ENERGY AUDIT 2017 -2018

ST. ALBERT'S COLLEGE

(Autonomous) Ernakulam

EXECUTED BY

ATHUL ENERGY CONSULTANTS PVT LTD

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ACKNOWLEDGEMENTS

We express our sincere gratitude to the management of **St. Albert's College (Autonomous) for** giving us an opportunity to carry out the project of Energy Audit in the college. We are extremely thankful to the management team, students and all staff of **St. Albert's College** for their support to carry out the studies and for their inputs and measurements related to the project of Energy audit. The energy audit conducted in the period March 2018.

St. Albert's College – TEAM

1.	***Rev. Fr. Antony Arackal***	***Rev. Fr. Antony Arackal***
2.	***Rev. Fr. Christy David Pathiala***	***Assistant Manager***
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8.	***Dr. Amal Joseph P.J.***	***Secretary Green Audit Team***

Also congratulating our Energy audit team members for successfully completing the assignment in time and making their best efforts to add value.

ENERGY AUDIT TEAM

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Yours faithfully

ATHUL ENERGY CONSULTANTS PVT LTD THRISSUR 680 020

Managing Director
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OBJECTIVE

An energy audit is a key to assessing the energy performance of facility and for developing an energy management program. The typical steps of an energy audit are:

- Preparation and planning
- Data collection and review
- Plant surveys and system measurements
- Observation and review of operating practices
- Data documentation and analysis
- Reporting of the results and recommendations

1.1. Definition of energy auditing

In the Indian Energy Conservation Act of 2001 **(BEE 2008)**, an energy audit is defined as: **"The verification, monitoring and analysis of the use of energy and submission of technical report containing recommendations for improving energy efficiency with cost-benefit analysis and an action plan to reduce energyconsumption."**

1.2. Objectives of Energy Auditing

The objectives of an energy audit can vary from one plant to another. However, an energy audit is usually conducted to understand how energy issued within the plant and to find opportunities for improvement and energy saving. Sometimes, energy audits are conducted to evaluate the effectiveness of an energy efficiency project or program. In St. Albert's College as per the request from the college, we have assessed the energy consumption and saving opportunities at present scenario.

Methodology for the study

The methodology adopted for energy audit starts from historical energy data analysis, power quality analysis, monitoring of operational practices, system evaluation, cost benefit analysis of the energy conservation opportunities, and prepare plan for implementation. The proposals given in the report includes economical energy efficiency measures to reduce facilities unnecessary energy consumption and cost. The energy conservation options, recommendations and cost benefit ratio, indicating payback period are included in this report.

Scope of Work

The Scope of Work includes:

1. Historical energy data analysis.
2. Electrical, Mechanical and Thermal energy analysis.
3. Power Quality Analysis.
4. Identification of Energy saving opportunities.
5. Cost Benefit Analysis.

DESCRIPTION OF SITE

St. Albert's College is an Autonomous Institution situated at the heart of the city of Kochi, affiliated to the Mahatma Gandhi University, Kottayam and is functioning under the management of the Archdiocese of Verapoly. The seeds of this portal of higher learning had already been sown when St. Albert's High School commenced its functioning in the year 1892. On August 18, 1898 the school got the recognition of Madras University. This has been a premier centre of learning for the young male children of wider Cochin area from its very inception. The College owes its origin to the foresight and sagacity of its Founder Patron, The Most Rev. Dr. Joseph Attipetty the first Indian Archbishop of the Archdiocese of Verapoly. His Grace, a noble prelate of rare vision and saintliness, was of the view of promoting higher education among his flock. It was with this vision that His Grace ventured upon the onerous mission of starting a College. The laboriousness of this colossal project, however, was shared by the selfless and devoted service of the Rt. Rev. Msgr. Alexander Lenthaparambil, the then Vicar General of the Archdiocese. Also in the forefront was the Very Rev. Msgr. Joseph Vaipicherry, who took charge as the Manager of both the High School and the College and the Secretary to the College Governing Body.

The mission was accomplished in 1946 when the University of Madras upgraded St. Albert's High School, Ernakulam to a second grade College. The College began to function on the 16 July 1946 in the old High School building with 150 students in the Intermediate Class. Degree courses were introduced in 1947. Subsequently classes were shifted to the new building just opposite to the old school building in 1951. In 1958, when the Kerala University Act came into force, the affiliation was shifted to the Kerala University. In 1983 when the Mahatma Gandhi University was established, the College became affiliated to the Mahatma Gandhi University. Throughout its history, the College has enjoyed the vision and the benevolent services of many great men of God. The Most Rev. Dr. Joseph Kelanthara, who succeeded the Most Rev. Dr. Joseph Attipetty, and the Most Rev. Dr. Cornelius Elenjikal, who then followed, spared no pains and efforts in maintaining the noble vision of his predecessor.

The contributions made by the Rt. Rev. Msgr. Emmanuel Lopez and the late Auxiliary Bishop the Rt. Rev. Dr. Antony Thannikot have helped the College in upholding the higher ideals of education. The College celebrated its Golden Jubilee in 1996-97 and there began a new eraof job oriented courses. During the time of the Most Rev. Dr. Daniel Acharuparambil, who was a visionary and philosopher, the college reached new heights in academic excellence. In 2009, the college was awarded 'A' grade by NAAC. In 2016 NAAC reaccredited the College at 'A' grade for the second time, was achieved during the time of Most Rev. Dr. Francis Kallarackal, the former patron.

In 2016 March University Grants Commission granted Autonomous status to the College. In 2017, the college was recertified for ISO 9001: 2015 by TUV Rheinland. The College has also been selected under FIST scheme of DST and Star college programme of DBT. Today, with 20 Under Graduate courses, 12 Post Graduate courses including Master's Programmes in Space Science and Technology, Business Administration, Social Work and 6 Research Centres leading to Ph.D., St. Albert's College (Autonomous) is indeed a front-runner in the field of higher education. Under the benevolent patronage of the Most Rev. Dr. Joseph Kalathiparambil, Metropolitan Archbishop of Verapoly, the College is marching ahead to higher echelons in the field of higher education.

VISION

To be a centre of excellence in all our endeavours, focusing on learning, teaching, research, consultancy, community involvement and nation building.

MISSION

Inspired by the Eternal Teacher, Jesus Christ, we strive towards the goal of equipping young people to meet the challenges of the modern times by providing an all-round formation. We exist for our students and provide them with a most friendly and growth oriented ambiance to develop social consciousness and civic responsibilities. We do everything in our capacity to ensure excellent standards that would secure them higher learning, leadership and life skills.

GENERAL DETAILS

The general details of the St. Albert's College are given below in table based on the data availed from the college and from their website.

TABLE 1: GENERAL DETAILS

Sl. No	Particulars	Details
1	Name & Address of College	**St. Albert's College** (Autonomous) Banerjee Road, Ernakulam – 682018
2	**Location**: Latitude, Longitude	9.9856^0N, 76.2786^0E
3	No: of Staffs	Teaching Staff – 141 Non-Teaching Staff - 42
4	No: of Students	2560
5	Working Time	08:00 to 13:30 (Regular Batch)
6	Build up area	10406.46 Sq.m
7	Total land area	13.63 Acres
8	DG Set	100 kVA
9	Solar – Grid Mode	40 kW
10	Water Consumption/day	20 KL
11	No: of electricity connections	05 Nos 1. College 2. Pappali Hall 3. Sports Campus 4. AIM 5. Hostel

WATER LINE DIAGRAM

Water line diagram of the campus is given below:

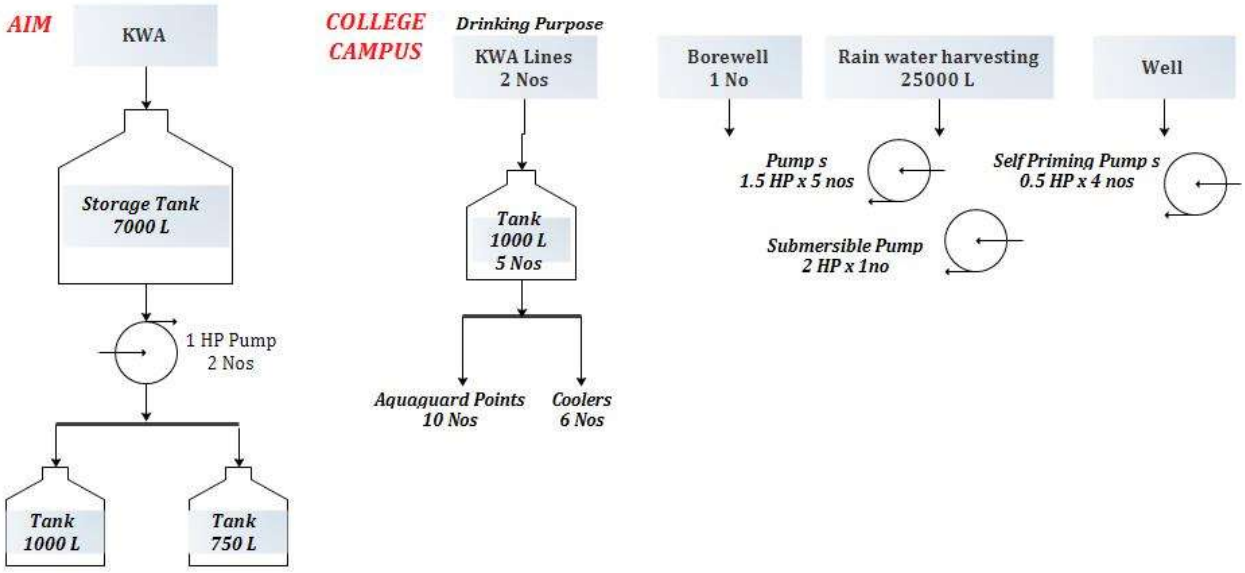

FIGURE 1: WATER LINE DIAGRAM

LOAD BALANCE

Load balance among the connected loads is given in the figure shown below. The major loads in the building are air conditioners, light fan load and office equipment's. Light and fan shares majority of the loads corresponding to 36% of the total connected load in the building.

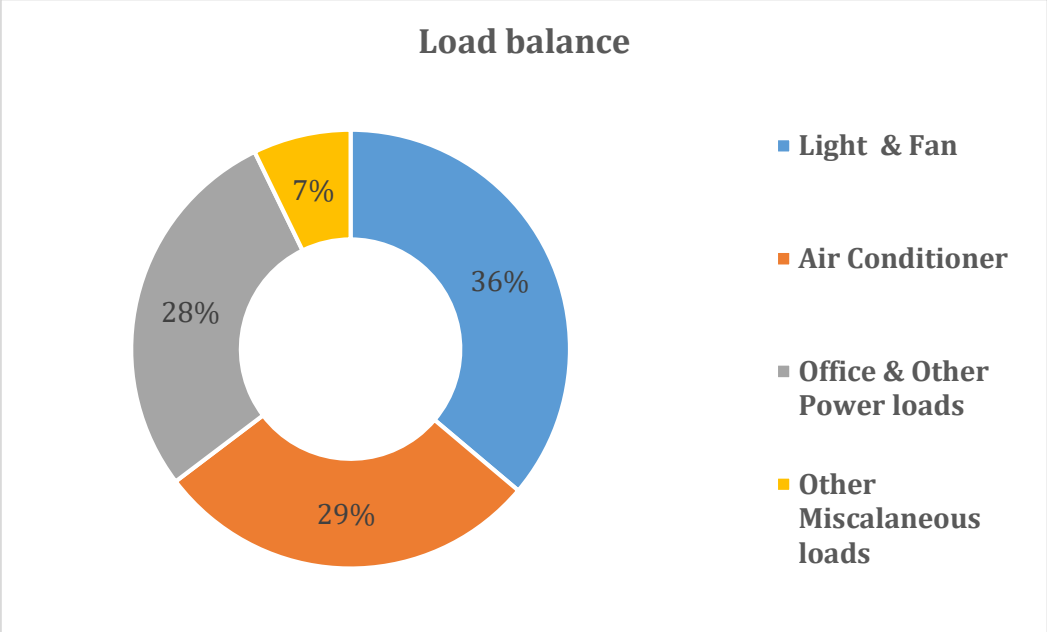

FIGURE 2: LOAD BALANCE

1. AUDIT SUMMARY – ACTIONS

The actionable summary of the audit report is given in the table below.

TABLE 2: ENERGY AUDIT SUMMARY – ACTIONS

Sl No:	Particulars	Location	Action to be taken	Remarks
1	Energy efficiency – Replacement of ceiling fans with BLDC fans	Office, faculty rooms, laboratories Sections	Change the existing old ceiling fans with BLDC fans	Power Consumption will reduce
2	Energy efficiency – Replacement of fluorescent lights with LED lights	Office, faculty rooms, laboratories Sections	Change the existing lights with LED lights	Power Consumption will reduce
3	Energy efficiency – Replacement of old split AC with New 5 star rated ones	Office Section	Change the old existing AC with 5-star ACs.	Power Consumption will reduce
4	Energy consumption – Set temperature of AC shall in between 24 – 27 °C		Change the temperature using the remote	Power consumption will reduce Increase the life time of AC.
5	Energy consumption – Optimise the fan speed for best comfort		Optimize the speed to 2 or 3 setting	Power consumption will reduce

2. ANNUAL CARBON FOOTPRINT OF APPLIANCES

The present carbon dioxide generation by appliances in the college and the projected value after the implementation of the energy conservation measures given in the figure below:

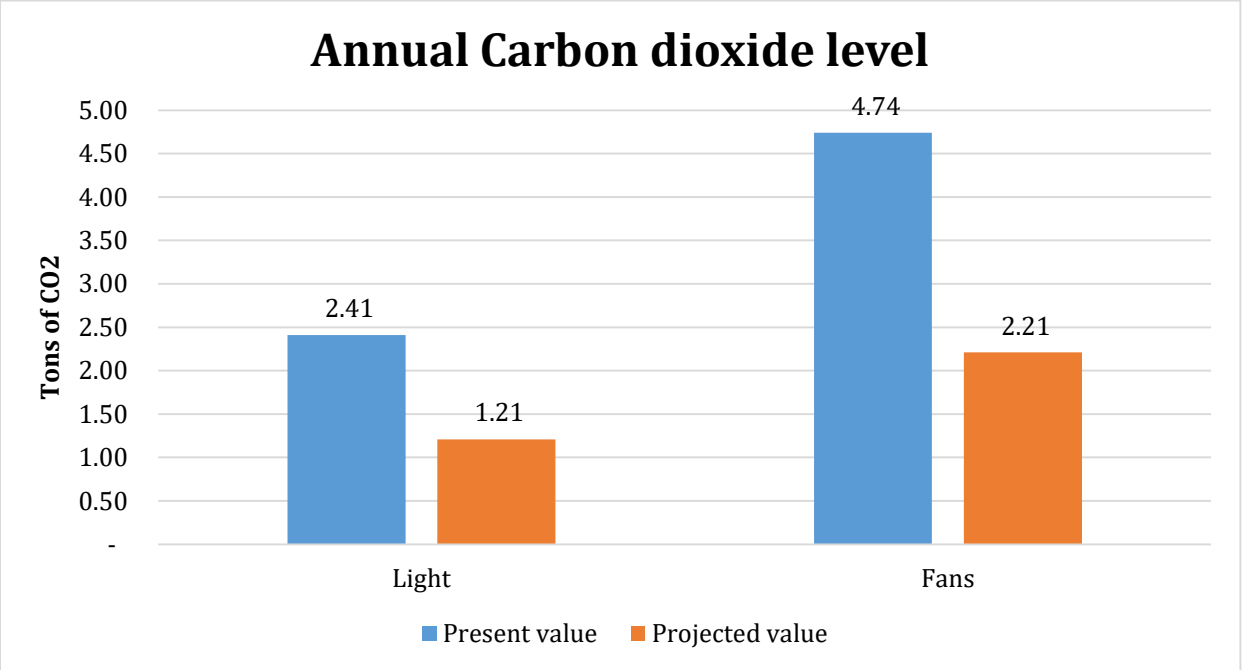

FIGURE 3: ANNUAL CO_2 EMISSION

3. ENERGY CONSERVATION MEASURES

The following table shows the energy conservation measures in the ascending rate of payback period.

TABLE 3: ENERGY SAVING PROPOSALS

Sl.No:	Energy conservation measures	Annual Energy Savings	Annual Financial Savings	Investment	Simple payback period
		kWh	Rs	Rs	Months
1	Replacement of Fluorescent & CFL lights with LED in college classrooms – (T8 - 30 nos with 20W) (CFL – 40 nos with 6W)	1,470	9,555	21,000	26
2	Replacement of Ceiling fans with BLDC fans 5 star rated (College campus – 40 nos) (AIM – 15 nos)	3,080	7,000	1,92,500	330
Total		***4,550***	***16,555***	***2,13,500***	

4. ENERGY PERFORMANCE INDEX (EPI)

EPI was based on the energy consumption in April 2018 to Mar 2019. The projected energy consumption after the implementation of energy saving proposals is given in the table below.

TABLE 4: ENERGY PERFORMANCE INDEX

Energy Performance and climate impact		Unit	Baseline	Projection
1	Annual Electricity Consumption	kWh	123113	118563
2	Annual Electricity consumption	TOE	10.59	10.20
3	Energy Performance Index	kWh/Sq. m	11.83	11.39
4	Energy Performance Index	TOE/Sq. m	0.00102	0.00980
5	Annual Carbon Footprint - Electricity	Ton CO_2	100.95	97.22

Note: Unit conversions:

TOE	=	10 million kCal (BEE energy audit manual)
MWh of electricity	=	0.82 Ton of CO_2 (www.cea.gov.in)
kWh of electricity	=	860 kCal (BEE energy audit manual)

5. CARBON FOOT PRINT

Carbon foot print is often used as short hand for the amount of carbon emission (usually in Tones) being emitted by an activity or by organization This is an important component in ecological foot print or the depicting the biological space reduction in the earth. Various environment protection and energy conservation connected with carbon footprint. College management taken took its accountability to protect nature and taken few steps for the carbon neutral campus.

1. Protecting and conserve lot of trees inside the campus and outside through various student's activities,
2. Replacement of Fluorescent tubes with energy efficient LED lights
3. Installation 40kW solar power plant in the college.
4. Sustainable construction of buildings for natural ventilation and light sin the classrooms and laboratories.

TABLE 5 CARBON FOOT PRINT

Particulars	Energy consumption reduction	Carbon Emission reduction	Total
	kWh	**Tons**	**%**
Solar power 40kW installation	48000	38.88	95.76
Tube light replacement of 60 Nos	2100	1.72	4.24
Total	***50,100***	***40.6***	***100***

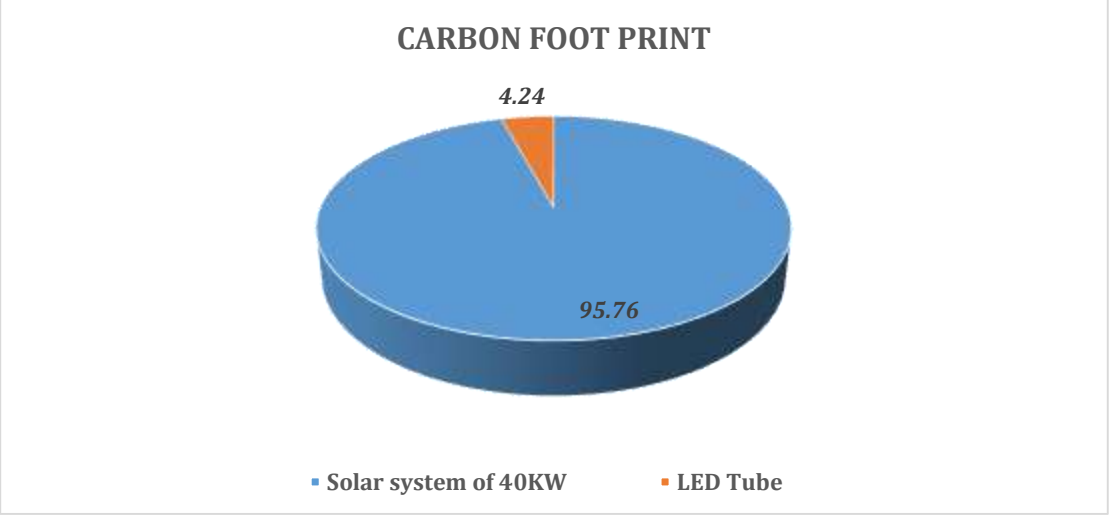

FIGURE 4: CARBON FOOT PRINT

ELECTRICITY CONSUMPTION ANALYSIS

This section gives the detail analysis of electricity consumption in the campus.

BASELINE DATA & CONSUMPTION: 12 MONTHS

The electricity baseline data, based on the bills, and the recorded, is summarized in the table below.

TABLE 6 : BASELINE DATA

Month	AIM	College	Pappali Hall	Sports Campus
Consumer No:	**1155467018051**	**1155465002752**	**1155465010924**	**1155456013841**
Tariff	**LT - 6F**	**LT - 6A**	**LT - 7A**	**LT - 6C**
Connected Load (kW)	**40.8**	**86.52**	**7**	**8**
Billing Period	**Monthly**	**Monthly**	**Bi Monthly**	**Bi Monthly**
Energy Consumption	***kWH***	***kWH***	***kWH***	***kWH***
Apr-17	5284	6150	438	
May-17	2915	3000		328
Jun-17	1855	6480	438	
Jul-17	3723	7140		293
Aug-17	4423	7620	438	
Sep-17	4029	7110		307
Oct-17	4480	3870	438	
Nov-17	3339	6930		338
Dec-17	3102	5700	438	
Jan-18	2741	7170		312
Feb-18	4002	7740	438	
Mar-18	3708	6390		
Total	***43601***	***75300***	***2628***	***1578***

Inference

i. Here there are 5 electricity connections in the college.

ii. Major consumption is from the college block.

TABLE 7: SOLAR CONSUMPTION IN COLLEGE

Month	Import	Export	Total
	kWh	kWh	kWh
Apr-17	6000	150	6150
May-17	2190	810	3000
Jun-17	3090	3390	6480
Jul-17	6480	660	7140
Aug-17	6990	630	7620
Sep-17	5970	1140	7110
Oct-17	3090	780	3870
Nov-17	5640	1290	6930
Dec-17	5040	660	5700
Jan-18	5580	1590	7170
Feb-18	6630	1110	7740
Mar-18	5280	1110	6390
Total	***61980***	***13320***	***75300***

ENERGY CONSUMPTION ANALYSIS

The annual energy consumption of various building blocks in the campus is given in the figure:

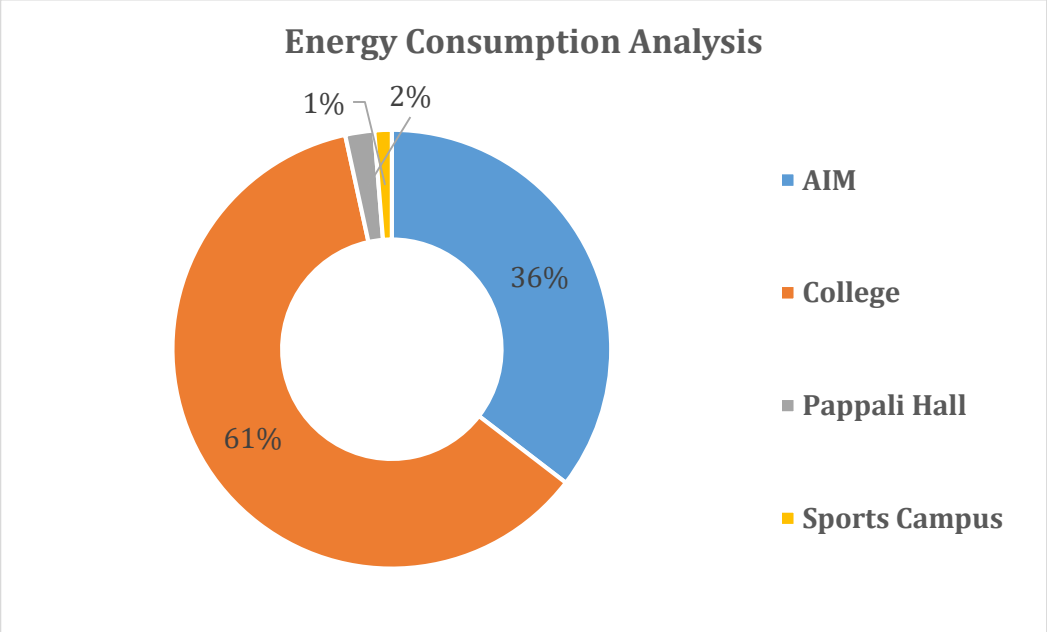

FIGURE 5: ENERGY CONSUMPTION ANALYSIS

Inference

i. Majority of the consumption is from the college block.

ii. More than 97% of the consumption is from college block and AIM.

SPECIFIC ELECTRICITY CONSUMPTION (KWH/SQ.M) – COLLEGE BLOCK

Specific electricity consumption is calculated based on the electricity consumption and the building area. The details of specific electricity consumption for the period from Apr 17 to Mar 18 are given below.

TABLE 8: SPECIFIC ELECTRICITY CONSUMPTION (KWH/SQ.M) – COLLEGE BLOCK

Month	Unit Consumption	Built up area	Specific Electricity Consumption
	kWh	M^2	kWh/m^2
Apr-17	6150	9427	0.65
May-17	3000	9427	0.32
Jun-17	6480	9427	0.69
Jul-17	7140	9427	0.76
Aug-17	7620	9427	0.81
Sep-17	7110	9427	0.75
Oct-17	3870	9427	0.41
Nov-17	6930	9427	0.74
Dec-17	5700	9427	0.60
Jan-18	7170	9427	0.76
Feb-18	7740	9427	0.82
Mar-18	6390	9427	0.68
Avg	***6275***	***9427***	***0.67***

The energy performance index is plotted in the below chart which gives a pictorial representation of the specific electricity consumption and units consumed in various months during the period from Apr 17 to Mar 18.

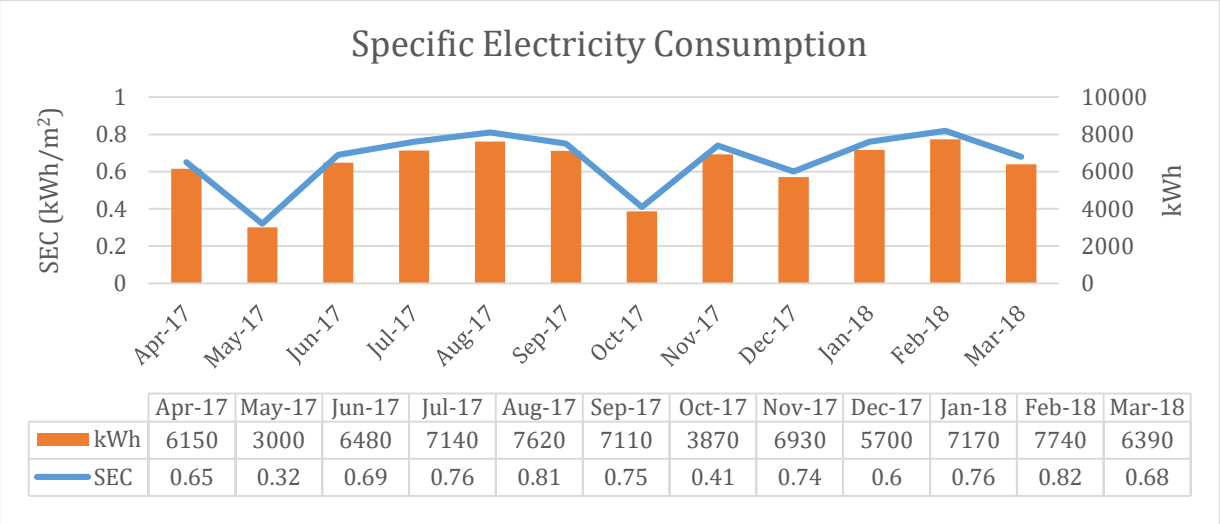

FIGURE 6: SPECIFIC ELECTRICITY CONSUMPTION – COLLEGE BLOCK

SPECIFIC ELECTRICITY CONSUMPTION (KWH/SQ.M) – AIM

Specific electricity consumption is calculated based on the electricity consumption and the building area. The details of specific electricity consumption for the period from Apr 17 to Mar 18 are given below.

TABLE 9: SPECIFIC ELECTRICITY CONSUMPTION (KWH/SQ.M) – AIM

Month	Unit Consumption	Built up area	Specific Electricity Consumption
	kWh	M^2	kWh/m^2
Apr-17	5284	979.46	5.39
May-17	2915	979.46	2.98
Jun-17	1855	979.46	1.89
Jul-17	3723	979.46	3.80
Aug-17	4423	979.46	4.52
Sep-17	4029	979.46	4.11
Oct-17	4480	979.46	4.57
Nov-17	3339	979.46	3.41
Dec-17	3102	979.46	3.17
Jan-18	2741	979.46	2.80
Feb-18	4002	979.46	4.09
Mar-18	3708	979.46	3.79
Avg	***3633.42***	***979***	***3.71***

The energy performance index is plotted in the below chart which gives a pictorial representation of the specific electricity consumption and units consumed in various months during the period from Apr 17 to Mar 18.

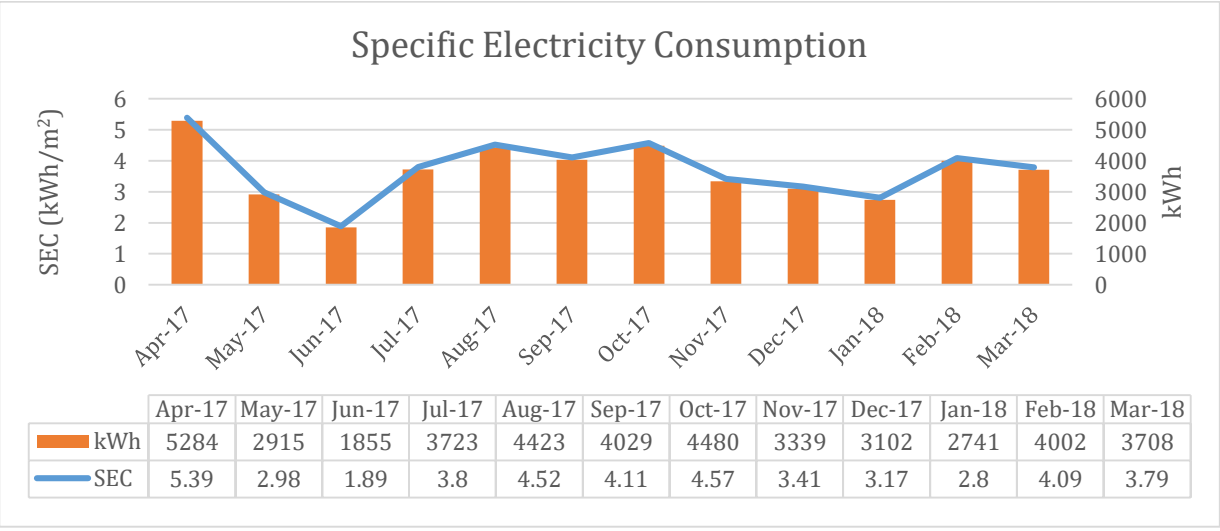

FIGURE 7: SPECIFIC ELECTRICITY CONSUMPTION – AIM

DIESEL GENERATOR

Diesel generator used in the college as backup supply. The following table gives the basic details of diesel generator in the college.

TABLE 10: DG DETAILS

Sl no	Rated power (kVA)	Engine	Alternator
1	100	Kirloskar	Kirloskar

Suggestions

i. Note down the running hours, unit consumption and diesel consumption of DG's.

ii. Frequent checking's should be done for DG's.

UPS

The major UPS details of the college is given below:

TABLE 11: UPS & BATTERIES DETAILS

Sl. No:		UPS			BATTERY		
	Location	Rated Capacity	Make	Year	Rating	Quantity	Make
		KVA			V, Ah	Nos	
1	Examination room	5	Supra	2017	12V 65Ah	8	Amaron Quanta
2	Admission room	10	Supra	2015	12V 40Ah	10	Exide
3	MBA	1	Creative		12V 65Ah	2	Exide
4	MBA	1	Creative		12V 65Ah	2	Exide
5	MBA	1	Creative		12V 65Ah	2	Exide
6	MBA	3	Creative		12V 65Ah	4	Exide
7	MBA	3	Creative		12V 65Ah	6	Exide
8	UPS room (Floor 1)	3	K S pwr s/m's		12V 65Ah	8	Exide

Suggestions

- UPS room should be ventilated properly.
- Petroleum jelly should be applied to the battery terminals.
- Battery water checking should be done periodically.
- UPS room should be kept neat and clean.

ELECTRICITY UTILITY DESCRIPTION

LIGHT & FAN

The light and fan loads connected in the college is tabulated in the following section.

TABLE 12: LIGHT & FAN LOADS

Particulars	LED Tube	T8	LED bulb	Ceiling fan	Table fan	Wall fan	CFL
Watts	**20**	**36**	**9**	**60**	**50**	**60**	**15**
TOTAL NOS	*592*	*241*	*170*	*416*	*17*	*14*	*97*
TOTAL KW	***11.84***	***8.676***	***1.53***	***24.96***	***0.85***	***0.84***	***1.455***

Inference

- Total light and fan loads come about **50.15 kW**.

Suggestions

- The LED lights shares the majority of the load in the light with 57% of total lighting load.
- By replacing existing fans with energy efficient fans BLDC fans, the net consumption would reduce considerably.

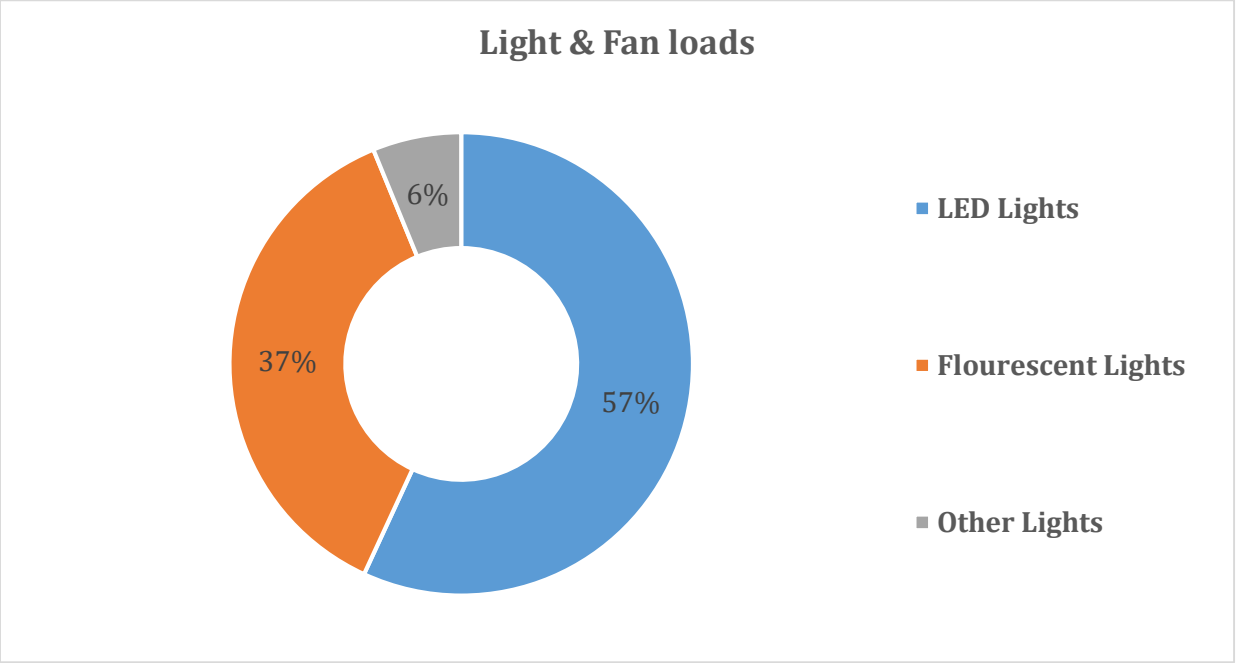

FIGURE 8: LIGHT AND FAN LOADS

AIR CONDITIONERS

The details of the Air-Conditioner installed in the college are tabulated below:

TABLE 13: AIR CONDITIONER LOAD

Sl.No:	Location	Type	Rated Capacity	Make	Rated Power	Star Rating	EER	Year
			TR		Watts			
Albertian Institute of Management								
1	Tutorial room	Ductable	5	Carrier	5130			2014
2	Tutorial room	Ductable	5	Carrier	5130			2014
3	Conference room	Split	1.5	Samsung	1700	3	3.6	
4	Class room	Split	2	Bluestar	2950			
5	Class room	Split	2	Bluestar	2951			
6	Class room	Split	2	Carrier	1234	3	3.95	2018
7	Computer Lab	Split	2	Carrier	1234	3	3.95	2018
8	Computer Lab	Split	2	Carrier	1234	3	3.95	2018
9	Computer Lab	Split	2	Carrier	1234	3	3.95	2018
10	Computer Lab	Split	2	Carrier	1234	3	3.95	2018
Main Block								
	Ground Floor							
1	MAC Lab	Split	2	Panasonic	1750			
2	MAC Lab	Split	2	Panasonic	1750			
3	Board room	Split	1	Voltas	1010	3	3.7	
4	Board room	Split	1.5	Samsung	1700	4	2.98	2018
	First Floor							
1	Asst Manager room	Split	1	Voltas	1210			
2	Concilium	Ductable	3		3450			
3	Tissue culture lab	Split	1.5	Carrier	1500	5	3.4	2010
4	Tissue culture lab	Split	1.5	Voltas	1550			
	Second Floor							
1	Microbiology Lab	Split	1.5	Commander	1650			

Suggestions

- Run ACs at 23 to 26^{0}C.
- Every degree below 26^{0}C increases energy consumption of AC.
- If lower temperature were preferred, it would be wiser to use the AC along with a ceiling fan.
- For future purchase, prefer five star rated AC's.
- Clean the filter of the AC's occasionally as it can help to reduce energy consumption.

COMPUTER & ACCESSORIES

The computer accessories and other power loads of the college are given below:

TABLE 14: COMPUTER ACCESSORIES & OTHER POWER LOADS

Sl. No:	Particulars	Rated Power	Quantity	Total Power
		Watts	Nos	kW
1	PC LCD	120	169	20.28
2	Projector	200	15	3
3	Printer	350	30	10.5
4	TV	150	6	0.9
5	Scanner	400	9	3.6
TOTAL			**38.98 kW**	

Inference

- Total connected load of computer accessories and other power loads of the college is **38.98 kW**.

ANNEXURE 1

ENERGY SAVING PROPOSAL – 1

REPLACEMENT OF CEILING FANS WITH BLDC FANS

Background

A BLDC fan takes in AC voltage and internally converts it into DC using SMPS. The main difference between BLDC and ordinary DC fans is the commutation method. A commutation is basically the technique of changing the direction of current in the motor for the rotational movement. In a BLDC motor, as there are no brushes, so the commutation is done by the driving algorithm in the Electronics. The main advantage is that over a period, due to mechanical contact in a brushed motor the commutators can undergo wear and tear, this thing is eliminated in BLDC Motor making the motor more rugged for long-term use. To explain, BLDC technology in simpler terms, BLDC uses a combination of Permanent Magnets and Electronics to achieve the kind of efficiency and performance, it delivers.

Proposal

Replace the ceiling fans with BLDC in the as per preference of operating hours as office areas and in security cabin. The wholesale price for one BLDC fan is Rs 3000. The average cost per unit is Rs 6.50. The calculation for the savings is given in the table below.

TABLE 15: EC PROPOSAL 1

Particulars	Unit	Class room	AIM
Power of existing ceiling fans at full speed	Watts	60	60
Power of BLDC fans at full speed	Watts	28	28
Difference in Wattage	Watts	32	32
Avg No: of working hours/day	Hrs	7	7
No: of working days per year (Average)	Nos	250	250
No: of working hours per annum	Hrs	1750	1750
Number of Ceiling Fans operating	Nos	40	15
kWh Saving per Annum	**Rs**	**2240**	**840**
Cost per kWH (Average)	Rs	6.5	6.5
Annual Financial Savings	**Rs**	**14560**	**5460**
Cost of BLDC Fans	Rs	3500	3500
Investment for BLDC Fans	**Rs**	**140000**	**52500**
Simple Payback period	**Months**	**115**	**115**

Note: BLDC fans are to be used mainly in the areas where the continuous running is required like Staffrooms, security rooms, classrooms etc.

ENERGY SAVING PROPOSAL – 2

REPLACEMENT OF FLUORESCENT LIGHT FITTINGS WITH LED

Background

The present light fittings are mainly been the fluorescent light of different ratings. By replacing these light fittings with LED, the consumption of electricity will reduce considerably.

TABLE 16: EC PROPOSAL 2

Particulars	Units	T8	CFL
Power of Fluorescent lights	Watts	36	15
Power of proposed LED tube	Watts	20	6
Difference in Wattage	Watts	16	9
Avg No: of working hours/day	Hrs	7	7
No: of working days per year (Average)	Nos	250	250
No: of working hours per annum	Hrs	1750	1750
Number of Lights operating	Nos	30	40
kWh Saving per Annum	**Rs**	**840**	**630**
Cost per kWH (Average)	Rs	6.5	6.5
Annual Financial Savings	**Rs**	**5460**	**4095**
Cost of LED tube	Rs	300	300
Investment for LED lights	**Rs**	**9000**	**12000**
Simple Payback period	**Months**	**20**	**35**

TABLE 17: SUMMARY OF EC PROPOSAL 2

Particulars	*Unit*	*Value*
Annual unit savings	kWh	1470
Total savings	Rs	9555
Total investment	Rs	21000
Payback period	months	26

ANNEXURE-2

LED specification

The Department of Electronics and information technology issued "Electronics and information Technology goods order 2012" on 3rd October 2012 the following standards for LED lamps are covered.

1. IS 15885 (Part -2/section 13)
2. IS 16102 (Part 1): 2012

As per this order, LED manufactures to get their product tested from BIS recognised labs.

Thus, the following electrical parameters and standards should ensure while purchasing LED in future based on the BIS standards. These are the minimum technical requirements for the acceptance of LED. In addition, the LED test certificates as per the various standards mentioned below should be examined while purchasing.

TABLE 18: LED SPECIFICATION

Sl no	Parameters	Requirements	Applicable IS
1	Light source	SMD LED chip	LM 80/IS 16106
2	System Efficacy	>= 110 lumen /watt	IS 16106:2012
3	LED Driver Efficiency	Minimum 85%	
4	**Harmonics**	**Maximum 10%**	**IS 16102-2-2012**
5	**Power factor**	**Minimum 0.95**	**IS 16102-2**
6	Frequency	50 Hz ±3%	LM-79 report
7	Operating voltage	110V – 320V	LM 79 report
8	Surge voltage	>4 kV	LM 79 report
9	Ambient temp	-10 to 50 deg C	LM 79 report
10	Degree of protection	IP 66	IS 10322
11	CRI	Minimum 70	IS 16102 - 2

ABBREVIATIONS

APFC	:	Automatic Power Factor controller
AVG	:	Average
BDV	:	Breakdown voltage
BEE	:	Bureau of energy efficiency
CEA	:	Central electrical authority
CFL	:	Compact fluorescent lamp
CFM	:	Feet cube per minute
DB	:	Distribution Board
DG Set	:	Diesel Generator Set
EC	:	Energy Conservation
FD	:	Forced draft
FY	:	Financial year
HPSV	:	High-pressure sodium vapour
HT	:	High Tension
ID	:	Induced draft
IEC	:	International electro technical commission
IEEE	:	The Institute of electrical and electronics engineers
IS	:	Indian Standard
KG	:	Kilogram
KVA	:	Kilo Volt Ampere
KVAH	:	Kilo volt Ampere Hour
KVAR	:	Kilo volt-ampere
KW	:	Kilo Watts
KWH	:	Kilowatt-hour
LED	:	Light emitting diode
MAX	:	Maximum
MH	:	Metal halide
NEMA	:	National Electrical Manufacturers Association
OLTC	:	On load tap changer
ONAN	:	Oil natural air natural
PCC	:	Point of common coupling
PSI	:	Pound square inch
RMD	:	Registered Maximum demand
SEC	:	Specific electricity consumption
SFU	:	Switch Fuse Unit
SLD	:	Single Line Diagram
TDD	:	Total demand distortion
THD	:	Total harmonics distortion
TOE	:	Tonne of oil equivalent
UPS	:	Uninterruptible power supply
VFD	:	Variable frequency drive

REFERENCES

1. BEE energy audit books
2. CEA regulations of grid connectivity-2007
3. IEEE Std. 519-1992.
4. National lighting code - 2010