Energy
& Eco- Audit

By TeamSustain, Kochi
For Marian College, Kuttikkanam

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Introduction

Organisation Name	:	Marian College
Site Name & Address	:	Marian College Kuttikkanam P.O Peermade, Idukki District Kerala, India
Dates of Visits	:	31 January 2017 to 2nd Feb 2017
Energy Auditors	:	Jayaraman C, Certified Energy Auditor Naijo Dominic Martin Paul
Visit Hosted by	:	Rev Fr James Kozhimala (Manager & Spiritual Director) Rev Dr Roy Abraham P. (Principal)

TeamSustain undertook Preliminary Energy Audit of Marian College, Kuttikkanam under the instruction of Rev Fr James Kozhimala (Manager & Spiritual Director)

The team consisting of 3 Engineers made their visit to the site of Marian College during the period from 31st Jan to 2nd Feb 2017 and carried out the Preliminary Energy Audit.

Objective

The objective of this Energy Audit is primarily to assess the viability of implementing energy efficiency improvement schemes and the potential for implementing renewable energy solutions such as Solar PV systems, Solar Water Heating, Wind Energy, Biogas and small Hydro Projects.

This objective can be achieved by :

Identifying and measuring current energy consumption to quantify the potential for energy savings. This will help assess the impact of the energy conservation measures in achieving the potential and provide a feed back to the management.

Identifying energy saving measures, including savings and implementation budget, and payback to create a financially viable project suitable for implementation.

Identifying other benefits, including renewal of equipment which has reached end of life or resolution of comfort issues. These are to be evaluated/quantified with a detailed feasibility report later.

Identifying additional metering and recording requirements, including any environmental conditions.

Identifying any potential technical, financial or other risks to the project as currently defined.

This Energy Audit is not an Investment Grade Audit and has been completed in a relatively short period by using readily available site information and applying rules of thumb. It is a concise survey, that has been prepared with all reasonable skill, care and diligence possible within a short period. All figures are indicative being derived from a sample data taken during a particular time, not considering various moderating and mediating factors. If all or part of this report is circulated to contractors or Energy Service Companies (ESCOs) to assist in preparation of tenders, neither the author nor the Client accept liability or responsibility for the accuracy or completeness of the information contained herein, which is classified as 'verifiable', i.e. the tenderer is at liberty to verify any or all such information.

Energy Performance

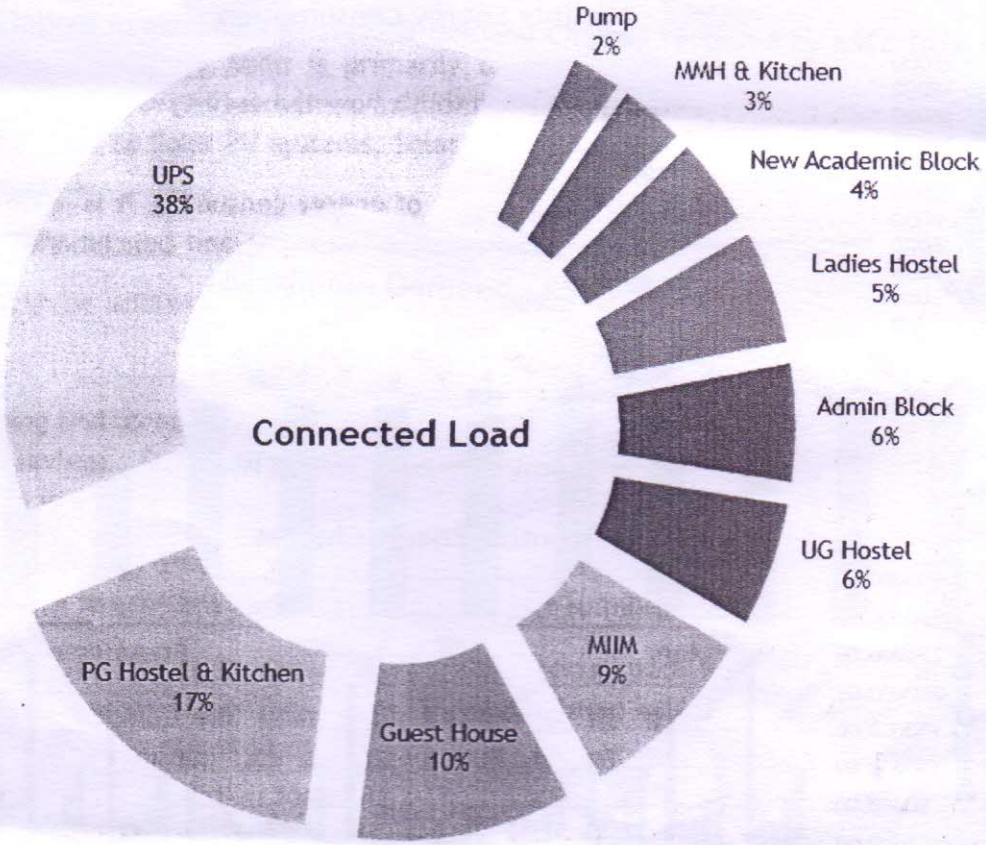
The objective of this subsection is to establish how the facility is performing in terms of energy consumption.

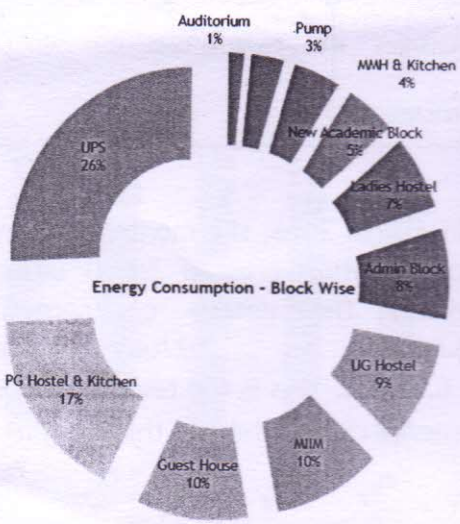
Basic requirement is monitoring and logging of energy consumed. It is recommended that each functional unit shall have a separate energy meter and benchmarks, that shall be closely monitored.

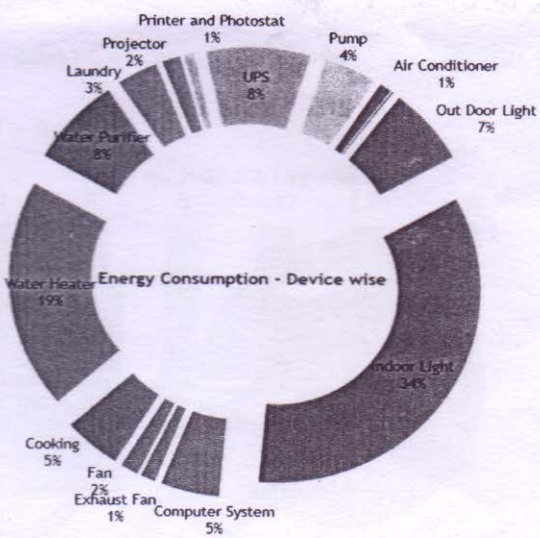
Simple Housekeeping Measures for Energy Savings

Particulars	Requirement
Display stickers to switch off un-utilised equipment like Computers, Printer, Photo Copying machines from mains	Equipment like Computers, printers, photo copiers etc. consume a "phantom" power when not switched off from mains
Have periodic maintenance for switchboards and distribution boards	Loose contacts and connections are a safety hazards as well as cause energy waste
Monitor Energy and Water consumption in every building after installing proper meters	We cannot conserve what we do not measure
Monitor Demand and Energy Consumption closely to avoid penalty and excess energy charges	Penalty and Excess charges to be avoided
Keeping Log Books for Energy Consumption, Generators and power failures	Need for verification of energy consumption and power failure

Electrical Load Analysis

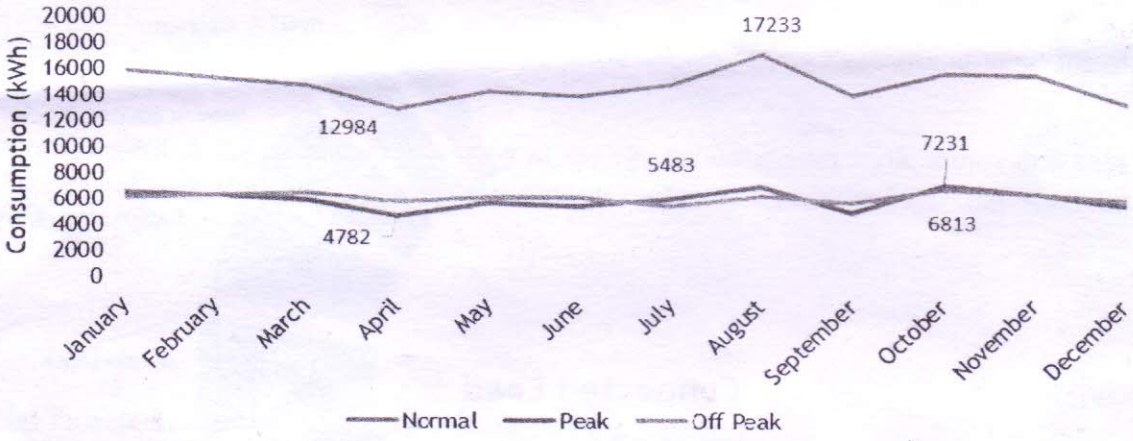




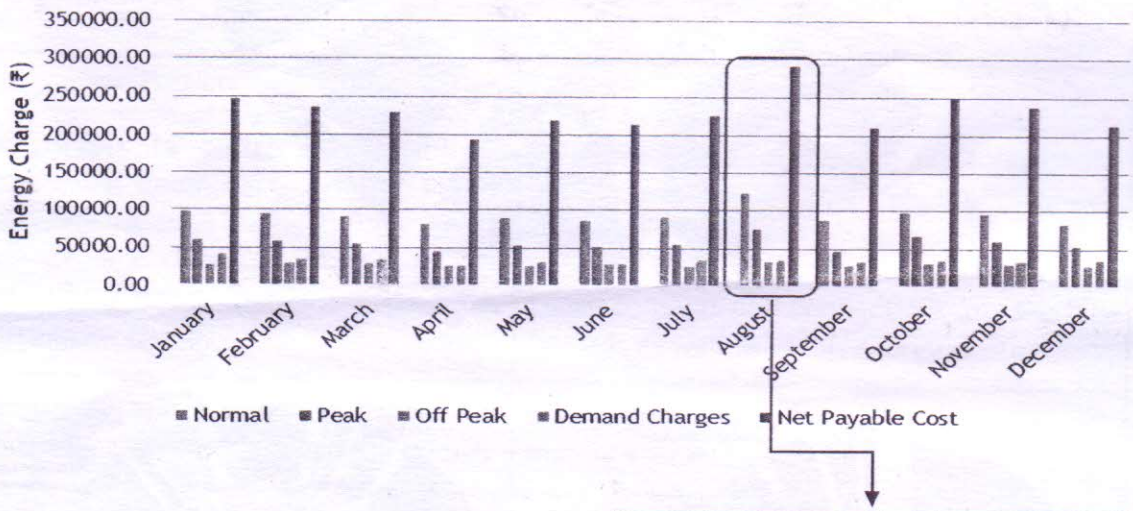


Energy Consumption and Charges

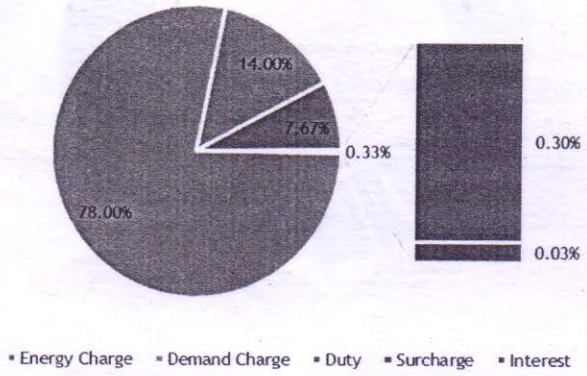
Monthly Energy Consumption



Monthly Energy Charges



Energy Cost Split Up



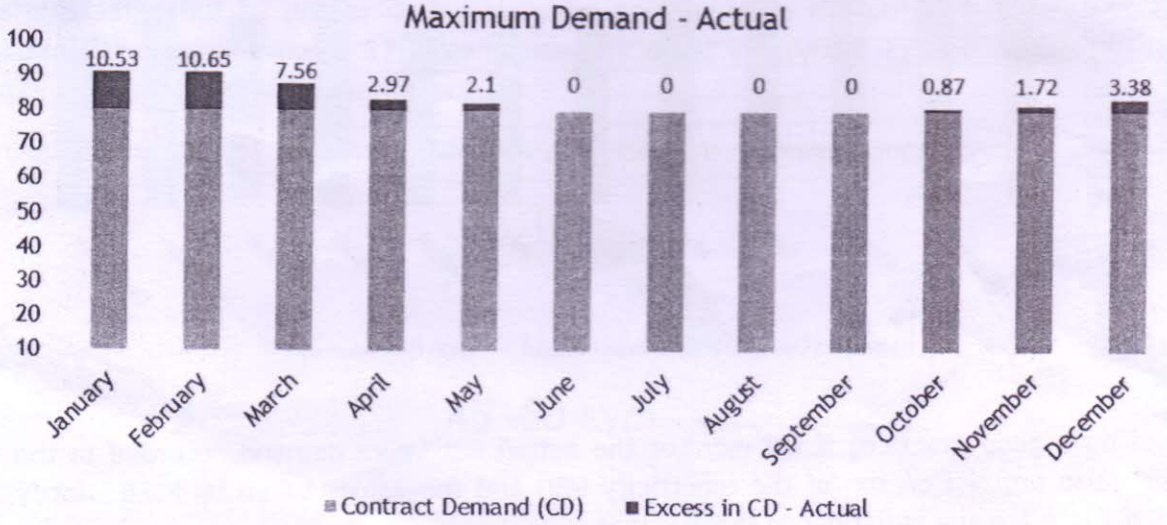
In August 2016, the monthly energy consumption crossed 30000 units' mark. The energy cost(normal) jumped to 7.2/unit from 6.2/unit. This is the reason for the energy charges hike in this month.

Maximum Demand & Demand Charges

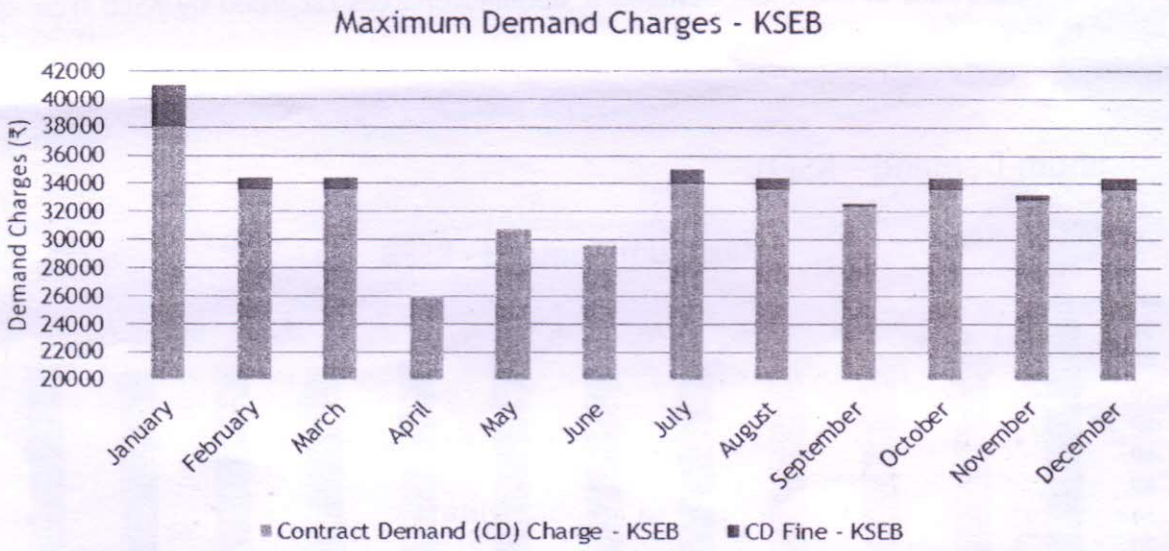
There are variations in Maximum Demand & Demand Charges recorded by KSEB from the actual values.

Maximum Demand - KSEB

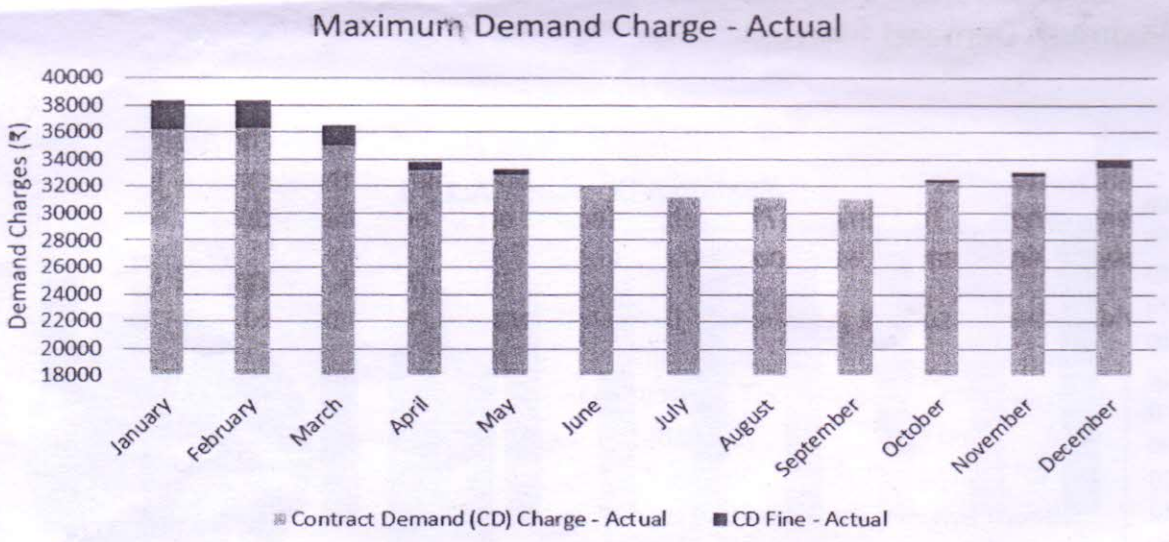
Maximum Demand - Actual



Demand Charges - KSEB



Demand Charges - Actual

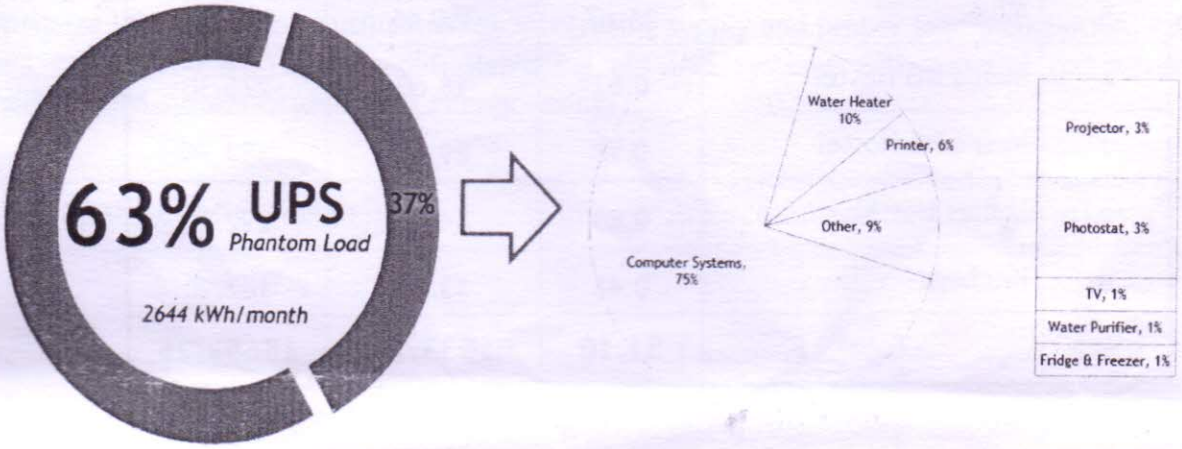


It will be a good practice, if we monitor the actual maximum demand recorded in the meter (also notified on top of the electricity bill) and the values taken by KSEB. Notify KSEB if there are any variations in these values.

Energy Savings Opportunity - Detailed Calculations and Rationale

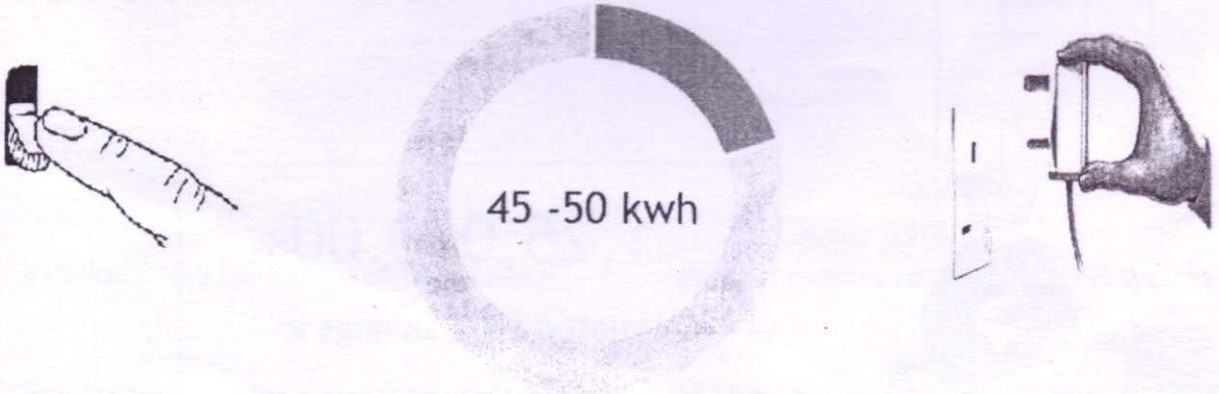
Recommendation No.1: Elimination of Phantom Loads

Rationale: Computers and printers and Photostat machines were found consuming a sizeable amount of power when it is plugged in and not in standby mode. Switch off computers, printers, LCD projectors and Photostat machines from the mains when not in use.



63% of the phantom load is contributed by the UPS System which is a necessity and cannot be eliminated but by proper optimisation we can minimise the phantom losses of UPS system. Whereas remaining **37%** contributed by other equipment can be eliminated by simply turning them off when not in use.

Providing master control switches for Labs and Library is recommended.



Energy savings per day

Calculated Phantom Power Loss in various Buildings

Sl No	Area	Daily Phantom Load (kWh)	Monthly Phantom Load (kWh)	Yearly Phantom Load (kWh)
1	Academic block	10.65	319.57	3888.13
2	Administrative building	22.20	665.88	8101.54
3	New academic block	1.32	39.73	483.41
4	Guest house	2.40	72.00	876.00
5	MIIM	11.67	350.16	4260.28
6	Men's UG Hostel	0.62	18.60	226.30
7	Men's PG Hostel	0.98	29.40	357.70
8	Ladies Hostel	0.80	24.00	292.00
9	Kitchen	0.46	13.80	167.90
	Total	**51.10**	**1533.14**	**18653.25**

1533 kWh

Energy Savings Per Annum

1,25,000.00+

Estimated Cost Savings in the Annual Energy Charge

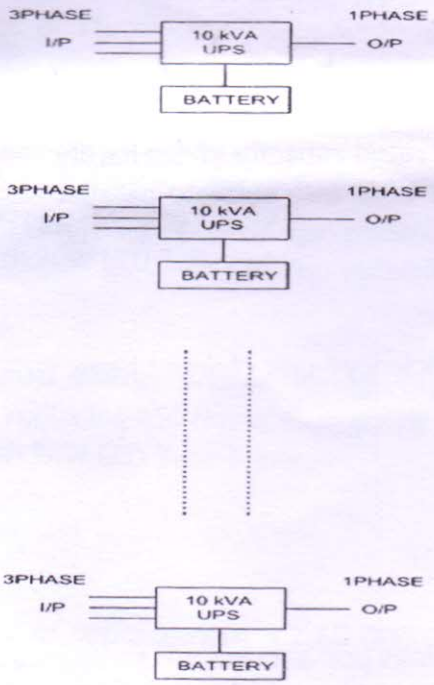
Recommendation No.2: Replace existing single unit ups systems with larger capacity parallel redundant/modular ups systems

Rationale: Existing UPSs are running at a very low load factor causing efficiency loss. Also, since there is no redundancy, failure of one UPS or Battery causes power interruption. The batteries were found to be old and hence causing excessive heat and losses.

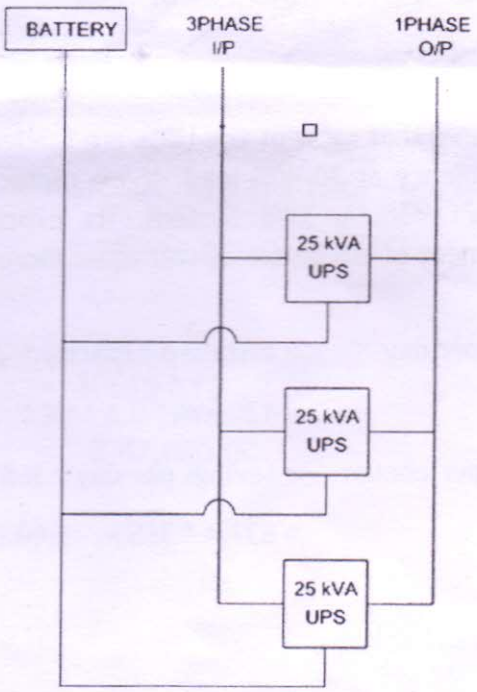
UPS Optimization

Optimize UPS and battery utilization by integrating supply and proper load distribution. All UPS are around 4 -12 years old. Replacing old UPS systems with parallel redundant modular UPS system readily gives energy savings.

Present Configuration	Recommended Configuration



Individual UPS for Individual Loads



Parallel redundant /Modular UPS System

The battery banks are connected to a common bus bar increasing reliability. The maintenance and repair of UPS and battery banks become much easier. Fault in a battery bank or UPS doesn't affect the loads in the recommended UPS configuration, whereas in present UPS configuration fault in a battery bank or UPS will directly affect the loads.

*7 * 10 kVA UPS in Administrative Block*

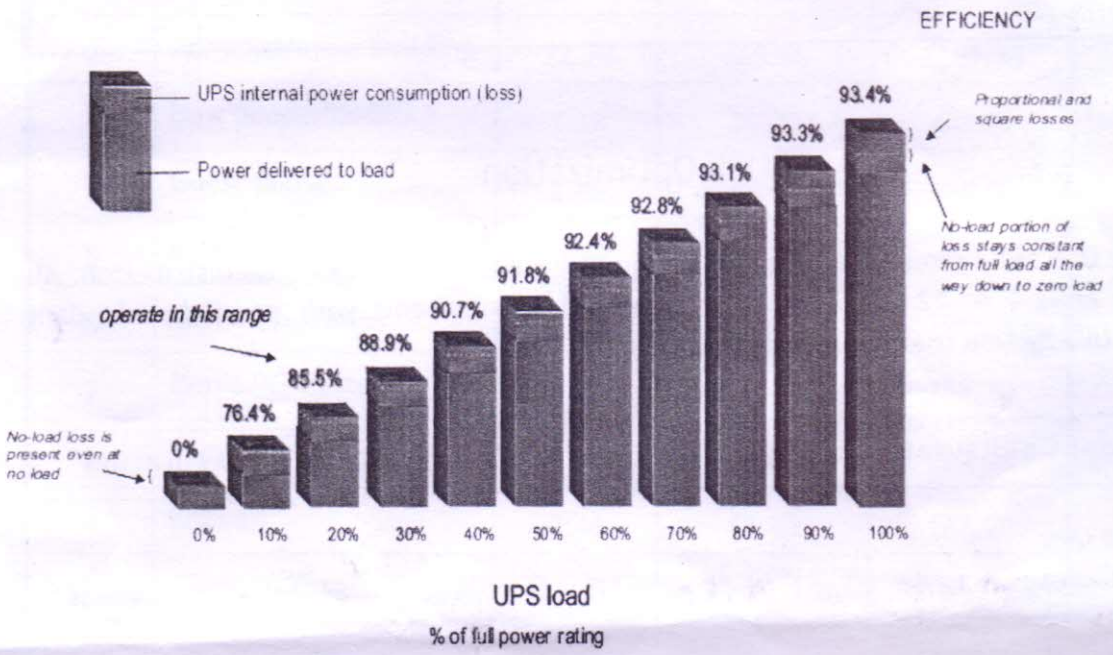
*1 * 10 kVA UPS in Administrative Block*

*1 * 5 kVA UPS in Administrative Block*

*1 * 3 kVA UPS (inefficient) in Library*

*2 * 1 kVA UPS (complaint) in Library*

Parallel redundant / Modular UPS System to replace these individual UPS systems with increased battery capacity.



We observe that most of the UPSs are loaded below 50% of its rated capacity giving hardly 90% efficiency at 30-40% load. If we replace these individual UPSs with suitable parallel redundant/Modular UPS System, its efficiency can be increased up to 2-3 %. The replacement of old batteries will again increase the system efficiency up to 5%.

Savings per day = Installed capacity * pf * increase in efficiency * unit charge * hours

= 130 kVA * 0.8 * 5% * 6.71/kWh * 24 = 837.4.00

Savings per annum = savings per day * 365

= 837.4 * 365 = 3,00,000.00 /Annum

Simple Payback = Investment/Savings per annum

Investment for Modular UPS + Battery = 18,00,000.00

Savings per annum = 3,00,000.00 /Annum

Payback in 6 Years

Recommendation No.3: Replace Fluorescent Tubes and CFLs with LED lights (in Guest House and Hostels)

Rationale: Presently the lighting is mainly met with Fluorescent lamps and CFLs. It is recommended to replace these lamps in Hostels and Guest House (Where the consumption is more) with 20W LED Tube lights.

Considering 6 hours of total operation out of which 4 hours during peak hours, the energy use is mostly during the peak hours (6 pm - 10 pm) where the unit cost for electricity is 9.3. Average energy charge during normal and off peak hours is 5.425. Along with this 10% electricity duty is added up with the unit cost. So, the effective energy cost will become 10.23 and 5.97 respectively.

Fluorescent Tube lights ⇨ LED Tube lights

Energy Savings expected by replacing 650 Nos of Fluorescent lamps with 20W LED Tube lights	= 2340 kWh/month
Monthly Energy Charge Savings expected by replacing 650 Nos of Fluorescent lamps with 20W LED Tube lights	= (1560 * 10.23) + (780 * 5.97) = 20,615.00
Annual Energy Charge Savings expected by replacing 650 Nos of Fluorescent lamps with 20W LED Tube lights	= 20615 * 12 = 2,47,000.00

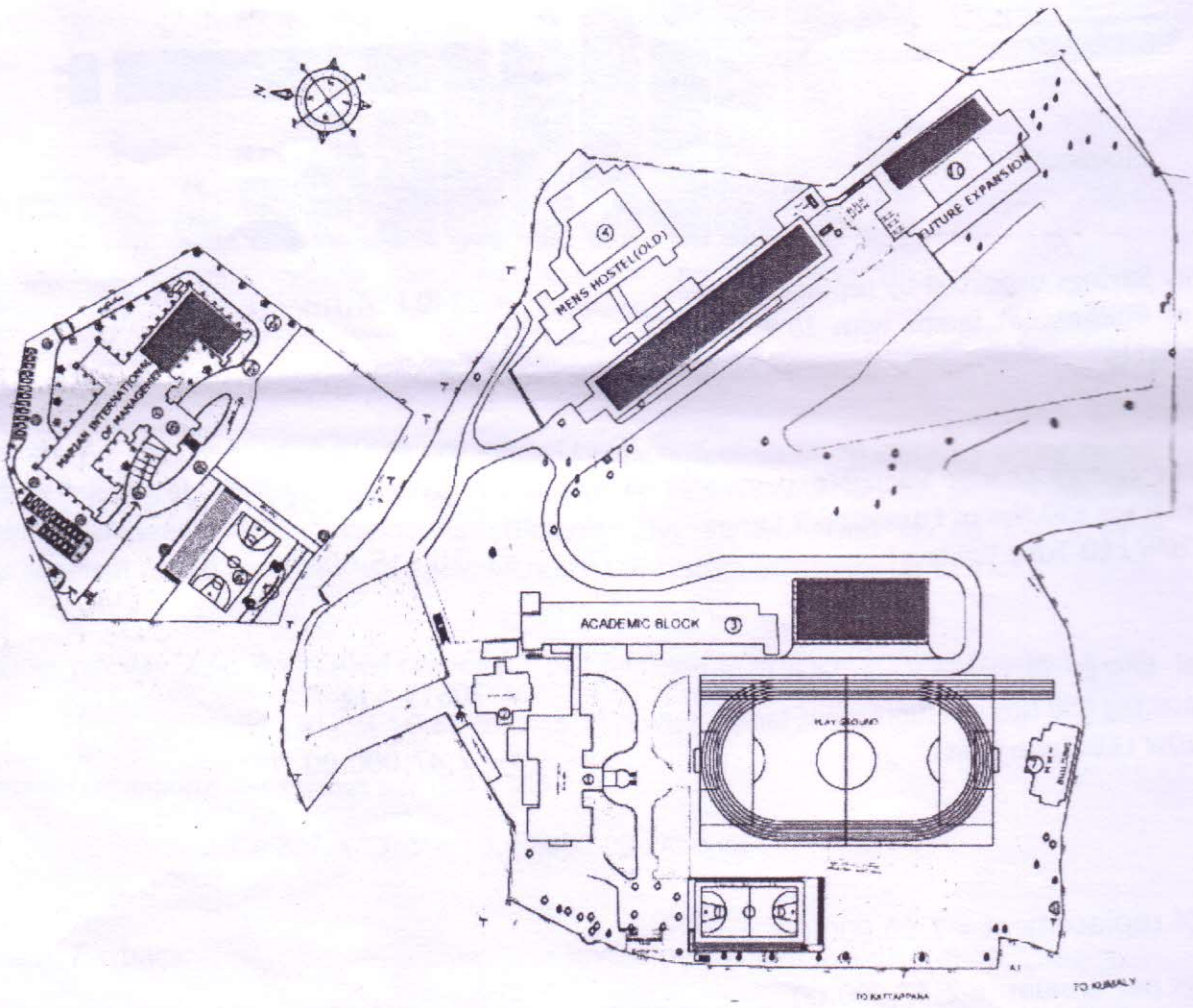
Cost of replacement = 2,60,000.00

Savings per annum = 2,47,000.00

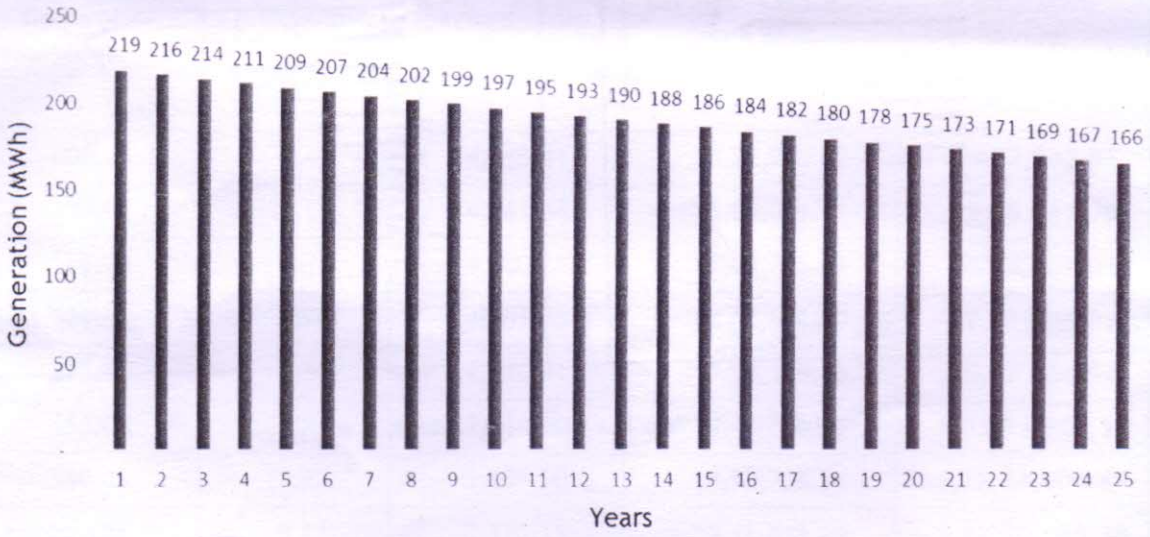
Payback in 1.05 years

Recommendation No 4: Install 150 kWp Grid connected Solar Photo Voltaic Systems on Roof Tops

Rationale: There is a scope for more than 150 kWp Solar photovoltaic system installation which can be designed and engineered after a dedicated site survey.

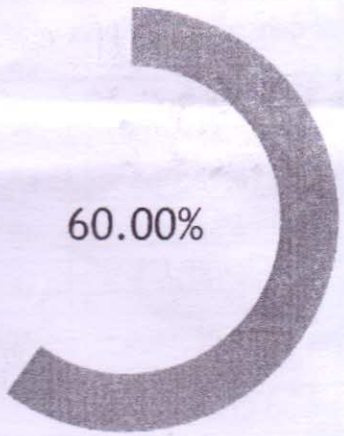


Considering an average production of 4 kWh from 1 kW at the site, 150 kWp will give an average daily production of 600 kWh. Annual production for 25 years considering derating factor of solar array is as shown below,



Energy Consumption met by Solar

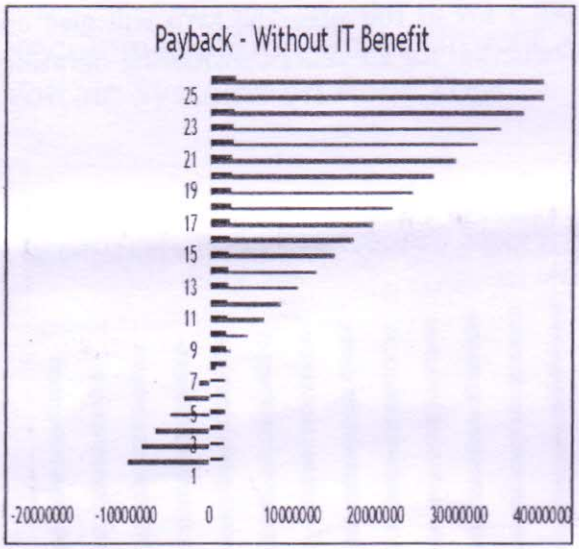
Analysis of the EB bill data shows that 325 MWh is consumed for the year 2016 and hence the solar installation is desirable to reduce consumption from KSEB.

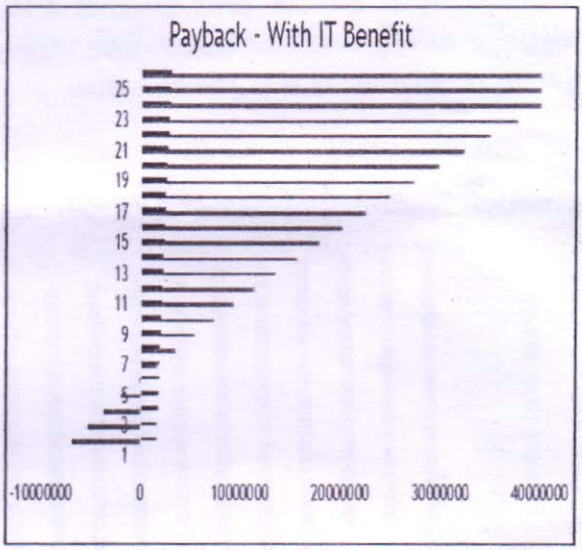


Detailed site survey is needed before the installation of Solar Grid connected system.

Payback Calculation

Without income tax or any other benefits, it will take **5 years and 8 months** for payback whereas if you avail of income tax benefits, then the payback will be much earlier within **4 years and 1 month.**





■ Savings Rs. /365 days in a year ■ Payback ■ Savings

Justification for Unit Charge

The unit charge has been arrived at by calculating average values of normal, peak and off peak consumption for a year at Marian College.

	`Normal	Peak	Off Peak	Total
Unit Consumption (kWh)	14,860.00	6,038.00	6,166.00	27,064.00
Unit Charge ( )	6.20	9.30	4.65	
Energy Charge ( )	92,132.00	56,153.40	28,671.90	176957.30
Duty ( )	9,213.20	5,615.34	2,867.19	17,695.73
Surcharge ( )	0.00	0.00	0.00	0.00
Demand Charge	0.00			
Possible Reduction in demand charge	0.00			
Effective normal unit cost	**6.82**	**10.23**	**5.12**	
Estimated Total solar generation per month				18,000.00
Net Metering Tally	14,860.00	3140.00	0.00	18,000.00
Total Estimated cost reduction/gain ( )	1,01,270.20.00	32,122.20	0.00	1,33,392.40

Effective energy unit cost = Total energy cost / Total energy generation

= (101270.20+322122.20)/18000

= **7.41**

Savings Calculation

Year	SPV Power Generation /Day	EB Rate/unit	Savings /day	Savings /365 days in a year	Cumulative savings
0					
1	600.00	7.41	4,446.41	16,22,940.87	16,22,940.87
2	593.04	7.69	4,561.84	16,65,071.11	32,88,011.98
3	586.16	7.98	4,680.26	17,08,295.03	49,96,307.01
4	579.36	8.29	4,801.76	17,52,641.00	67,48,948.01
5	572.64	8.60	4,926.41	17,98,138.16	85,47,086.16
6	566.00	8.93	5,054.29	18,44,816.39	1,03,91,902.55
7	559.43	9.27	5,185.50	18,92,706.34	1,22,84,608.89
8	552.94	9.62	5,320.11	19,41,839.49	1,42,26,448.38
9	546.53	9.99	5,458.21	19,92,248.09	1,62,18,696.46
10	540.19	10.37	5,599.90	20,43,965.25	1,82,62,661.72
11	533.92	10.76	5,745.27	20,97,024.95	2,03,59,686.67
12	527.73	11.17	5,894.42	21,51,462.04	2,25,11,148.72
13	521.61	11.59	6,047.43	22,07,312.28	2,47,18,460.99
14	515.56	12.03	6,204.42	22,64,612.34	2,69,83,073.33
15	509.58	12.49	6,365.48	23,23,399.86	2,93,06,473.20
16	503.67	12.97	6,530.72	23,83,713.47	3,16,90,186.66
17	497.82	13.46	6,700.25	24,45,592.76	3,41,35,779.42
18	492.05	13.97	6,874.19	25,09,078.39	3,66,44,857.82
19	486.34	14.50	7,052.64	25,74,212.06	3,92,19,069.88
20	480.70	15.05	7,235.72	26,41,036.55	4,18,60,106.42
21	475.12	15.62	7,423.55	27,09,595.74	4,45,69,702.16
22	469.61	16.22	7,616.26	27,79,934.68	4,73,49,636.84
23	464.16	16.83	7,813.97	28,52,099.56	5,02,01,736.40
24	458.78	17.47	8,016.82	29,26,137.78	5,31,27,874.18
25	453.46	18.14	8,224.93	30,02,097.98	5,61,29,972.16

Payback without Income Tax Benefit

Total Investment for 150 kWp Grid Tie System = 97,50,000.00

Payback in 5 years and 8 months

Payback with Income tax benefit

Accelerated depreciation is a method of depreciation used to depreciate the assets in a manner that greater deductions are allowed in the first few years. It is one aspect of the tax, that facilitates greater investment in renewable energy and ultimately lower costs for consumers.

In solar projects, accelerated depreciation is widely used as an incentive to lessen the burden of tax. In India, accelerated depreciation (AD) allows investors and project developers to take advantage of up to 40% of the project cost as per MNRE standards.

Year	Written down value	Dep @ 40%	Tax Saving
1	97,50,000.00	39,00,000.00	11,70,000.00
2	58,50,000.00	23,40,000.00	7,02,000.00
3	35,10,000.00	14,04,000.00	4,21,200.00
4	21,06,000.00	8,42,400.00	2,52,720.00
5	12,63,600.00	5,05,440.00	1,51,632.00
6	7,58,160.00	3,03,264.00	90,979.20
7	4,54,896.00	1,81,958.40	54,587.52
		94,77,062.40	**28,43,118.72**

Total Investment for 150 kWp Grid Tie System = 97,50,000.00

Income Tax Benefit = 28,43,118.72

Actual Investment = Total investment - IT Benefit

= 69,06,881.28

Payback in 4 years and 1 months

Recommendation no.5: Install a food waste based Bio Gas System to replace LPG Cylinders in Laundry or Kitchen

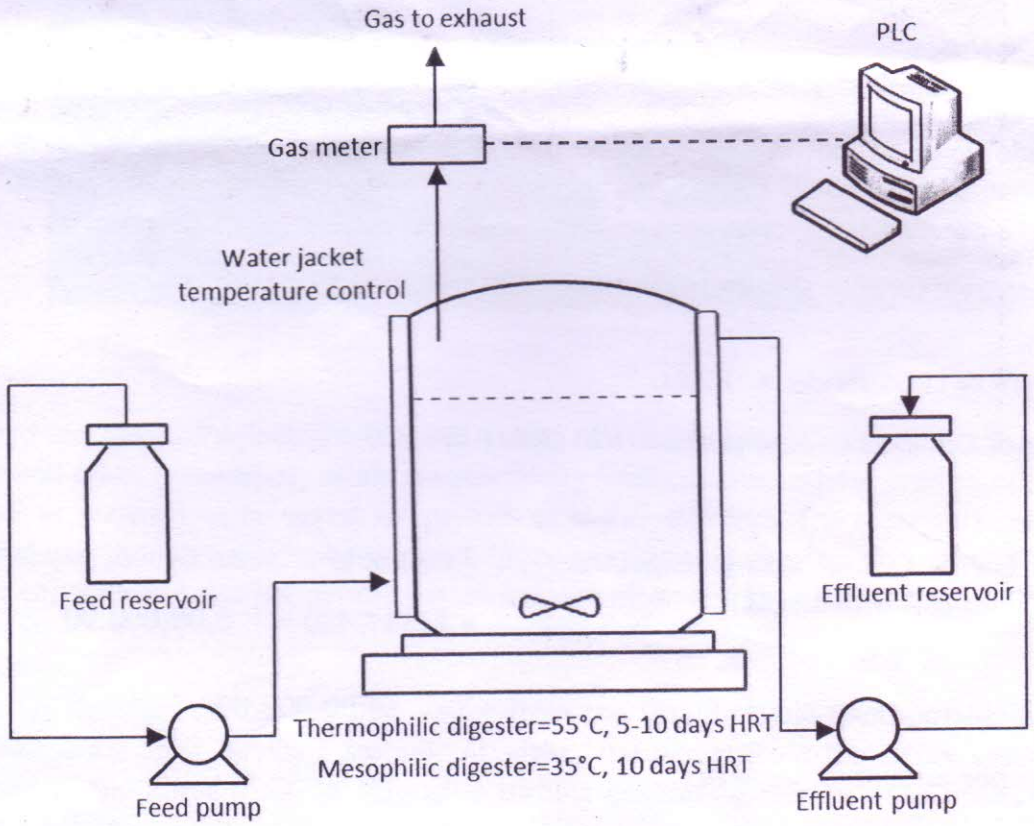
Rationale: To make energy from bio degradable food waste through Anaerobic Digestion in a profitable way that can replace the LPG and reduce environment pollution.

The Institute has a canteen catering to more than 700 students and other staff. Bio degradable food waste is available in huge quantity which is presently disposed of without any utilisation.

High Performance TMAD:

Thermophilic and Mesophilic Anaerobic Digesters can be used for optimum biogas productions. These types of advanced digesters are expected to produce 30% more bio-gas from the same waste than the conventional digesters.

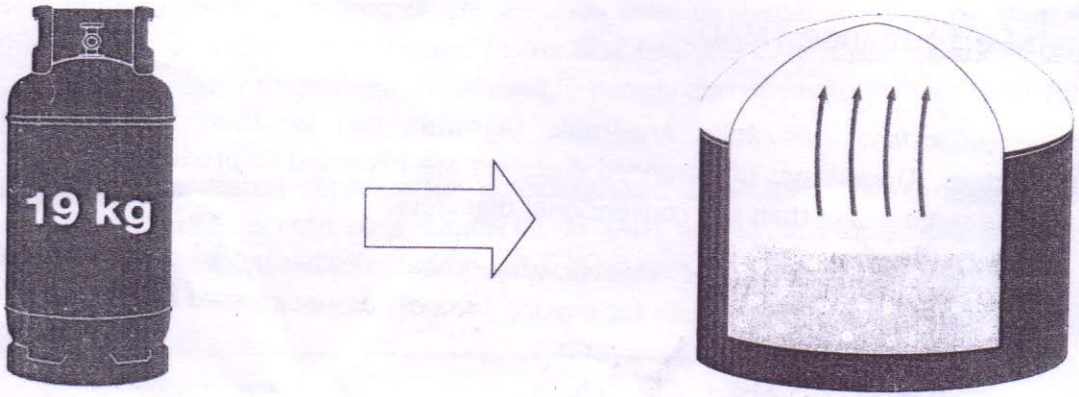
Biogas can be used for cooking, electricity and heat; discharged slurry can be used as an organic fertiliser and other waste for making compost or compressed briquette etc.



2 Stage High Performances Anaerobic Digester

No of Persons	700 nos
Expected Daily Food Waste from Mess	140kg*
Expected LPG Cylinder Replacements	2 to 3
Application	Replacing the LPG used in existing Dryer
Expected Volume of Digester	6m3
Expected Volume of Storage Tank	0.3m3
Expected Slurry Out Put	0.3m3

** The food waste calculated per head 200gm per day.*



LPG *BIOGAS*

As an additional option night soil can be used as feed stock which would produce more biogas output that could be used as supplement for fuel in Kitchen and boiler. This requires a detailed site survey.

At present, replacing LPG at Laundry (Dryers) is considered.

Cost of 19 kg LPG cylinder = 1388/-

Number of Cylinders needed per year = 2* (365/1.5) = 480

Annual Energy Charge Savings expected by replacing LPG with Biogas = Cost of LPG * No of Cylinders/year

= 1388 * 480 = 6,00,000.00

Investment for TMAD Biogas Plant = 16,00,000.00

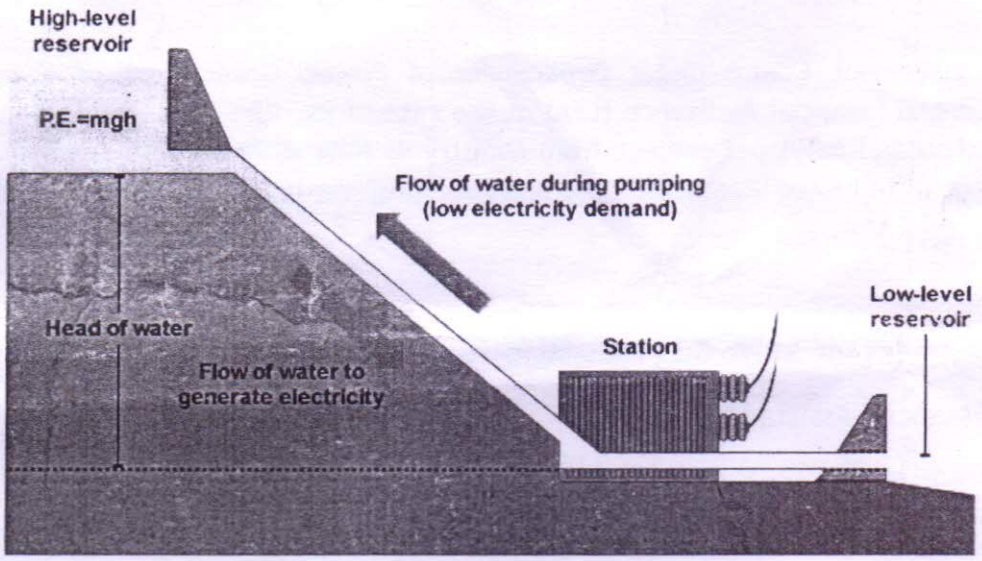
Savings per annum = 6,60,000.00

Payback in 2.5 years

Recommendation No.6: Powering Up High Mast Light Using Pumped Hydroelectric Energy Storage

Rationale: The Institute has two natural water ponds at different elevation. It is also observed that there is a High Mast Outdoor light that consume approximately 15 -20 units per day during peak hours. A combination of generator (pump as turbine) and solar pump can be utilized to power up the high mast light. Thus, the high mast light will not be affected by any power failures.

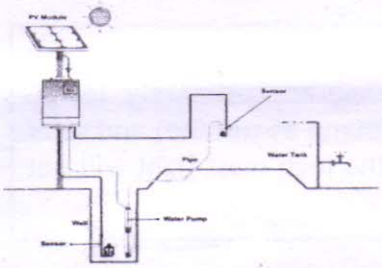
Pumped-storage hydroelectricity (PSH) or pumped hydroelectric energy storage (PHES) is a type of hydroelectric energy storage used by electric power systems for load balancing. The method stores energy in the form of gravitational potential energy of water, pumped from a lower elevation reservoir to a higher elevation.



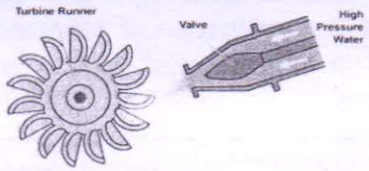
Pumped-storage hydroelectricity allows energy from intermittent sources (such as solar, wind) and other renewables, or excess electricity from continuous base-load sources (such as coal or nuclear) to be saved for periods of higher demand. The reservoirs used with pumped storage are smaller compared to conventional hydroelectric dams of similar power capacity and also the generating periods are often less than half a day.

At Marian College, during day time water from the lower reservoir is pumped to upper reservoir using solar pumping system. At night, the water from the upper reservoir is released to the lower reservoir through a turbine generating electricity to power up the high mast light.

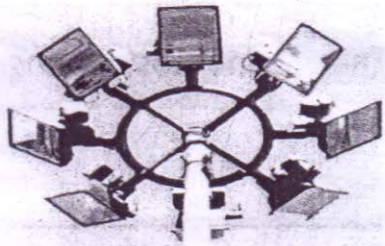
Installing a **5kW** Pumped Hydroelectric storage system with Solar Pump and a Pico Hydel Plant using pump as turbine will be enough for meeting the high mast light load.



Solar Pumping System



Pump as Turbine



High Mast Light

Detailed site survey is needed before the installation of Solar Grid connected system.

Energy Management Centre under Department of Power, Government of Kerala has sourced Central Financial Assistance (CFA) at the rate of Rs. 1,50,000/- (Rupees One lakh and fifty thousand only) per project from Ministry of New & Renewable Energy (MNRE), Government of India for Pico hydroelectric power projects up to a maximum capacity of 5kW.

Total Investment for 5 kWp Grid Tie System	=	6,50,000.00
Central Financial Assistance	=	1,50,000.00

Actual Investment = Total investment - Central Financial Assistance

= **5,00,000.00**

Unit rate during peak time with 10% duty (6 pm - 10 pm) = 10.23

Savings per annum for considering DG unit rate as well = **75,000.00**

Payback in 6.6 years

Executive Summary

Energy and Cost Saving Opportunities

S.No	Recommendations	Annual Financial Savings	Investment	Simple Pay Back Period
1	Replace existing multiple single unit UPS systems with larger capacity parallel redundant/modular UPS systems and Batteries	3,00,000.00	18,00,000.00	6 years
2	Elimination of Phantom load	1,30,000.00	Nil	Immediate
3	Replace Fluorescent Tubes and CFLs with LED lights (in Guest House and Hostels)	2,47,000.00	2,60,000.00	1.05 years
4	Install 150 kWp Grid Connected Solar Photo Voltaic Systems on Roof Tops	17,50,000.00	1,50,00,000.00	6 years
6	Install a food waste based Bio Gas System to replace LPG Cylinders in Laundry or Kitchen	6,60,000.00	16,00,000.00	2.5 years
7	Install a Solar Pump and Pico Hydel Plant to light up the High Mast Light	75,000.00	5,00,000.00	6.6 years