0.5	0.08
		Amp System	1	500	0.5	0.5	0.25
		LED Tube	3	20	0.06	4	0.24
Varanda	2nd	Tube Light	5	40	0.2	1	0.2
		LED	1	2	0.002	0.5	0.001

		Halogen	11	100	1.1	6	6.6
		HPSV	2	250	0.5	6	3
Room No E4 Ladies Hostel	Gr	Ceiling Fan	2	60	0.12	3	0.36
					0		0
		LED Tube Light	2	20	0.04	4	0.16
Corridor of Eng & Beng. Deptt	Gr	Ceiling Fan	1	60	0.06	3	0.18
					0		0
		LED Tube Light	3	20	0.06	4	0.24
		Router	2	12	0.024	5	0.12
Staff Room WH/02		Ceiling Fan	2	80	0.16	3	0.48
					0		0
		LED Desktop	1	90	0.09	3	0.27
		LED Tube Light	2	20	0.04	3	0.12
		LED Bulb	1	6	0.006	3	0.018
		Exhaust Fan	1	75	0.075	3	0.225
Staff Room WH/07	Gr	Ceiling Fan	2	80	0.16	3	0.48
					0		0
		LED Desktop	1	90	0.09	5	0.45
		LED Tube Light	2	20	0.04	5	0.2
		CFL Light	1	42	0.042	5	0.21
Room No B1 Bengali Hall	Gr	Ceiling Fan	4	80	0.32	3.75	1.2
					0		0
		LED Tube Light	4	20	0.08	3	0.24
Room No E3	Gr	Ceiling Fan	2	80	0.16	3	0.48
		LED Tube Light	2	20	0.04	5	0.2
Room No B2	Gr	Ceiling Fan	2	80	0.16	3.75	0.6
		Tube Light	2	20	0.04	5	0.2
Room No B3		Ceiling Fan	2	80	0.16	3.75	0.6
		LED Tube Light	2	20	0.04	3	0.12
Wash Room	Gr	LED Tube Light	2	20	0.04	3	0.12
		Exhaust Fan	1	75	0.075	3	0.225

Sanskrit Hall	1st	Ceiling Fan	2	80	0.16	3	0.48
		LED Tube Light	2	20	0.04	3	0.12
		Table Fan	1	100	0.1	3	0.3
Wash Room	1st	Exhaust Fan	3	100	0.3	3	0.9
Santali Deptt. Hall	1st	Ceiling Fan	2	80	0.16	3	0.48
					0.16	3	0.48
		LED Tube Light	2	20	0.04	4	0.16
Economics -2		Ceiling Fan	2	80	0.16	3	0.48
		LED Tube Light	2	20	0.04	3	0.12
Economics-1	1st	Ceiling Fan	2	80	0.16	3	0.48
		LED Tube Light	2	20	0.04	4	0.16
Economics-3	1st	Ceiling Fan	2	80	0.16	3	0.48
		LED Tube Light	2	20	0.04	3	0.12
Santali- 1	1st	Ceiling Fan	2	80	0.16	3.75	0.6
		LED Tube Light	2	20	0.04	2	0.08
		Table Fan	1	100	0.1	2	0.2
Santali-2	1st	Ceiling Fan	2	80	0.16	3	0.48
		LED Tube Light	2	20	0.04	4	0.16
		Table Fan	1	100	0.1	1	0.1
Santali 3	1st	Ceiling Fan	2	80	0.16	3	0.48
		LED Tube Light	2	20	0.04	3	0.12
		Table Fan	1	100	0.1	3	0.3
Sanskrit Staff Room	1st	Ceiling Fan	2	80	0.16	3	0.48
		LED Tube Light	2	20	0.04	3	0.12
		CFL Light	1	44	0.044	3	0.132
		LED Desktop	1	60	0.06	3	0.18
Corridor	1st	Led Tube Light	3	20	0.06	3	0.18
		Wifi router	2	12	0.024	24	0.576
Staff Room	2nd	Ceiling Fan	4	80	0.32	3.75	1.2

		LED Desktop	1	60	0.06	3	0.18
		Printer	2	150	0.3	3	0.9
		LED Light	16	20	0.32	3	0.96
Bengali Deptt.	2nd	LED Light	4	20	0.08	3	0.24
		Wifi Router	1	12	0.012	3	0.036
Stair 1st floor to 2nd floor		LED Light	3	20	0.06	3	0.18
Computer Lab		Ceiling Fan	4	60	0.24	3.75	0.9
		LED Light	11	20	0.22	3	0.66
		Wifi Router	1	12	0.012	5	0.06
Math 1	2nd	Ceiling Fan	3	60	0.18	3.75	0.675
		LED Light	10	20	0.2	5	1
Math 2	2nd	Ceiling Fan	2	60	0.12	3.75	0.45
		LED Light	6	20	0.12	5	0.6
R3	2nd	Ceiling Fan	4	60	0.24	3.75	0.9
		LED Light	10	20	0.2	5	1
R2		Ceiling Fan	4	60	0.24	3.75	0.9
		LED Light	10	20	0.2	5	1
R1		Ceiling Fan	4	60	0.24	3.75	0.9
		LED Light	10	20	0.2	5	1
Math Corridor	2nd	Ceiling Fan	1	60	0.06	3.75	0.225
		LED Light	5	20	0.1	2.5	0.25
Washroom	2nd	Exhaust Fan	4	75	0.3	2.5	0.75
		LED Light	4	20	0.08	5	0.4
Room No-1 Darwin, Nutrition deptt	1st	Ceiling Fan	5	60	0.3	3.75	1.125
					0		0
		Tube Light	7	40	0.28	2	0.56
		Laminar Airflow	1	250	0.25	2	0.5
		BOD Incubator	1	250	0.25	0.5	0.125
		Autoclave	1	250	0.25	1	0.25
Room No-2 Darwin, Nutrition deptt.	1st	Ceiling Fan	5	60	0.3	3.75	1.125
					0		0
		Tube Light	7	40	0.28	4.5	1.26

		Water Bath	1	500	0.5	4.5	2.25
		Hot air oven	1	500	0.5	4.5	2.25
Teachers Room Darwin, Nutrition deptt		Ceiling Fan	2	60	0.12	3.75	0.45
					0		0
		Tube Light	2	40	0.08	3	0.24
		LED Desktop	1	60	0.06	3	0.18
		Printer	1	250	0.25	1	0.25
		Fridge	1	120	0.12	24	2.88
		Wifi router	1	12	0.012	6	0.072
Kitchen Lab Darwin, Nutrition deptt.		Tube Light	1	40	0.04	4	0.16
					0		0
		Exhaust Fan	1	75	0.075	2	0.15
		Weight Machine	1	60	0.06	1.25	0.075
		Microwave Oven	1	1270	1.27	1.25	1.5875
		Mixer Grinder	1	600	0.6	1.25	0.75
Girls Common Room		Ceiling Fan	2	60	0.12	2.5	0.3
		CFL Light	5	9	0.045	3	0.135
		Exhaust Fan	3	75	0.225	4	0.9
Teachers' Staff Room		Ceiling Fan	9	80	0.72	3.75	2.7
		Tube Light	5	40	0.2	3	0.6
		TV	1	150	0.15	2	0.3
		LED Light	14	12	0.168	5	0.84
		Submersible Pump	5	1500	7.5	0.5	3.75
DB01 Darwin History Deptt.	Gr	Ceiling Fan	6	60	0.36	3.75	1.35
					0		0
					0		0
		Tube Light	8	40	0.32	4	1.28
DB02 Darwin History Deptt.		Ceiling Fan	6	60	0.36	3	1.08
					0		0
					0		0

		Tube Light	6	40	0.24	4	0.96
		LED Tube Light	2	20	0.04	4	0.16
DB03		Ceiling Fan	6	60	0.36	3.75	1.35
Darwin					0		0
Pol Sc Deptt.					0		0
		Tube Light	4	40	0.16	4	0.64
		LED Tube Light	3	20	0.06	4	0.24
Darwin Bhawan Teachers Room		Ceiling Fan	3	60	0.18	3.75	0.675
					0		0
		Tube Light	4	40	0.16	4	0.64
		LED Tube Light	1	20	0.02	4	0.08
		Led Light	1	18	0.018	4	0.072
		Exhaust Fan	1	75	0.075	4	0.3
		Wall Fan	1	60	0.06	4	0.24
		LED Desktop	3	60	0.18	4	0.72
Darwin Bhawan	Gr	Ceiling Fan	2	60	0.12	3	0.36
Corridor					0		0
		LED Tube Light	1	20	0.02	5	0.1
Darwin Bhawan		Ceiling Fan	12	60	0.72	3.75	2.7
SN Bose Lab					0		0
		Tube Light	21	40	0.84	4	3.36
		CFL Light	8	15	0.12	4	0.48
		Exhaust Fan	2	75	0.15	2	0.3
		Electron Spin	1	75	0.075	2	0.15
		Resonance Spectrometer			0		0
		Scintific Oscilloscope	1	40	0.04	2	0.08
		Constant Current Source	1	25	0.025	2	0.05
		PID Controlled	1	75	0.075	2	0.15

		Oven					
		Digital Microvoltmeter	1	25	0.025	2	0.05
		Study of Dielectric Constant	1	250	0.25	2	0.5
		Hall Effect Setup	1	25	0.025	2	0.05
		Digital Gaussmeter	1	25	0.025	2	0.05
		Electromagnet & constant current Power supply	1	250	0.25	2	0.5
Botany Room	1st	Ceiling Fan	5	80	0.4	3	1.2
		Tube Light	4	40	0.16	6	0.96
		Projector	1	250	0.25	1	0.25
		BOD Incubator	1	300	0.3	0.1	0.03
		Vertical Autoclave	1	250	0.25	0.15	0.0375
		Heater	1	1500	1.5	0.1	0.15
		Cold Centrifuge	1	110	0.11	0.1	0.011
		Spectrophotometer	1	15	0.015	0.2	0.003
		Electronic Balance	1	60	0.06	0.5	0.03
F-27	1st	Ceiling Fan	6	80	0.48	3.55	1.704
		Tube Light	6	40	0.24	6	1.44
NCC Office		Ceiling Fan	7	80	0.56	3.55	1.988
		Tube Light	11	40	0.44	8	3.52
F-14		Ceiling Fan	3	80	0.24	3.55	0.852
		Tube Light	4	40	0.16	8	1.28
		Computer	1	100	0.1	2	0.2
		Fridge	1	100	0.1	8	0.8
English Deptt		Ceiling Fan	2	80	0.16	3.55	0.568
		Tube Light	4	40	0.16	6	0.96
		Table Fan	4	60	0.24	6	1.44
		CFL	2	20	0.04	6	0.24

Chemistry Bathroom		CFL	1	20	0.02	6	0.12
Student Canteen		Ceiling Fan	10	80	0.8	4.55	3.64
		Tube Light	8	40	0.32	10	3.2
		LED Tube	1	20	0.02	3	0.06
		Fridge	3	100	0.3	6	1.8
F-25		Ceiling Fan	6	80	0.48	3.55	1.704
		Tube Light	2	40	0.08	6	0.48
		LED Tube	4	20	0.08	6	0.48
Librarian Room		Ceiling Fan	6	80	0.48	3.55	1.704
		Tube Light	7	40	0.28	2	0.56
		Printer	1	250	0.25	1	0.25
		Computer	1	100	0.1	1	0.1
		UPS	1	250	0.25	1	0.25
Library		Ceiling Fan	12	80	0.96	2	1.92
		Tube Light	16	40	0.64	6	3.84
		Printer	1	250	0.25	1	0.25
		Computer	4	100	0.4	2	0.8
Online Office		Ceiling Fan	4	80	0.32	4	1.28
		Tube Light	4	40	0.16	8	1.28
		LED Light	1	30	0.03	9	0.27
		Xerox Machine	2	250	0.5	1	0.5
		Computer	6	100	0.6	3	1.8
		AC	3	1900	5.7	2	11.4
		Printer	2	250	0.5	1	0.5
F-15		Ceiling Fan	4	80	0.32	4	1.28
		Tube Light	6	40	0.24	8	1.92
F-23		Ceiling Fan	6	80	0.48	2	0.96
		Tube Light	6	40	0.24	3	0.72
F-24		Ceiling Fan	8	80	0.64	3	1.92
		Tube Light	6	40	0.24	3	0.72
		LED Light	2	20	0.04	3	0.12
F-16 Store Room		Ceiling Fan	2	80	0.16	3.5	0.56
					0		0
		Tube Light	6	40	0.24	3	0.72

		LED Light	6	20	0.12	2	0.24
Muslim Hostel Room No-5		Ceiling Fan	1	80	0.08	2	0.16
					0		0
		Tube Light	2	40	0.08	4	0.32
		Table Fan	1	80	0.08	2	0.16
Muslim Hostel Room No-2		Tube Light	2	40	0.08	5	0.4
					0		0
		LED Light	1	9	0.009	2	0.018
1st Floor		Ceiling Fan	2	80	0.16	3	0.48
		Tube Light	2	40	0.08	5	0.4
		LED Tube Light	2	10	0.02	2	0.04
Room No 3		Ceiling Fan	1	80	0.08	2.5	0.2
		Tube Light	2	40	0.08	4	0.32
		LED Bulb	1	9	0.009	4	0.036
Wash Room		LED Bulb	1	9	0.009	3	0.027
		Water Pump	1	1200	1.2	0.15	0.18
Store Room		Tube Light	2	40	0.08	4	0.32
Corridor		LED Bulb	1	9	0.009	4	0.036

3. Quantification by End Use

The loads were segregated based on the end use as lighting and fans, air conditioning, computers, printers, water pumping, instruments in the laboratories. Quantification, types and necessary measurements were carried out. The details are given here.

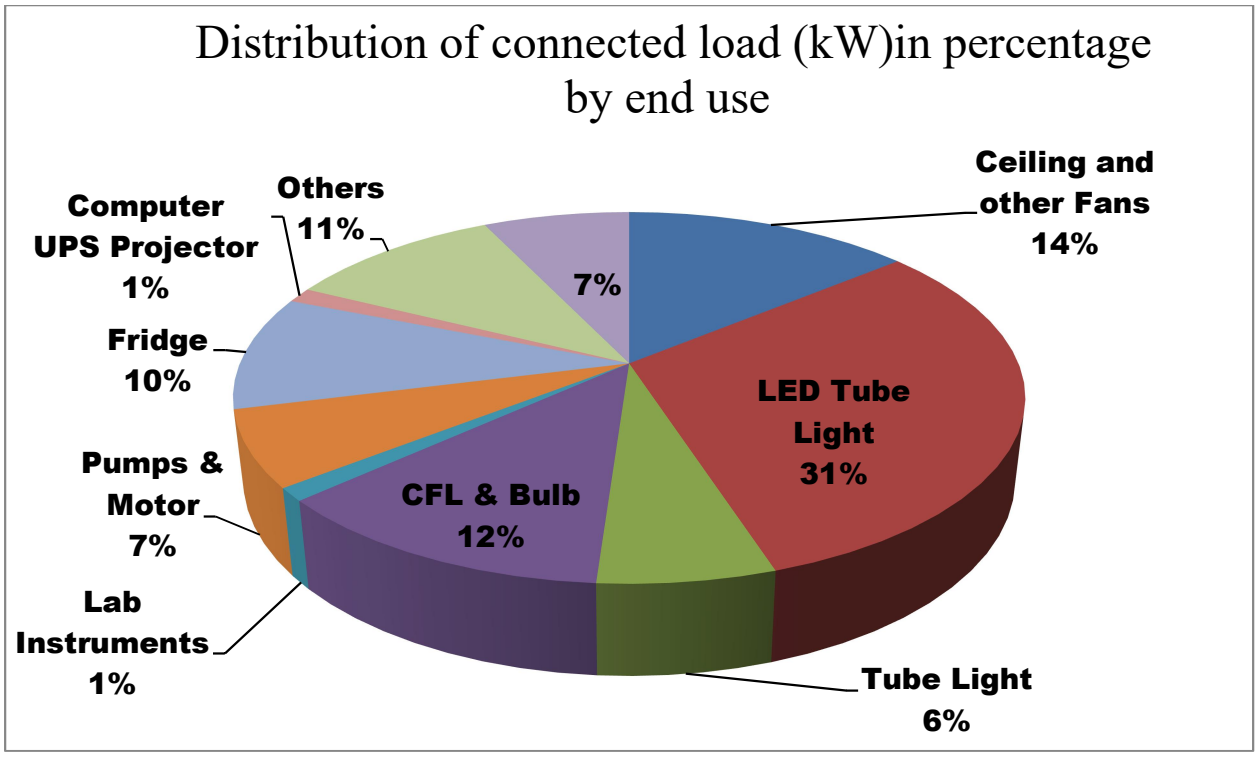

Fig. 3.1 Distribution of connected load in percentage by end use in Bejoy Narayan Mahavidyalaya.

Connected Load is also given in the Fig 3.2

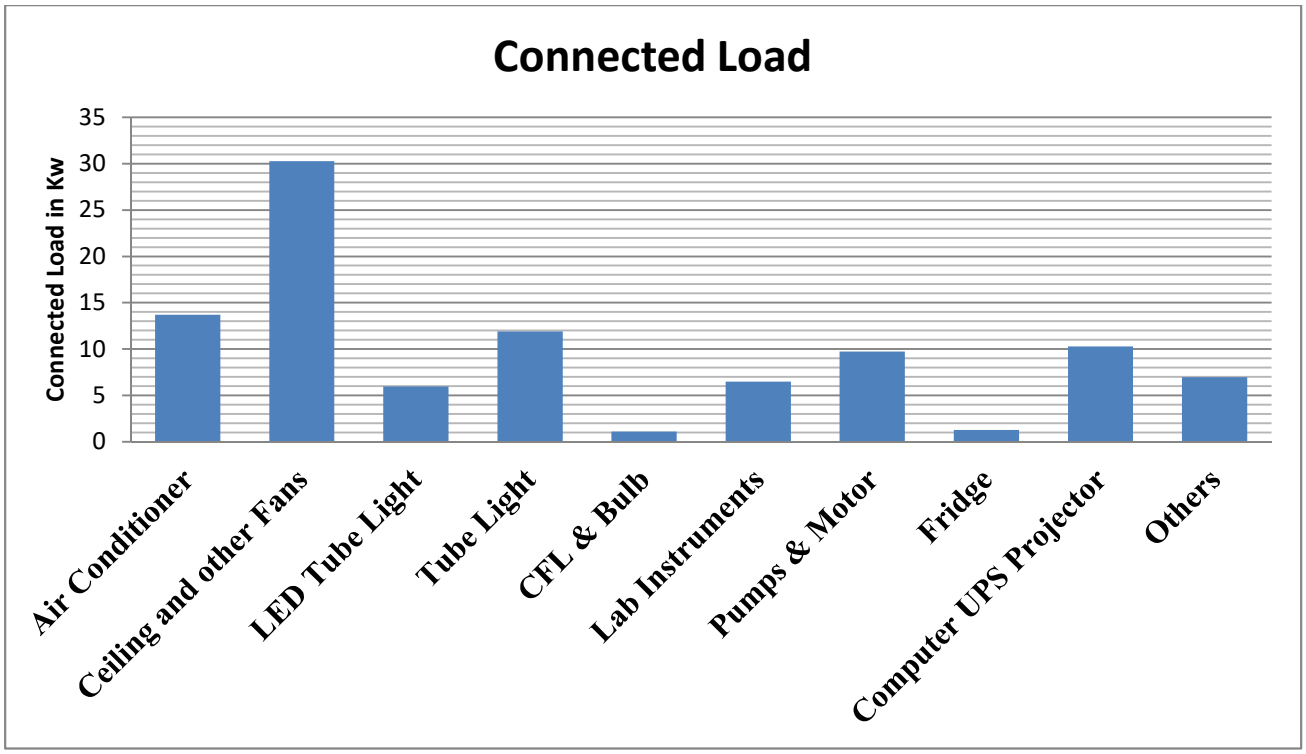

Fig 3.2: Conncted Load (kW) in the Bejoy Narayan Mahavidyalaya

4. 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 Bejoy Narayan Mahavidyalaya is energy consumed per person (includes teaching staff and students). The benchmarking parameters are hereunder.

- Departmental energy performance
- Consumed per sq.m of area and
- Per capita consumption

4.1 Building Energy Performance

The details of the daily energy consumption in the building against the connected load are shown

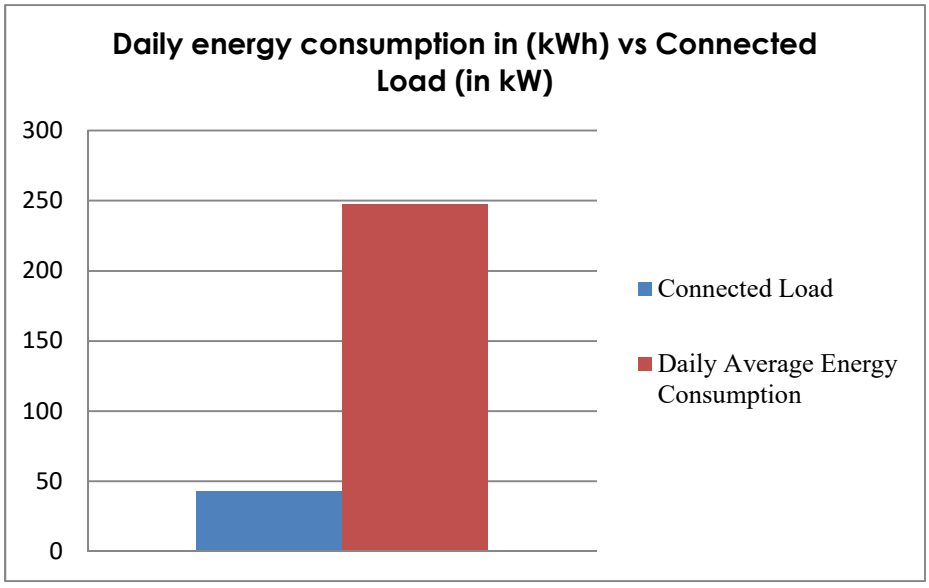

Fig 4.1.1: Daily energy consumption in (kWh) against Connected Load in 2022

4.2 Equipment Wise Consumption

Electrical gadgets wise per day consumption has been given in Fig 4.2

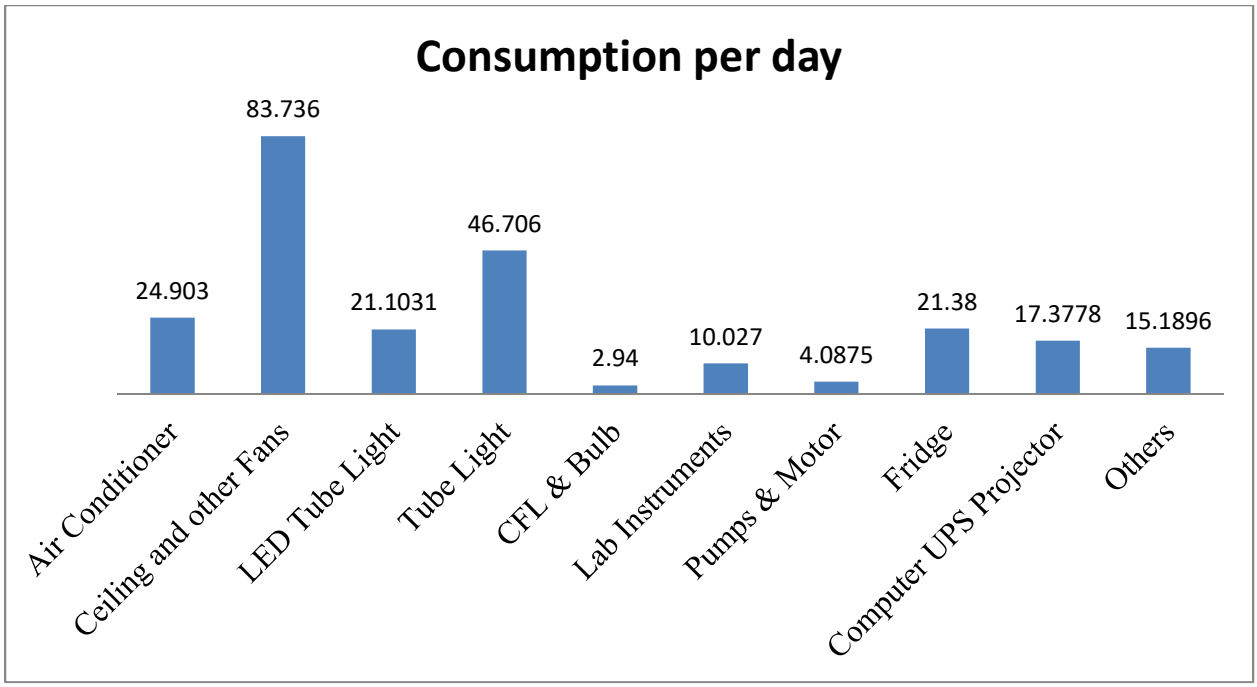

Fig 4.2.1: Daily average consumption (kWh)

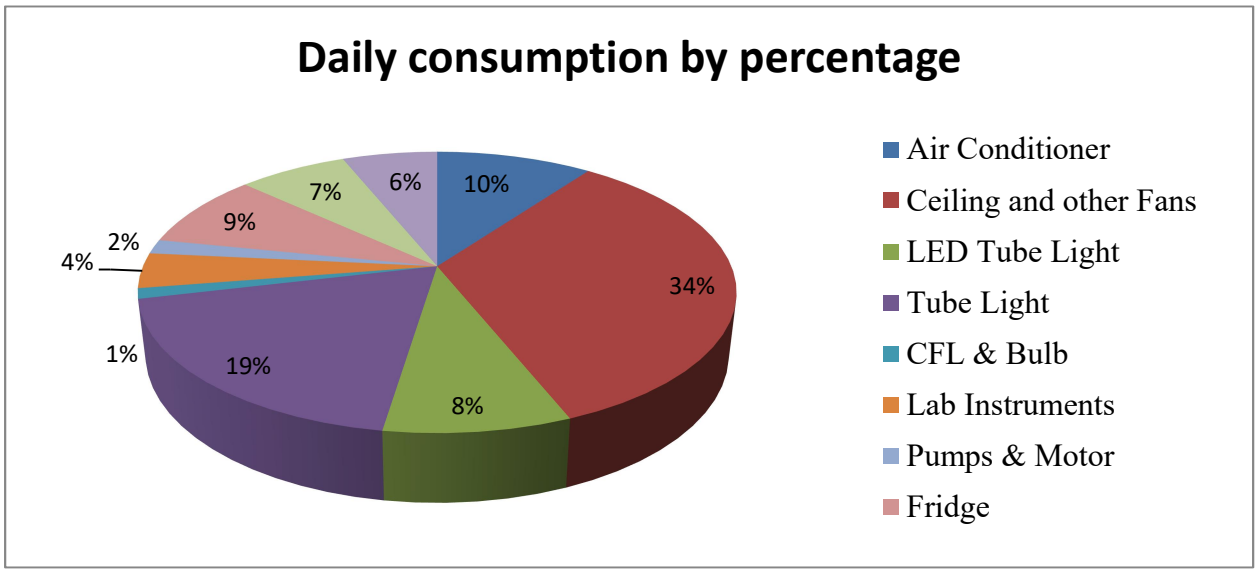

Fig 4.2.2: Daily average percentage consumption (kWh)

4.3 Unit Area Energy Consumption

The energy consumption per sq. ft for the buildings

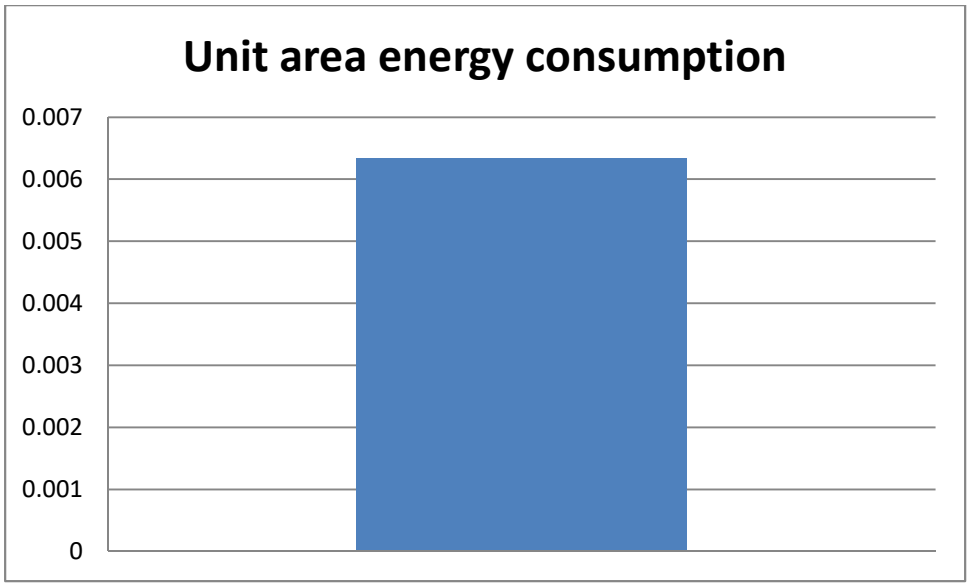

Fig. 4.3 Building area unit consumption in sq. ft

4.4 Yearly energy consumption

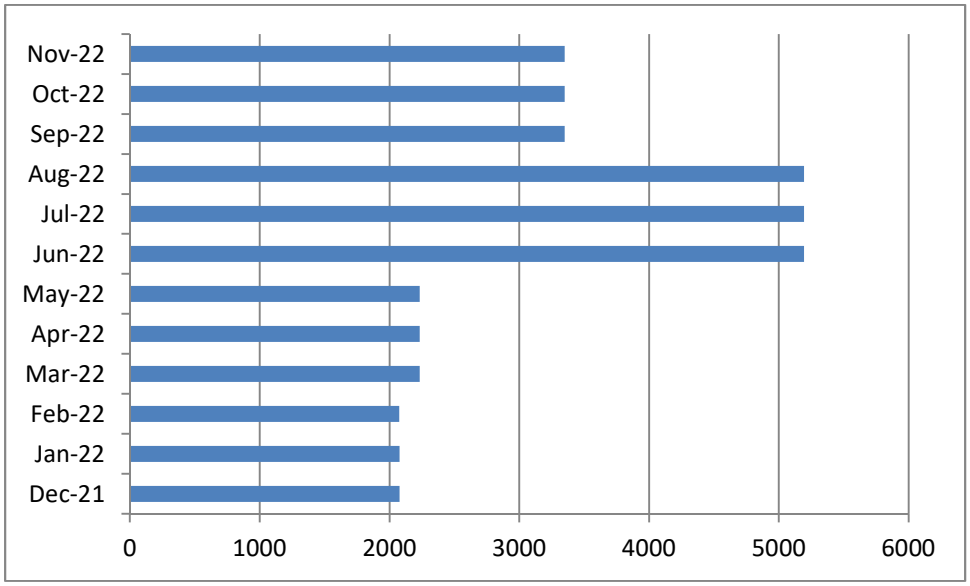

Fig 4.5.1 Yearly energy consumption

Due to Covid-19 lockdown restrictions the college was closed from March 2020 to 15.11.2021. Latest data- points of energy consumption for 2021 22 (December 2021 to November 2022) has been taken as standard.

4.5 ECBC Standards and Comparison

As per the Energy Conservation Building Code (ECBC) – 2007, published by the Bureau of Energy Efficiency (BEE), Govt. of India, recommended levels of lighting power density are as given below in Table 4.1.

Space/ application	Lighting power density in W/sq.m.
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	
General 200	Reading Room 200
Reading tables 200	Bathrooms 50
Computer Workspace 300	Interior Parking Area 20
Music Rooms 200	Sports halls 200

Table 4.1: ECBC recommended levels for lighting power density

4.6 Illumination Level

Measured Lux Level as in the Table 4.1

Place	Lux level (lx)
Class Room	160
Office	180
Laboratory	160
Common area	130

5. Recommendation

Based on the power consumption data analysis, few steps have been proposed for improving energy efficiently in the buildings of the college. Given below are few important

recommendations for better energy efficiency.

5.1 Replacing Conventional Ballast FTLs with Electronic Ballast FTLs

5.1.1 Cost Analysis of Replacement (Calculation for 100 Conventional Ballast FTL is done here)

- Conventional Ballast FTL=100
- Average consumption of power of Conventional Ballast FTL=52W
- Average consumption of power of Electronic Ballast FTL=40W
- Power can be saved per FTL= (52-40)W= 12W
- Total power can be saved= 100*12W=1200W= 1.2kW
- Average FTL use per year =280*7hours=1960 hours
- Total energy can be saved per year=1.2kW * 1960 hours= 2352kWh
- Saving in Rs. Per year=2352 kWh * 8= Rs.18816
- Average cost of replacing each FTL= Rs. 150
- Total cost of the replacement of 100 Conventional Ballasts FTLs= 100 * 150= 15000
- Capital cost recovery time needed= 15000/18816 = 0.797 years.

Hence time needed for the capital cost recovery is 0.797 years for replacing 100 Conventional Ballast FTLs with Electronic Ballast FTLs of the campus.

5.2 Installing Motion Sensors in Corridors

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

5.2.1 Cost Analysis Motion Sensors in Corridors

- Average number of tube lights in a corridor=10
- Average power consumption of the tube lights= 40W
- Average number of motion sensor required= 10
- Average reduction in usage of tube lights per day by motion sensor=4hours

- Total energy can be saved in a corridor per year=(10*40W*4hours*280days) / 1000= 448 kWh
- Saving in Rs per year=448*10=Rs. 4480
- Average cost of installation per motion sensors= Rs. 250
- Total cost of installing motion sensors in a corridor= 10 *250= Rs. 2500
- Capital cost Recovery time= 2500/4480= 0.5 years.

Hence the time needed for the capital cost recovery is 0.5 years for installing motion sensors in corridors

5.2.2 Occupancy Sensors

Occupancy sensors are widely used for light and fan energy conservation issues. The majority of the time, it is utilised to detect human presence in the vicinity and switches on the lights. It differs from a motion sensor, such as those used for outdoor security lighting, in that you don't need to flail your arms wildly because a motion sensor would tim out and you'd need to manually turn it back on. As soon as you leave the room, an occupancy sensor times out. To match it to the fan, check the fan's specifications to determine how many watts of load it needs, and then check the occupancy sensor's specifications to see how many watts of load it can handle.

5.3 Replacing Old ACs with New Star Rated ACs

5.3.1 Cost of Replacement of the ACs (Calculation for 100 Old Window ACs)

- Old Window ACs of 1.5 tons =5
- Average consumption of power of the old window ACs= 2000W
- Average consumption of power of a new 5 star rated AC with 1.5 ton capacity= 1500W
- Power can be saved per AC= (2000-1500)W=500W
- Power consumption can be saved per AC=500W
- Total power saving= 5*500=2500= 2.5 kW
- Average use of AC per year=280*4= 1120 hours
- Total Energy saved per year= 2.5kW*1120hrs=2,800kWh

- Saving in Rs per year=2,800*10= Rs.28,000
- Average cost of replacing each old window ACs with new 5 star rated split ACs both of capacity 1.5 tons= Rs. 26000
- Total cost of replacing all AC= 5*38000= Rs. 1,90,000
- Capital cost recovery time needed= 1,90,000/26,000= 7.3 years.

Therefore time needed for the capital cost recovery is 7.3 years for replacing 5 old windows ACs of 1.5 tons with 5 new 5 star rated new split ACs of 1.5 tons of the campus. The split AC's are costlier than the window AC's but their energy efficiency in terms of consumption is higher.

5.3.2 Better Practices for ACs

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

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

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

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

5.4. Energy saving by using Super-Efficient (BLDC) Fans

A Super-Efficient (BLDC) Fan consumes 30 watts whereas a conventional fan consumes 80 watts.

- Hence energy savings per fan per hour = 50 Wh
- Total Energy savings by Super-Efficient Fans = 50W X Operating hours
- (Per day Per fan) = 50W X 6.5 Hrs = 325 Wh = 0.325 KWh (Per day Per fan)

- Cost saving per day per fan = 0.325 KWh X Rs. 10 = Rs. 3.25/-
- Cost saving per day for 200 fans =Rs. 3.25/-X 200= Rs. 650/- (Per day)
- Total annual cost saving by using Super-Efficient Fans = Rs. 650/- X Total no.
- of operating days =Rs. 650- X 180 days =Rs. 1,17,000/-
- Cost of buying 200 Super-Efficient (BLDC) Fans = Rs. 3000/- X 200= Rs.6,00,000/-

Hence the time needed for the capital cost recovery is 5.12 years for BLDC fan.

Recommended to buy super-efficient ceiling fans instead of ordinary fan whenever there is requirement for new purchase. Also note that always use proper capacitor for ordinary fan and change the capacitor a necessary.

5.5. Energy Saving By Replacing Old Tubelights With Led lights

A 40 watt old tube light can be replaced with a LED tube light which has a power rating of 20 watt.

- Energy saving per light per hour = 20 watt
- Energy saving per light per day= 20 watt X 6.5hrs = 130 Wh=0.13 kWh
- Total annual energy saving per light = 0.13 kWh X 280 days= 36.4 kWh
- Total annual energy cost saving per light = 36.4 kWh X Rs. 10 = Rs. 364/-
- Total annual energy cost saving by replacing all the old tubelights = Rs. 364/- X 500 = Rs. 1,82,000/-
- Cost for buying 500 LED tube lights = Rs. 250/- X 500 = Rs. 1,20,000/-
- Payback period = (Rs. 1,20,000/-)/ (Rs. 1,82,000/-) = 8 months

Payback period is much shorter than the lifespan of LED tubelights (Lifespan of a LED tubelight is usually 20000 hrs+; which is around 8.4 years considering operating hour is 6.5 hours a day). Hence it is recommended to replace all the existing tubelights with LED light.

5.6 Electric wiring:

Power loss in old electric wirings is more than current electrical wiring and also old electrical

wirings are not secured. It is recommended to maintain electric wiring with licensed electricians. Some of electric wires are laid with the help of iron angle from the main building to the new building. A further consultation with the licensed electrician is required in regard to the safety of the system. It is recommended to use proper cable try to laying the cable or wire with proper earthing arrangement.

It is also recommended that installation of modern electrical distribution board (ACDB) with proper load distribution in generator room and other floors wherever required.

5.7 Civil work.

Maintenance and check of roofs/ceilings by professionals are recommended for all the buildings.

6. Maximum Utilization of Renewable Energy Resources

National Assessment and Accrediation Council (NAAC)'s Vision is "To make quality the defining element of higher education in India through a combination of self and external quality evaluation, promotion and sustenance initiatives." Under NAAC criteria, Criterion VII, INNOVATIONS AND BEST PRACTICES, the key aspects are as follows-

- Environment Consciousness.
- Innovations
- Best Practices.

Under Environmental Consciousness focuses are given on topics like-

- Energy Conservations
- Rain Water Harvesting
- Maximum Use of Renewable Energy sources
- Wastes Recycling
- Efforts for carbon neutrality
- Check dam constructions

- Solid wastes, Hazardous wastes, and E-wastes Managements
- Plantations and gardening
- Efforts for Carbon neutrality
- Minimum uses of paper, plastics

6. 1 Renewable Resources

India has a huge potential in generating solar energy using the unutilized space on the rooftops of any buildings. Solar power generated from any individual's household, industrial building, commercial buildings and institutional buildings or in any other types of buildings can substitute a huge amount of power demand from non-renewable power sources and can be partly used to fulfil the energy demand of the inhabitants of the building and in case of surplus can be fed into the grid. Till date, 26 states have notified their regulation to provide with Net Metering/ Gross Metering facilities to support the installations of solar rooftops. In recent times it is possible to generate solar power of about Rs. 5.50/kWh from the rooftop solar system, which is much cheaper than the electricity generation from a diesel generator sets. It is also cheaper than the cost at which most DISCOMS which would avail power to the domestic, industrial and commercial consumers. The new Technologies and initiatives will help India rise as a major country using their roof space for rooftop solar energy system on a huge scale. Nearly 60 million tonnes of CO2 per year will be reduced due to 40 GW of power, with the India's commitment toward its contribution in mitigating the global effect of climate change. The National Solar Mission was launched on the 11th January, 2010 by the Prime Minister. The Mission has set the ambitious target of deploying 20,000 MW of grid connected solar power by 2022 is aimed at reducing the cost of solar power generation in the country through (i) long term policy; (ii) large scale deployment goals; (iii) aggressive R&D; and (iv) domestic production of critical raw materials, components and products, as a result to achieve grid tariff parity by 2022. Mission will create an enabling policy framework to achieve this objective and make India a global leader in solar energy. Further, Government has revised the target of Grid Connected Solar Power Projects from 20,000 MW by the year 2021-22 to 100,000 MW by the year 2021-22 under the National Solar Mission and it was approved by Cabinet on 17th June 2015.

6.2 Solar Cell

Solar cells represent the fundamental power conversion unit of a photovoltaic system. For practical operation, solar cells are usually assembled into modules. Its operation is based on the ability of semiconductors to convert sunlight directly into electricity by exploiting the photovoltaic effect. In the conversion process, the incident energy of light creates mobile charged particles in the semiconductor, which are then separated by the device structure and produce electricity.

Depending upon the type of absorbing material used, manufacturing technique / process adopted, and type of junction formed etc., the solar cell technologies can be broadly classified as following:

- Wafer based crystalline silicon solar cells
- Thin-film solar cells, which includes, Copper Indium Gallium Diselenide (CIGS), Cadmium Telluride, Amorphous silicon (a-Si) etc.
- Concentrating Photovoltaic (CPV) and
- Emerging technologies such as thin-film silicon, dye sensitized solar cells; polymer organic solar cells etc.

Material	Thick-ness	Efficiency (%)	Colour	Features
Mono-crystalline Si solar cells	0.3 mm	15 – 18	Dark blue, black with AR coating, grey without Anti Reflective (AR) coating	Lengthy production procedure, wafer sawing necessary. Best researched solar cell material – highest power/area ratio.
Poly-crystalline Si solar cells	0.3 mm	13 – 15	Blue with AR coating, silver-grey without AR coating	Wafer sawing necessary. Most important production procedure at least for the next ten years.
Poly-crystalline	0.3 mm	10 %	Blue with AR	Lower efficiency than mono-

Material	Thick-ness	Efficiency (%)	Colour	Features
transparent Si solar cells			coating, silver-grey without AR coating	crystalline solar cells. Attractive solar cells for different BIPV applications.
EFG (Edge Defined Film fed Growth)	0.28 mm	14	Blue, with AR coating	Limited use of this production procedure Very fast crystal growth, no wafer sawing necessary
Poly-crystalline ribbon Si solar cells	0.3 mm	12	Blue, with AR coating, silver-grey without AR coating	Limited use of this production procedure, no wafer sawing necessary. Decrease in production costs expected in the future.
Apex (polycrystaline Si) solar cells	0.03 to 0.1 mm + ceramic substrate	9.5	Blue, with AR coating, silver-grey without AR coating	Production procedure used only by one producer, no wafer sawing, production in form of band possible. Significant decrease in production costs expected in the future.
Mono-crystaline dendritic web Si solar cells	0.13 mm incl contacts	13	Blue, with AR coating	Limited use of this production procedure, no wafer sawing, production in form of band possible.
Amorphous silicon	0.0001 mm + 1 to 3 mm substrate	5 – 8	Red-blue, Black	Lower efficiency, shorter life span. No sawing necessary, possible production in the form of band.
Cadmium Telluride (CdTe)	0.008 mm + 3	6 – 9 (module)	Dark Energy, Black	Poisonous raw materials, significant decrease in

Material	Thick-ness	Efficiency (%)	Colour	Features
	mm glass substrate			production costs expected in the future.
Copper-Indium-Selenide (CIS)	0.003 mm + 3 mm glass substrate	7.5 – 9.5 (module)	Black	Limited Indium supply in nature. Significant decrease in production costs possible in the future.
Hybrid silicon (HIT) solar cell	0.02 mm	18	Dark blue, black	Limited use of this production procedure, higher efficiency, better temperature coefficient and lower thickness.

Table 6.2: Comparison of different Solar Cell Technologies

6.3 Solar PV System

A PV system essentially consists of modules (array of solar cells generating the electricity) and a balance of system (BoS) including the cabling, battery, charge controller and DC/AC inverter and other auxiliaries/support system. Most of the systems are in flat-plate variety having fixed orientation while some of the system uses sun-tracking (single or double axis) concentrators in order to achieve high radiation on smaller areas for higher efficiency. The storage system (batteries) is not required in grid connected SPV systems.

A Solar PV module is the smallest PV unit that can be used to generate electricity. Although individual PV cells produce only small amount of electricity, PV modules are manufactured with varying electrical outputs ranging from a few watts to more than 100 watts of direct current (DC) electricity. The modules can be connected into PV arrays for powering a wide variety of electrical equipment. A typical schematic of grid-connected PV system is given in Figure 6.

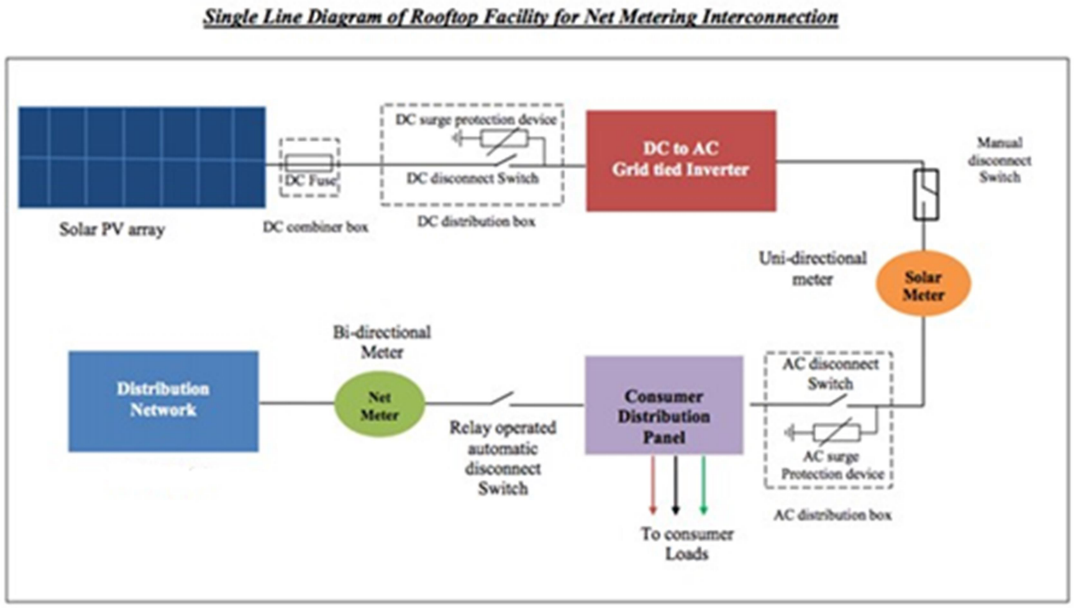

Fig 6.3: Single Line diagram with Net metering facility

6.4 Current Solar Capacity

The college has installed 2.3 kW of solar Rooftop PV plant.

6.5 Further scope of Solar Capacity Utilization

The college has adequate shade-free rooftop space for utilization of solar energy. A detailed available rooftop area is hereunder.

Building Name	**Shade less Area**	**Approx Installation capacity**
All buildings	4400 sq ft	44 kWp

Therefore, harness able rooftop solar potential is approximately total 44kWp.

A 44 kW of solar PV plant will produce approximately 66,000 units of electricity per year. If the current two roofs are fully utilised in regard to rooftop installation then the college will be completely energy independent. But the installed capacity restriction and grid injection has to be complied with policy of state discoms.

7. Disposal and Reclying of Waste

7.1 Waste Management

The waste is segregated at source by providing separate dust bins for Biodegradable and Plastic waste. Segregation of chemical waste generated in chemistry, zoology lab and other laboratories. Solid and liquid waste from the college are also decomposed here.

Waste Category	Method of disposal
Solid waste from canteen	Organic Manure
Plastic Waste	Through Authorised recycler
Solid Waste from Lab	Composting
	Organic manure

7.2 Waste to Compost (WTC) Machine

On 27.01.2021 sanitary napkin burning incinerator has been installed with sanitary napkin vending machine for proper waste management of used napkin.

7.2.1 WTC Procedure

I. The machine has Input door, Output door, Blades for Mixing, process is noiseless and odorless.
II. Humidity sensor which sense the moisture in the wet waste, Heater, Saw dust with Micro-Organism, Air Ventilation, pipe which directly connect to the sewage system.
III. First step is to put organic waste in the Machine from waste input door then close the door.
IV. Blades start mixing all the waste in the machine at 2 RPM (Rotation per Minute) Clock wise and Anti-Clock Wise.
V. Humidity Sensor in the machine, as it is known that organic waste content 70-80% water.
VI. Once waste is sensed by the humidity sensor Heater will automatically turns On & Water gets evaporate, here we achieve 70-80% volume reduction and steam goes out through

pipe which is directly connect to sewage system. e Air Ventilation is provided for Micro Organism to be in live condition.

VII. After that rest of materials are l decomposed by bacteria and hereby 80-95% volume reduction is achieved.

VIII. Per day you will get 10% compost, but no need to remove on a daily basis once in a 7-8 days when compost reaches to Maximum Indicator Line of Machine.

IX. Once byproduct came out from the machine we sent it to Laboratory to check the compost.

X. Microorganisms operate best under neutral to acidic conditions, with pH's in the range of 5.5 to 8. During the initial stages of decomposition, organic acids are formed. The acidic conditions are favourable for growth of fungi and breakdown of lignin and cellulose. As composting proceeds, the organic acids become neutralized, and mature compost generally has a pH between 6 and 8.

XI. Zero Maintenance

7.3 E-Waste Management

Over the last two decades, the amount of consumer and business electronic equipment has increased continuously. At the same time, rapid changes in information and communication technologies, the concomitant increasing versatility of most electronic devices together with the downward trend in prices have led to a drastically reduced lifespan for most electronic equipment. Almost every used electronic items are considered as e-waste such as discarded cellphones, cameras, CD players, TVs, radios, drillers, fax machines, photocopiers, printers, toners, ink cartridges, batteries, rechargeable batteries, digital calculators and clocks, CRT monitors, electric solders, computer mother boards, key board, industrial and house hold electronic machinery such as oven, fridge, sewing & washing machines, fan, air-conditioner, grinder, iron, heater, military and laboratory electronic equipment's, etc. The rapid growth of technology, rise in per capita income of people in developing nation, up gradation of technical innovations and a high rate of obsolescence in the electronics industry have led to one of the fastest growing waste streams in the world which consist of end of life electronic waste products.

Electronic waste or e-waste is one of the fastest growing waste streams around the world, growing at a rate of 3–5% per annum or approximately three times faster than normal municipal solid waste. Managing electronic waste (or e-waste) is one of the most rapidly growing pollution problems worldwide. New technologies are rapidly superseding millions of analogue appliances leading to their disposal in prescribed landfills despite potentially their adverse impacts on the environment. The consistent advent of new designs, ‘‘smart’’ functions and technology during the last 20 years is causing the rapid obsolescence of many electronic items. The lifespan of many electronic goods has been substantially shortened due to advancements in electronics, attractive consumer designs and marketing and compatibility issues. In line with the institutional e-waste management best practices the college follows the policy on the e-waste. The e-waste and defective item from computer lab and other places are stored properly. On 15.12.2020 the institution has disposed e-waste through J.S. Pigments in scientific and eco-friendly manner (certificate no. JSPPL/20/L/1218 dated 14.06.2021).

8. Water Footprint

Water footprints help individuals, businesses and countries because they reveal water use patterns, from the individual level all the way to the national level. They shine a light on the water used in all the processes involved in manufacturing and producing our goods and services. A water footprint also accounts for the amount of water contaminated during manufacturing and production because that water is made unusable and is, essentially, taken out of the system.

The water footprint gives everyone - from individuals to business managers to public officials - a solid frame of reference that helps us all be more efficient and sustainable with our water use and appreciate the role of water in our lives. A water footprint is measured in terms of the volume of water consumed, evaporated and polluted.

Blue Water Footprint : The amount of surface water and groundwater required (evaporated or used directly) to make a product.

Energy Water Footprint : The amount of rainwater required (evaporated or used directly) to make a product.

Grey Water Footprint : The amount of freshwater required to mix and dilute pollutants enough to maintain water quality according to certain standards (like the ones established in the US Clean Water Act) as a result of making a product.

The college has total 4 overhead tanks and 2 (one reserved for emergency) pumps which runs almost avg 1 hrs a day.

The water pumps details-

Water Pump Capacity	Types	Number of pump	Instantaneous current draw	Water suction from
2 HP	3 phase Centrifugal Pumps	2	2.9 A per phase per pump	Ground water. Water supply from local govt. body
2 (two) water pumps are used daily One emergency pump should be kept as standby. It is recommended to use one emergency purpose water pump alternately.				

9. Rain Water Harvesting

Watering harvesting means capturing rain water, where it falls and capture the runoff from catchment and streams etc. Generally, water harvesting is direct rainwater collection. This collected water could be stored for later use and recharged into the ground water again.

10. Carbon Neutrality

Students and staff members are made aware of pollution caused by use of vehicles and bicycles. Most of the students in the college use bicycle for commuting and most of the staff members reside nearby. They either avail public transport, bicycle or rickshaw. Besides, residences of some of the staff are in the vicinity of the college and they commute by walking. About 2-3 % staff members use private car for coming. In the college campus almost 70 % of the students are using public transport, more than 29% of the student are using bicycles, and less than 1% of the

student using private conventional vehicles. The carbon consumption awareness programme improves carbon emission at individual as well as social level. It also helps the college authorities to avoid air and noise pollution in the campus due to vehicles or any activity in it. The nature club (CANOPY) of the college decided and announced every Friday as no vehicle day for the past few months. On that day everyone come to the college by public transport.

11. Environment Awareness Programme

To generate environmental awareness among young generation, UGC as well as The university of Burdwan has taken "Fundamentals of Environmental Studies" as compulsory subject to all first semester Batchelor degree students. Syllabus topics must consist of following:

a. Air Pollution its causes, effects & installation of various devices that reduces the air pollution.
b. Water Pollution its causes, effects & various methods to prevent the it.
c. Sound Pollution its causes, effects & installed equipments that reduces it.
d. Noise Pollution its effects on surroundings.

The Syllabus covers the following units. The details of the syllabus has been appended in ***Annexure I***

12. Conclusion

The college campus follows a height of carbon neutrality practices. A large number of the students use bicycle for their daily commute. Available shade free rooftop may generate solar power which may exceed the annual energy requirement of the college. However, existing rooftop solar policy of the state government / DISCOM may not support the switch to solar power completely but majority of electrical requirement can be replaced by rooftop solar system.

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Annexure I

Fundamentals of Environmental Studies mandatory for first semester Bachelor students in Burdwan University

Unit 1: Basic of Environmental Studies

Definition, Nature, Scope and Importance; Components of environment: Environmental education

Unit 2: Natural Resources: Renewable & Non-renewable Resources

Nature and natural resources their conservation and associated problems:

• Forest resources: Uses, types and importance, Joint Forest Management & Tribal population, Deforestation and its effects

• Water resources: Distribution of water on Earth; Use, over exploitation of surface and ground water; Dams: Benefits and problems; Flood and Drought

• Mineral resources: Mineral resources in India; Use and exploitation, Social impacts of mining

• Food resources: World food problems and food insecurities.

• Energy resources: Renewable and Non-renewable energy sources; Use of alternate energy sources - Case studies

• Land resources: Land as a resource; Land degradation, landslides, soil erosion, desertification

• Use of resources for sustainable development

Unit 3: Ecology & Ecosystems

Concept of ecology, Population ecology, Community ecology

• Concept of an ecosystem, different types of ecosystem

• Food chains, food weds and ecological succession

• Energy flow in the ecosystem and energy flow models

Unit 4: Biodiversity & Conservation

• Biodiversity: Levels of biological diversity

• Values of biodiversity

• Hot-Spots of biodiversity, Mega-biodiversity countries

• Threat to biodiversity

• Threatened and endemic species of India

• Conservation of biodiversity (In- situ and Ex-situ)

• Ecosystem services: Ecological, Economical, Social, Ethical, Aesthetical and Informational values

Unit 5: Environmental Pollution & Management

(a) Nature, Causes, Effects and Control measures of –

(i) Air pollution

(ii) Water pollution

(iii) Soil pollution

(iv) Noise pollution

(v) Nuclear hazards

(b) Fireworks Pollution: Definition, Composition/Ingredients, effects, monitoring strategies

• Solid waste management: Causes, effects and disposal methods; Management of biomedical and municipal solid wastes

• Disaster management: Floods, Earthquake, Cyclone and Landslides

Unit 6: Environmental Policies & Practices

• Constitutional Provisions for protecting environment- Articles 48(A), 51 A (g)

• Environmental Laws: The Environment (Protection) Act, 1986; The Air (Prevention and Control of Pollution) Act, 1981; The Water (Prevention and Control of Pollution) Act 1974; Forest (Conservation) Act, 1980

• The wildlife Protection Act, 1972

• Climate change, Global warming, ENSO, Acid rain, Ozone layer depletion; Montreal and Kyoto Protocols

Unit 7: Human Communities & Environment

• Human population growth; Impacts on environment

• Population explosion – Family Welfare Programme

• Environment and human health: Concept of health and disease; Common communicable and Non-communicable diseases; Public awareness

• Environment movements in India: Chipko Movements, Silent Valley Movement, Movements in Karnataka

Unit 8: Field Work Report/Project Report/Term paper (based on any one of the following topics and to be evaluated by internal teachers only)

• Environmental assets - River/Forest/Grassland/Hill/Mountain etc.

• Environmental pollution - Urban/Rural/Industrial/Agricultural

• Study of common Plants/Insect /Birds/Wild life etc.

• Study of simple ecosystems: Pond/River/Hill slope etc.

• Municipal solid waste management