Detail Energy Audit Report

Ground Zero Energy Solutions

CHARTERED ELECTRICAL ENGINEERS AND CONSULTANTS

Nurturing Friendship with Electricity

ENERGY AUDIT REPORT

(Dr. Panjabrao Deshmukh Memorial Medical College, Amravati)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

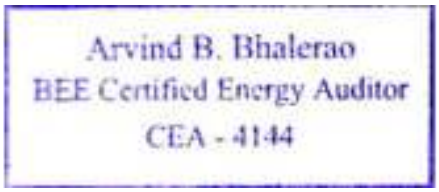
BEE	:	Bureau of Energy Efficiency
A2XFY	:	Aluminum conductor- Cross linked polyethylene insulation with Formed steel strip armor with PVC cable sheath
COP	:	Coefficient of Performance
DG	:	Diesel Generator
ECO	:	Energy Conservation Opportunities
FTL	:	Florescent Tube light
HT	:	High Tension
3.5C	:	3 cores of 3 phases with neutral core half of the phase core
AB Switch	:	Air Breaker switch
kVAh	:	kilo Volt Ampere Hour
kWh	:	kilo Watt Hours
LED	:	Light Emitting Diode
LT	:	Low Tension
ACB	:	Air Circuit Breaker
HRC	:	High Rupturing Capacity Fuse
HVAC	:	Heating Ventilation & Air Conditioning
TOD	:	Time Of Day tairff
SLD	:	Single Line Diagram
PF	:	Power Factor
MD	:	Maximum Demand
UoM	:	Unit of Measurement
CFM	:	Cubic Feet per Minute

I. ACKNOWLEDGEMENT

Ground Zero Energy Solutions humbly acknowledges wholehearted support provided by the management of the Dr. PDMMC, Amravati during the assessment exercise. The gym staff were immensely courteous in assisting in the assessment work. We are thankful to all of them. Energy audit was conducted in the month of July & August 2022.

Energy audit team
Ground Zero Energy Solutions

Place: Amravati
Date: September 17, 2022.



for, Ground Zero Energy Solutions
Mr. Arvind B. Bhalerao,
BEE certified Energy auditor
(AEA-0160)

II. ENERGY AUDIT TEAM

The team which carried out the whole energy audit exercise comprised following members.

SN	Name	Qualification
2	Mr. Om V. Bapat	ME, Electrical power systems
1	Mr. Arvind B. Bhalerao	MTech, BEE certified Accredited Energy Auditor (AEA-0160)
3	Mr. Kundan D. Dhonde	BE, Electrical engineering
4	Mr. Akash Panshire	ITI

Table 1: Energy audit team

SN	Energy Conservation Opportunities (ECOs)	Annual Electricity & fuel savings (kWh & kL)	Annual cost savings (Rs.)	Capital investment (Rs.)	Simple payback period (Months)
Short term projects (Less than 1 year)					
1	Supplying combined load of transformers TF-1 & TF2 with one transformer TF-2 for loss reduction and keeping TF1 out of service.	35,042.53	339,912.50	100000	3.53
2	Supplying load of DG-1 & DG-2 from only DG-2 and keeping DG1 out of service. DG3 will keep catering to its existing load.	1170.00	82215.90	30000	4.38
3	Air storage tank of 150-liter capacity shall be connected to the existing compressor.	2628	25491.6	20000	9
Medium term projects (1 to 3 years)					
4	Installing 100 kVAR APFC panel to maintain PF unity and avail maximum PF incentives in electricity bill per month.		662,950.00	400,000.00	7.24
5	Replacing all 1125 Nos. of fluorescent tubes (FTL T-12) of 40W with 20W LED tubes.	108583.2	1053257.04	365625	4.17
6	Replacing 200 kVA non-Star rated conventional transformer with a BEE 3-Star energy efficient transformer to reduce the losses significantly.	17,885.73	173,491.58	340,000.00	23.52
Long term projects (3 to 5 years)					
7	Replacing all 46 Nos. of streetlights of 200W with 100W LED streetlights.	6716	65,145.20	230,000.00	42.37
8	Replacing all 1141 Nos. of ceiling fans of 60W with 28W Energy efficient (EE) fans.	53672.44	520,622.67	3,423,000.00	78.90
Total		**225,697.90**	**2,260,136.49**	**4,508,625.00**	**23.94**

Table 2: Executive summary of Energy Conservation Opportunities

1. INTRODUCTION OF THE FACILITY

1.1 ABOUT DR. PDMMC, AMRAVATI

Fig 1.1: Dr. PDMMC campus

The campus of Dr. Panjabrao Deshmukh Memorial Medical College is spread over a above 1 lakh sq. meter area. It runs a multi & super specialty hospital of 550 beds with 21 indoor wards & 24/7 emergency services.

For various critical ailments the hospital is equipped with the following facilities,

a) ICCU, MICU, SICU, PICU & NICU, Obstetrics ICU service, Respiratory Critical Care Unit, Pediatric Critical Care unit, Post surgery Critical Care Unit. The hospital has a fully functional Respiratory, Neuro, Trauma, Burn and Dialysis Centre.
b) Digital X-Ray, 16 slice C.T. Scan, Ultra-Sonography, Color Doppler, 2D Echo and Mammography, EEG, PFT, ECT and MRI Facilities.
c) Pathology, Microbiology, Hematology, Cytology & Biochemistry Laboratories provides all routine tests along with hormone estimation.
d) 14 Advanced Operation Theaters.
e) Fully Equipped Hemodialysis service.
f) 24 X 7 full-fledged Blood Bank with blood component Facility.
g) Mother Milk Bank Facility.
h) Lift for Patients.
i) Bio- Medical Waste Management.
j) Central Laundry.
k) Central sterile supply department.

The multi-disciplinary medical college is affiliated to Maharashtra University of Health Sciences, Nashik.

1.2 OBJECTIVES OF THE STUDY

The purpose of this Energy Audit study is to investigate the energy consumption pattern and explore possibilities of energy conservation measures on account of load distribution, technology advancement, equipment aging and general maintenance requirements. The scope of this study is as under;

a) To study the performance of various energy consuming plant & machinery.
b) Performance comparison with relevant benchmarks.
c) To suggest the Energy Conservation Opportunities (ECOs).
d) To prepare first order cos-benefit analysis of proposed ECOs.
e) Recommendations for better compliance to standards.

1.3 ANNUAL ELECTRICAL CONSUMPTION DATA

S.N.	Parameters	Unit	Values
1	Annual electricity consumption	kWh/year	12,21,403.00
2	Annual electricity bill	Rs/year	6,96,95,910.00
3	Daily working hours	Hours/day	24.00
4	Annual operating days	Days/year	365
5	Rate of electricity	Rs/kWh	9.70

Table 1.1: Annual data

2. ENERGY AUDIT APPROACH & METHODOLOGY

2.1 APPROACH

The audit exercise was based on the following activities,

- Organize meeting with various departments to understand the working of the facility and to collect the electricity bill data, manuals and datasheets of various electrical equipment.
- Carry out field studies to measure the performance of various electrical equipment.
- Analyze the collected data and compare it with the benchmarks as per the BEE guidelines.
- Identify the Energy Conservation opportunities.
- Evaluation of the ECOs and prioritization of the ECOs on the basis of savings and investment.
- Preparation of the energy audit report.

2.2 METHODOLOGY

Fig 2.1: Methodology

2.3 INSTRUMENTS USED IN AN ENERGY AUDIT

- 3 Phase Power analyzer
- Thermo Anemometer
- Thermo hygrometer
- Vane anemometer
- Flue gas analyzer
- Infrared thermal imager
- Lux meter
- Digital clamp-on Multimeter
- Digital clamp-on earth resistance tester
- Infrared thermometer

3. HISTORICAL DATA ANALYSIS

3.1 ELECTRICAL SINGLE LINE DIAGRAM

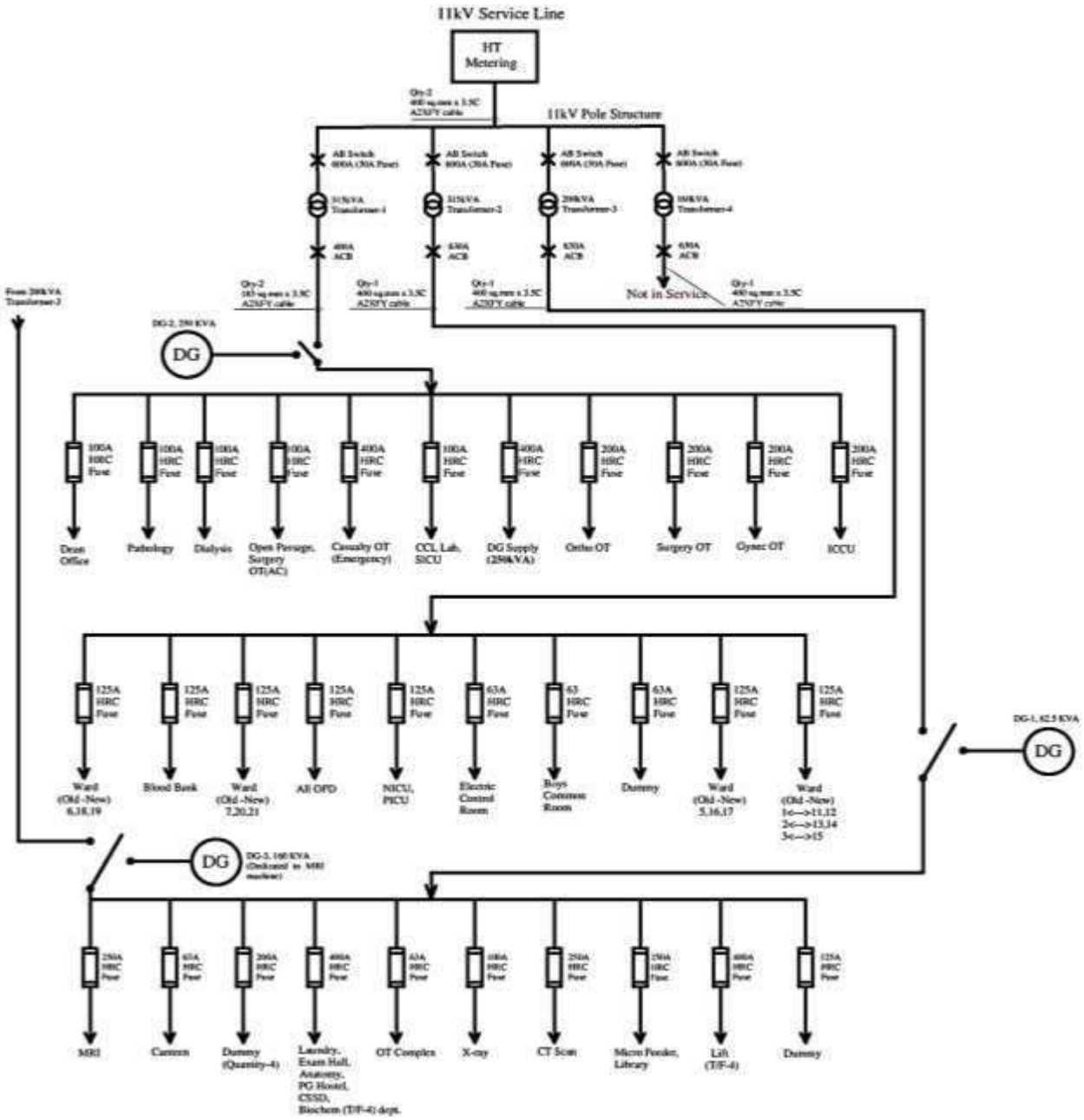


Fig 3.1: Existing electrical load distribution

3.2 PRESENT ENERGY CONSUMPTION

3.2.1 LOAD MIX

HVAC, water pumps, air compressing system, lighting, fans and medical equipment are identified as the major energy consuming loads in the hospital and college. Proportion of these energy consuming loads is depicted in the Pie chart below,

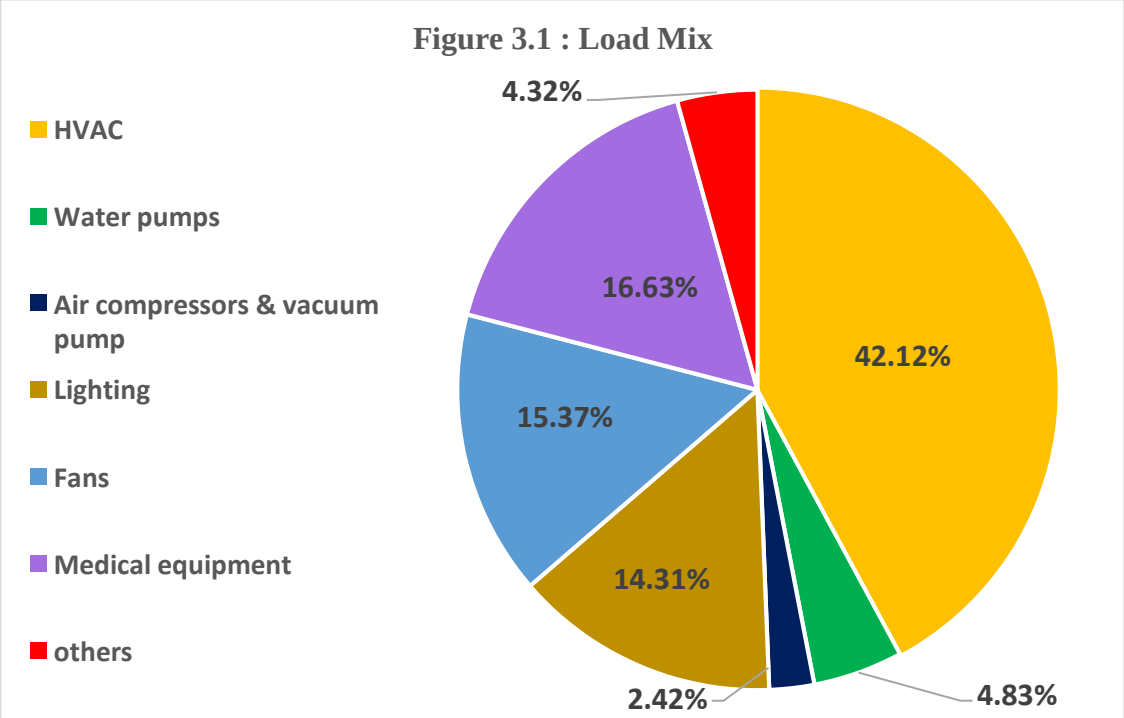


Figure 3.1 : Load Mix

- **Observations & recommendations:**
  a) Two higher energy consuming loads are air conditioning and medical equipment. More than 50% of energy is being consumed by these two loads.
  b) The second area of focus would be lighting, and fans installed at the facility. These two together account for 29.7% of the total load.
  c) Water pumps and air compressors consume 7.25% of energy.
  d) Others shown in the Pie chart include plug-in equipment like computers, small medical equipment etc.

3.3 ELECTRICITY TARIFF DETAILS

Table 3.1: Electricity tariff details

CONSUMER DETAILS				
Consumer Name	M/S Secretary Shri Shivaji Educational Society Medical College			
Consumer No	359019001651			
Meter No	076-00310510			
Date of connection	20-02-1991			
Circle	Amravati circle 620			
TARIFF DETAILS				
Parameters	Unit	2017-18	2018-19	2019-20
Tariff applicable from		April 2017	September 2018	April 2019
Tariff category		HT-IX B	HT-IX B	HT-IX B
Connected load	kW	431	431	431
Contract demand	kVA	400	400	400
50% of contract demand	kVA	200	200	200
Feeder voltage	kV	11	11	11
Energy charges	Rs/kWh	9.10	9.65	9.70
Wheeling charges	Rs/kWh	0.83	0.78	0.76
Demand charges	Rs/kVA /month	250	350	391
Excess demand charges	Rs/kVA	375	405	586.5
TOD tariff applicable	Y/N	Y	Y	Y
Load factor incentive applicable	Y/N	Y	Y	Y
PF incentive/penalty applicable	Y/N	Y	Y	Y

- **Observations & recommendations:**
  a) Above table shows that demand charges have increased by 56.4% in 2019-20 as compared to 2017-18 year.
  b) The energy charges are increased by 6.60% in 2019-20 as compared to year 2017-18.
  c) Other features like TOD tariff, PF incentives/penalty and load factor incentives are also applicable.
  d) The facility is at present availing TOD benefits and PF incentives partially.

3.4 ELECTRICITY BILL ANALYSIS

Bill Month	kWh	kVA MD	Bill demand	Billed PF	Load factor (%)	Demand charges (Rs.)	Wheeling charges (Rs.)	Energy charges (Rs.)	TOD tariff EC (Rs.)	FAC (Rs.)	Electricity duty (Rs.)	Tax on Sale (Rs.)	PF Penalty/PF incentive	Total Bill without arrears	Gross Unit rate Rs/kWh
Jul-19	129,440.00	324.00	324.00	0.990	40.00	126,684.00	98,374.40	1,255,568.00	-17,137.50	59,542.40	0.00	24,645.38	-37,942.35	1,509,734	11.66
Jun-19	160,570.00	375.00	375.00	0.990	56.00	146,625.00	122,033.20	1,557,529.00	-20,462.50	131,667.40	406,852.34	30,572.53	-48,434.80	2,326,382	14.49
May-19	161,558.00	348.00	348.00	0.992	54.00	136,068.00	122,784.08	1,567,112.60	-18,724.10	140,555.46	409,037.17	30,760.64	-48,694.90	2,338,899	14.48
Apr-19	133,204.00	320.00	320.00	0.993	48.00	125,120.00	101,235.04	1,292,078.80	-15,703.00	111,891.36	339,070.56	25,362.04	-40,365.54	1,938,689	14.55
Mar-19	110,578.00	252.00	262.00	0.990	37.00	91,700.00	86,250.84	1,067,077.70	-14,342.70	84,039.28	276,092.07	21,054.05	-32,868.10	1,579,003	14.28
Feb-19	74,178.00	251.00	262.00	0.946	28.00	91,700.00	57,858.84	715,817.70	-8,337.30	37,830.78	187,922.70	14,123.49	0.00	1,096,916	14.79
Jan-19	74,692.00	168.00	262.00	0.837	25.00	91,700.00	58,259.76	720,777.80	-8,150.00	65,728.96	194,946.34	14,221.36	32,491.06	1,169,975	15.66
Dec-18	76,423.00	182.00	262.00	0.834	31.00	91,700.00	59,609.94	737,481.95	-9,473.60	52,731.87	195,729.48	6,908.94	37,281.81	1,171,970	15.34
Nov-18	85,959.00	227.00	262.00	0.880	34.00	91,700.00	67,048.02	829,504.35	-11,049.60	28,366.47	211,169.54	7,770.69	15,083.54	1,239,593	14.42
Oct-18	115,163.00	273.00	273.00	0.908	43.00	95,550.00	89,827.14	1,111,322.95	-13,243.50	110,556.48	292,742.74	10,410.74	0.00	1,697,167	14.74
Sep-18	109,640.00	273.00	273.00	0.904	42.00	95,550.00	85,519.20	1,058,026.00	-14,183.60	55,916.40	204,932.48	9,911.46	0.00	1,495,672	13.64
Total	**1,231,405**					**1,184,097**	**948,800**	**11,912,297**	**-150,807**	**878,827**	**2,718,495**	**195,741**	**-123,449**	**17,564,001**	
Avg	**111,946**	**272**	**293**	**1**	**40**	**107,645**	**86,255**	**1,082,936**	**-13,710**	**79,893**	**247,136**	**17,795**	**-11,223**	**1,596,727**	**14**
Max	**161,558**	**375**	**375**	**1**	**56**	**146,625**	**122,784**	**1,567,113**	**-8,150**	**140,555**	**409,037**	**30,761**	**37,282**	**2,338,899**	**16**
Min	**74,178**	**168**	**262**	**1**	**25**	**91,700**	**57,859**	**715,818**	**-20,463**	**28,366**	**0**	**6,909**	**-48,695**	**1,096,916**	**12**

Table 3.2: Electricity bill analysis

- **Observations & recommendations:**

a) Facility is getting TOD tariff rebates.

b) Since September 18 to January 19, facility was getting PF penalty but from March 19 it is getting incentive till July 19.

c) The maximum demand always remained lower than the contract demand. It reached maximum value 375 kVA during month of May 2019.

d) The consumer is eligible to take benefit of load factor incentive. But, due to variations in hospital load, the load factor never rises to 75% to claim incentive.

e) The consumer can take maximum benefit of PF incentive by maintaining load power factor at 0.999 lagging at all time. Installation of Automatic Power Factor Control (APFC) panel will maintain the PF at desired level automatically with very small payback period on investment.

3.4.1 ENERGY CONSUMPTION TREND FOR YEAR 2017-18 & 2018-19

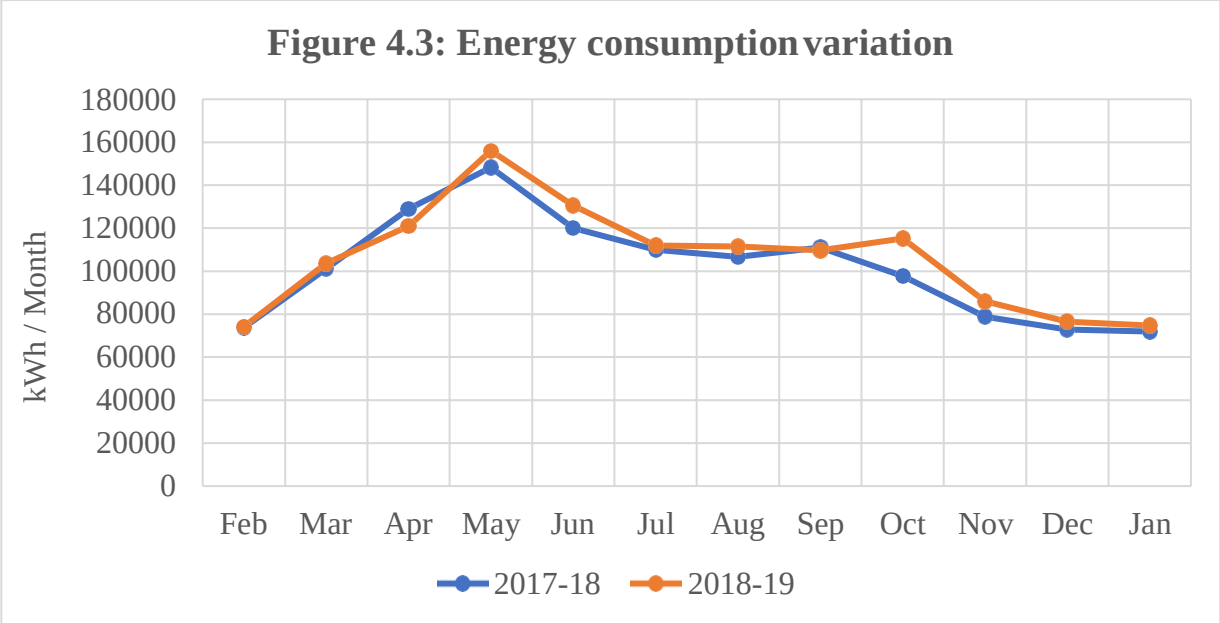


Figure 4.3: Energy consumption variation

Observations:

1. The electricity consumption has increased as compared to the previous year however the consumption pattern is same.
2. The electricity consumption trend is varying as per the seasonal effect on the cooling load.

3.4.2 DEMAND CURVE

Following figure shows the demand variation throughout the year. It shows comparison between actual, contract and minimum billed demand for Sept-18 to July-19.

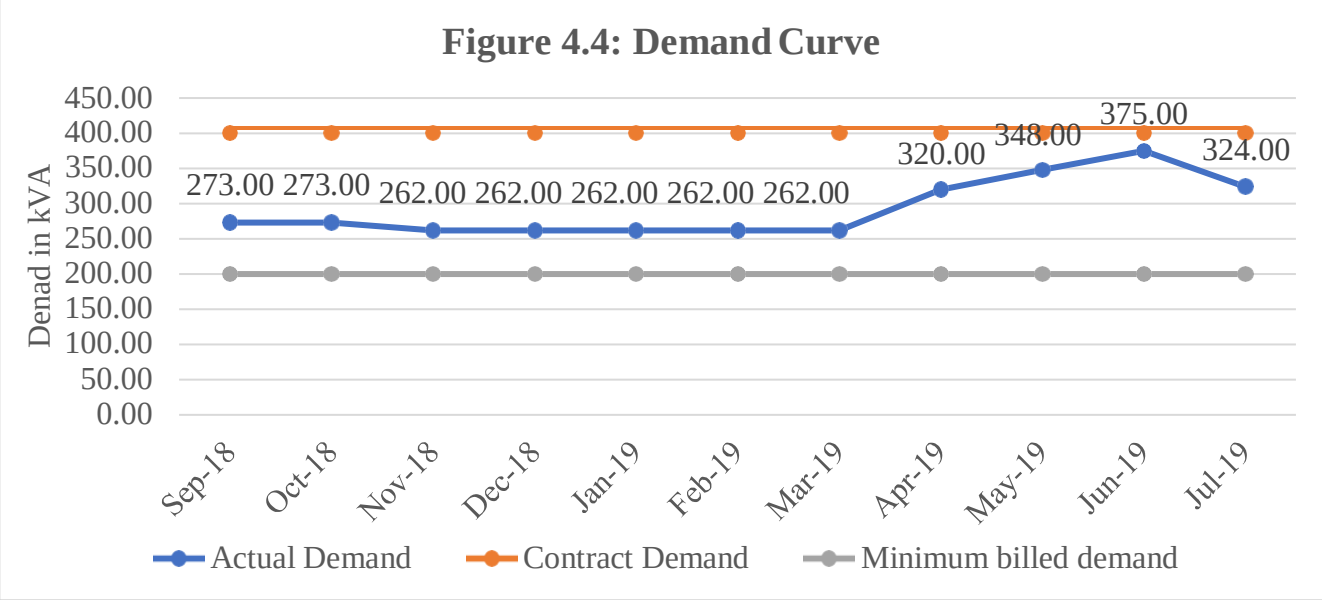


Figure 4.4: Demand Curve

- **Observations:**

a) Demand is varying exactly as per the expected seasonal variation.
b) Actual demand was highest in month of June 2019.
c) Actual demand was more than 80% of the contract demand for 4 months of summer.

3.4.3 POWER FACTOR VARIATION

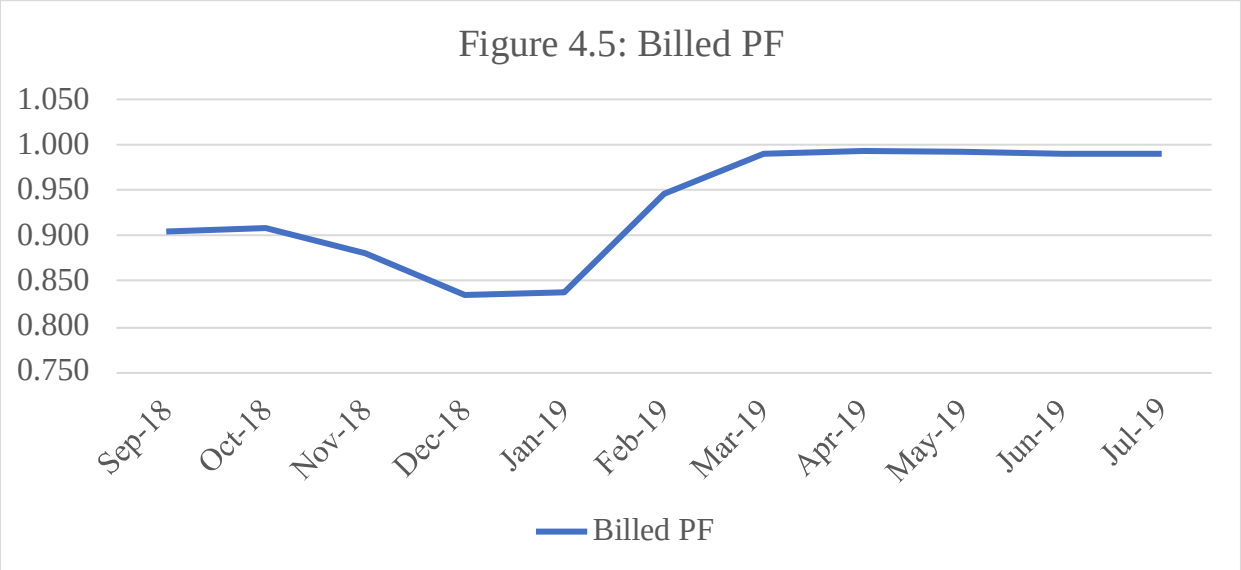


Figure 4.5: Billed PF

- **Observations:**

a) It has been observed that, power factor is less for lesser KVA demand and more for more kVA demand. Power factor variation is following the load variations.
b) After the last revision in tariff in April 2019, power factor can be seen rising.
c) Actual demand was highest in month of June 2019.

3.4.4 ECO-1: INSTALLING 100 KVAR APFC PANEL TO MAINTAIN PF UNITY AND AVAIL MAXIMUM PF INCENTIVES IN ELECTRICITY BILL PER MONTH.

Table 3.3: Saving calculation for ECO-1		
	UoM	
A. Proposed system	:	Automatic Power factor control Panel is not installed to maintain power factor near unity.
B. Upgraded system	:	100 kVAR APFC panel is installed on date 15/7/2020 to maintain PF unity.
C. Energy savings Calculations		
The facility has got PF incentive from Sept-18 to July-19	Rs./annum	123,448.00
Improved PF	---	0.999
PF incentives with PF 0.999 lagging	Rs./annum	609,753.00
Cost saving	Rs./annum	486305.00
Existing demand charges	Rs./annum	1,184,097
Reduced Demand charges with reduced kVA demand	Rs./annum	1,007,452.00
Demand charges saving	Rs./annum	176,645
Total cost saving	Rs./annum	662,950.00
Investment (Cost of 100 kVAR APFC panel)	Rs.	12,00,000.00

4. PERFORMANCE EVALUATION & ECOS

4.1 TRANSFORMER PERFORMANCE EVALUATION

Electrical distribution at PDMMC is supplied with 4 distribution transformers working in parallel. The load is being supplied by three transformers. 1 transformer is out of service. The performance of the transformers has been evaluated with the help of three phase power analyzer. Following table shows the analysis.

SN	Parameters	Unit	TF-1	TF-2	TF-3	TF-4 (Not in service)
Name Plate Data						
1	Capacity	kVA	315	315	200	NA
2	Primary voltage	Volts	11000	11000	11000	NA
3	Primary current	Amps	16.53	16.53	10.5	NA
4	Secondary voltage	Volts	433	433	433	NA
5	Secondary current	Amps	420	420	266.5	NA
6	Impedance	%	4.90%	4.90%	4.86%	NA
7	No load loss*	kW	0.69	0.69	0.64	NA
8	On load loss*	kW	5.1	5.1	4.45	NA
Test data						
9	Test duration	min	60	60	60	(Not in service)
10	Actual load (avg)	kVA	65	66.39	103	NA
11	Average PF	--	0.998	0.995	0.998	NA
12	Percent Loading	%	20.63	21.08	51.50	NA
13	Maximum KVA load	kVA	90	90.65	128	NA
14	Maximum percent loading	%	29%	29%	64%	NA
15	No load consumption	kWh/day	16.56	16.56	15.36	NA
16	Consumption due to load loss	kWh/day	25.26	25.80	55.00	NA
17	Total energy loss	kWh/day	41.82	42.36	70.36	NA
18	All day efficiency	%	96.76%	96.78%	96.56%	NA
19	Voltage imbalance	%	0.33%	0.33%	0.46%	NA
20	Current imbalance	%	37%	37%	4.00%	NA

Table 4.1: Transformer performance evaluation

- **Observations & recommendations:**
  a) Distribution transformer efficiency will be maximum when the loading is in between 35% to 55%.
  b) TF-3 is having highest all-day efficiency (99.15%) amongst the transformer fleet with 51.5% loading.
  c) As per the above analysis, loading of TF-1 and TF-2 is below 35% i.e., around 21%. Efficiency of operation can be increased by maintaining transformer loading in between 35%-55%.
  d) Maximum load on TF1 & TF-2 is around 90 kVA.
  e) It is recommended that, using only 1 transformer of 315 kVA to supply the load of TF-1 & TF-2 i.e., maximum 180 kVA would give maximum efficiency with optimum loading for one 315 kVA transformer.

4.1.1 ECO-2: SUPPLYING COMBINED LOAD OF TRANSFORMERS TF-1 & TF2 WITH ONE TRANSFORMER TF-2 FOR LOSS REDUCTION AND KEEPING TF1 OUT OF SERVICE.

Table 4.2: Saving calculation for ECO-2

	UoM	
A. Proposed system	:	2 Nos. of 315 kVA (TF-1 & TF-2) and 1 No. of 200 kVA (TF-3) transformers are connected to cater their respective dedicated loads.
B. Upgraded system	:	Supplying combined load of transformers on dated 15/11/2020 TF-1 & TF2 with one transformer TF-2 for loss reduction and keeping TF1 out of service.
D. Energy savings Calculations for combining load of TF-1 & TF-2 on TF-2 for efficiency improvement		
Capacity of TF-2	kVA	315
Present maximum KVA load on TF-2	kVA	90.65
Present max loading	%	28.78%
Power supplied by TF2	kW	85.211
Present All day efficiency	%	96.78%
Input power drawn	kW	88.04
Existing load on TF-2	kVA	180.65
Existing % loading	%	57.35

Existing power supplied at full load	kW	169.81
Improved All day efficiency	%	98.09
Input Drawn by transformer	kW	173.12
Input power saved due to improved efficiency	kW	3.31
Input power saved due to keeping TF1 on standby	kW	0.69
Total Power saved	kW	4.00
Total annual energy saving	kWh	35042.5258
Annual Cost savings**	Rs./annum	339,912.50
Investment (cost of cabling and main breaker)	Rs.	100000

4.1.2 ECO-3: REPLACING 200 KVA NON-STAR RATED CONVENTIONAL TRANSFORMER WITH A BEE 3-STAR ENERGY EFFICIENT TRANSFORMER TO REDUCE THE LOSSES SIGNIFICANTLY.

Table 4.3: Saving calculation for ECO-3

	UoM	
A. Existing system	:	1 No. of 200 kVA (TF-3) Non-star rated conventional transformer exists.
B. Upgraded system	:	200 kVA non-Star are disconnected and load is shifted to 315KVA ‘ B’ Transformer on dated 16/11/2021.
C. Energy savings Calculations		
Capacity of TF-3	kVA	200
Annual energy consumption due to losses of existing 200 kVA TF-3	kWh/annum	25,682.13

Specified total losses for 3-Star rated transformer at 50% loading	W	890
Specified total losses for 3-Star rated transformer at 100% loading	W	2700
Present loading on 200 kVA transformer	%	51.50
Annual energy loss due to losses for 3-Star rated transformer	kWh/annum	7,796.40
Energy saving with 3-star energy efficient transformer	kWh/annum	17,885.73
Cost saving	Rs. /annum	173,491.58
Investment (cost of 200 kVA 3-star rated distribution transformer)	Rs.	340,000.00

4.2 DG SET PERFORMANCE EVALUATION

SN	Parameters	Unit	DG-1	DG-2	DG-3
Nameplate Data					
1	Capacity	kVA	62.5	250	160
2	Output voltage	Volts	415	415	415
3	Rated current	Amps	81	328	209
4	Output Power factor	Volts	0.8	0.8	0.8
5	Fuel consumption at 100% load & 50% load resp.	Ltrs/hour	14.1 & 7.5	56.9 & 29.9	36.6 & 19.1
6	Fuel tank capacity	Ltrs	150	460	300
7	Max voltage dip at full load	%	equal or <20%	equal or <19%	equal or <20%
8	Alternator efficiency at 100% load, PF 0.8	%	91	93.6	92.8
Test data					
9	Test duration	min	60	60	60
10	Actual load (avg)	kVA	20.16	55.41	44
11	Loading	%	32.26%	22.16%	27.50%
12	Maximum load	kVA	21.61	67.96	48
13	Percent Maximum loading	%	35%	27%	30%
14	Energy generated	kWh/Hr	19.56	53.75	42.68
15	Fuel consumed	ltr/hr	5.87	16.12	12.80
16	Cost of fuel/month	Rs/month	6,330.00	8,250	8,490.00
17	Voltage imbalance	%	0.94%	0.82%	0.36%
18	Current imbalance	%	16%	3%	9.78%
19	Ambient temperature	Deg. Cel	34.4	34.4	34.5
20	Flue gas temperature	Deg. Cel	110	136	188
21	Carbon Monoxide (CO)	PPM	527	391	381
22	Oxygen O2	%	16	40.2	21.5
23	CO2 produced	gm/ltr	13,400	35,296	28,024

Table 4.4: DG set performance evaluation

- **Observations & recommendations:**
  a) Alternators are sized for kVA rating with highest efficiency attainable at a loading of around 70% and more.
  b) All the DG sets installed at the premises are underloaded.
  c) Consider parallel operation of two 250 kVA DGs for improved loading and fuel economy thereof.
  d) Keeping 62.5 kVA generator on 100% standby to save on maintenance, fuel and poor efficiency operation.
  e) Loading only two generators of 250 kVA with the total load will give maximum up to 80% of loading other than summer months on the single DG optimizing the efficiency of DG set.
  f) Current imbalance on 62.5 kVA generator is above the permissible limit of 10% as per the BEE guidelines.

4.2.1 ECO-4: SUPPLYING TOTAL FACILITY LOAD FROM DG-2 & DG-3 OF 250 KVA EACH.

Table 4.5: Saving calculation for ECO-4		
	UoM	
A. Existing system	:	2 Nos. of 250 kVA (DG2 & DG3) and 1 No. of 62.5 kVA (DG-1) diesel generators are installed to cater their respective dedicated loads.
B. Upgraded system	:	Supplying load of DG-1 & DG-2 on January 2020 from only DG-2 and keeping DG1 out of service. DG3 will keep catering to its existing load.
C. Energy savings Estimation		
D. Annual fuel expenses for existing arrangement		
Annual Fuel consumption of DG1 assuming 50% loading and 13 hrs operation per month	L	1170.00
Annual Fuel consumption of DG2 assuming 50% loading and 13 hrs operation per month	L	4664.40
Combined fuel consumption of DG1 & DG2	L	5834.40
Cost of fuel (Diesel at Rs. 70.27 / liter) for existing three generators in operation	Rs./annum	409983.3

E. Annual saving estimation for operation of DG-2 to supply load of DG-1 & DG-2.		
Annual Fuel consumption of DG2 assuming 50% loading and 13 hrs operation per month	L	4664.40
Annual saving in fuel consumption	L/annum	1170.00
Cost of fuel (Diesel at Rs. 70.27 / liter) for only DG-2 in operation	Rs./Annum	327767.39
Annual savings on fuel consumption	Rs./Annum	82215.90
Investment for combining loads on DG1 & DG2 on DG2 (only cabling expenses)	Rs.	30000

4.3 COMPRESSOR PERFORMANCE EVALUATION

SN	Parameters	Unit	Air Comp-1	Air Comp-2 (out of service)	Air Comp-3
Nameplate data					
1	Location of compressor		near medical store	near medical store	Medical college building
2	Service locations		Emergency ICU, Casualty OT, PICU, NICU, Gaynec ICU, Obstetrics ICU		SICU, AKD(Dialysis), Gaynec OT, Surgery OT
3	Type of compressor		Reciprocating	Reciprocating	Reciprocating
4	Motor rating	HP/kW	5/3.70	5/3.70	5/3.70
5	No. of cylinders	Nos.	2	2	2
6	Maximum flow rate	CFM	20	20	20
7	Reciever tank capacity	Ltrs	150	150	No receiver
8	Cylinder bore size	inches	4	4	4
9	Stroke length	inches	2.75	2.75	2.75
10	Maximum pressure measurement limit	kg/cm2	12.5	12.5	12.5
11	Piston displacement	CFM & Ltr/min	17.3 & 490	17.3 & 490	17.3 & 490
12	Control strategy employed		Automatic On/Off control	Automatic On/Off control	Automatic On/Off control
Test data					
13	Load pressure [Gauge]	kg/cm2	6	NA	NA
14	Unload pressure [gauge]	kg/cm2	8	NA	NA
15	Load kW	kW	2.7	NA	3
16	Unload kW	kW	0	0	0
17	Load time	minutes	0.60	NA	0.18

18	Unload time	minutes	5.09	NA	1.50
19	Load due point		5	NA	No dryer
20	Unload due point		1	NA	No dryer
21	Ambient temperature	Deg. Cel	34.4	NA	34.4
Calculated data					
22	Actual capacity	CFM	17.04	NA	NA (No pressure measuring gauge)
23	Compressed air generated	ft3	10.224		
24	Capacity shortfall	%	14.80%	NA	NA
25	Leakage in compressed air system	%	10.54%	NA	10.90%
26	Leakage quantity	CFM	1.7960	NA	NA
27	Specific power consumption	kW/CFM	0.1585	NA	NA
28	Power lost due to leakage	kW	0.28458	NA	NA
29	Power consumption	kWh/annum	23652.00	NA	26280
30	Volumetric efficiency	%	19.42	NA	NA (No pressure measuring gauge)

Table 4.6: Air compressor performance evaluation

- **Observations & recommendations:**
  a) Air storage tank is necessary for air compressor-3 situated in medical college building. Thermal imaging of this compressor shows temperature more than 80 ^{0}C. This shows that, the compressor motor runs continuously with very meager unload time.
  b) Air storage tank will store the air at required pressure and reduce the motor load time and its power consumption.
  c) Air compressor-3 shall be fitted with a regenerative dryer system to take out the maximum moisture content in the air. Moisture damages the internal parts of the piping and corrode it.

4.3.1 ECO-5: AIR STORAGE TANK OF 150 LITER CAPACITY SHALL BE CONNECTED TO THE EXISTING COMPRESSOR (AIR COMP-3)

Table 4.5: Saving calculation for ECO-5		
	UoM	
A. Existing system	:	Air compressor- 3 is installed without any air storage tank and pressure gauge.
B. Upgraded system	:	Air storage tank of 150-liter capacity is to be connected to the existing compressor on December 2019
C. Energy savings Calculations		
Total load-unload time of Air comp-3	Mins	1.68
Load kW	kW	3
Energy consumed per load operation of 0.18 min	kWh	0.0092
Energy consumed per annum	kWh/annum	26280
Cost of energy	Rs./annum	254916
Pressure requirement	kg/cm2	6
Energy consumed with an air storage tank	kWh/annum	23652
Annual energy saving	kWh/annum	2628
Cost of energy	Rs./annum	229424.4
Cost saving	Rs./annum	25491.6
Investment (Air storage tank)	Rs.	20000

4.4 WATER PUMP PERFORMANCE EVALUATION

Table 4.6: Water pump performance evaluation						
SN	**Parameters**	**Unit**	**Pump-1**	**Pump-2**	**Pump-3**	**Pump-4**
Design parameters						
1	Power rating	HP/kW	7.5/5.5	7.5/5.5	7.5/5.5	7.5/5.5
2	Current	kVA	12	13.3	13.2	15
3	Voltage	Volts	400	403	402	399
4	PF		0.845	0.865	0.832	0.852
5	Flow	m3/hr	31	29.9	31.25	25
6	Head	mtrs	33.5	39.6	35	40
	Hydraulic power generated	kW	2.8	3.2	3.0	2.7
	Power drawn by motor	kW	7.0	8.0	7.6	8.8
7	Overall efficiency	%	40	40	39	31

Observations

a) The 4 Nos. of water pumps installed in the premises run 24 X 7.
b) All 4 pumps supply water from 4 separate open wells.
c) The Water is pumped from all the 4 pumps into 2.5 lakh liter overhead tank.
d) It has been observed that, tank never gets filled completely.
e) There is a scope for energy saving by improving power factor which is at average 0.850.

4.5 PERFORMANCE EVALUATION OF CHILLER

Table 4.7: Chiller unit (Ductable Packaged Air conditioner)			
SN	**Parameters**	**Unit**	**Value**
Nameplate data			
1	compressor capacity	kW	29.89
2	Rated compressor input	kW	9
3	Maximum pressure	kg/cm^2	28.5
4	Refrigerant		R22
Test data			
5	Voltage	Volts	426
6	Current	Amps	20
7	PF		0.864
8	No. of compressors	Nos.	2.00
9	Total power drawn by compressors	kW	12.75
10	Hot water temperature- Compressor-1	^0C	40.00
11	Chilled water temperature- Compressor-1	^0C	11.80
12	Hot water temperature- Compressor-2	^0C	40.00
13	Chilled water temperature- Compressor-2	^0C	1.60
14	Chiller pump power	kW	1.48
15	Average air velocity (across suction side filter)	m/s	1.00
16	Cross section area	m^2	1.092
17	Air flow rate	m^3/s	1
18	Air flow rate per hour	m^3/h	3600
19	Dry bulb temperature -inlet	^0C	30.9
20	Wet bulb temperature-inlet	^0C	27.4
21	Enthalpy (h in)-inlet	kcal/kg	20.78
22	Dry bulb temperature-outlet	^0C	23.7
23	Wet bulb temperature-outlet	^0C	22.1
24	Enthalpy (h out)-outlet	kcal/kg	15.52
25	Density of air	kg/m^3	1.225
26	Total TR delivered	TR	7.67
27	Total cooling effect delivered	kW	26.92
28	EER	W/W	2.35
29	Specific power consumption	kW/TR	1.50

Observations & recommendations:

a) Measured value of outlet wet bulb and dry bulb temperature is higher than the prescribed values.
b) It has been observed that, insulation on chilled and hot water pipe has got worn out. Proper Insulation on chilled water and hot water pipe is advisable for optimum chiller performance.

4.6 ENERGY CONSUMPTION OF LIGHTING SYSTEM

4.6.1 TYPES OF LIGHTING FIXTURES AND THEIR CONSUMPTION ANALYSIS

The facility is having around 1719 numbers of different luminaries of 66 kW. Following table shows the building-wise, luminary-wise annual energy consumption of these luminaries.

Table 4.8: Wards & Hospital Lighting chart

SN	Location / Section		Type of Lighting Load													
	Location	Section	LED Tube	Watt	LED Bulb	Watt	FTL-T12	Watt	CFL	Watt	Ceiling Fan	Watt	Wall Fan	Watt	Exhaust Fan	Watt
1	Electric Room/Dept.			20	4	7	8	40		13	5	60		50	3	45
2	Wards	Ward No. 16 & 17		20		7	47	40		13	39	60		50	2	45
3		Ward No.11		20		7	35	40		13	29	60		50		45
4		Ward No.2		20		7	38	40		13	37	60		50	2	45
5		Ward No.3 & 4		20		7	51	40		13	64	60		50	2	45
6		Ward No. 5 & 6		20		7	49	40		13	48	60		50	2	45
7		Ward No. 7 & 8		20		7	19	40		13	18	60		50	6	45
8		TF (Offices)		20		7	28	40		13	32	60		50		45
9		Ward No. 14 & 15	36	20		7	1	40	1	13	39	60		50		45
10		Ward No. 20 & 21		20		7	31	40		13	43	60		50	2	45
	Location	**Section**	**LED Tube**	**Watt**	**LED Bulb**	**Watt**	**FTL-T12**	**Watt**	**CFL**	**Watt**	**Ceiling Fan**	**Watt**	**Wall Fan**	**Watt**	**Exhaust Fan**	**Watt**
11		Ward No. 18 & 19		20		7	42	40		13	49	60		50		45
12		Ward No. 12 & 13		20	8	7	52	40		13	49	60		50	2	45
13	First Floor	Gynic ICU		20	20	7	5	40		13	10	60		50		45
14		SICU		20		7	12	40	17	13	13	60		50		45
15		Medical		20		7	2	40		13	2	60		50		45
16		Hall,Rooms		20		7		40		13		60		50		45
17	Second Floor	ICCU		20	10	7	2	40		13	10	60		50		45
18		ICU		20	10	7	2	40		13	10	60		50		45
19		Medcine Dept.		20		7	16	40		13	16	60		50		45
20		Outdoor		20		7	13	40	1	13	1	60		50		45
21		Ward No. 9 & 10		20	1	7	34	40	2	13	38	60		50		45
22		Outdoor		20		7	5	40		13	2	60		50		45
23		Rooms		20		7	2	40		13	2	60		50		45

24		PICU		20	10	7		40		13	4	60		50		45
25		NICU		20	21	7	2	40		13	5	60		50		45
26	Ward No.1	Ward no.1(Male)		20		7	7	40		13	7	60		50	2	45
27		Ward no.1(Female)		20		7	7	40		13	7	60		50	2	45
28		Outdoor		20		7	3	40		13		60		50		45
29		Rooms		20		7	7	40		13	7	60		50	1	45
	Ward No.22	MRI Room		20	4	7		40		13		60		50		45
30		Sonography Section		20		7	2	40		13	2	60		50		45
31		X-ray rooms		20		7	9	40		13	7	60		50		45
32		Registration room		20		7	2	40		13	1	60		50		45
33		Corridor		20		7	9	40		13	4	60		50		45
34	Ground Floor	Account Section		20		7	2	40		13	1	60		50		45
35		Corridor		20		7	3	40		13		60		50		45
36		Office(mahatma fule)		20		7	6	40		13	3	60		50		45
37		Emergency Section		20		7	24	40		13	16	60		50		45
38		Emrgency Sect. ICU		20		7	7	40		13	6	60		50		45
39		Medical	6	20		7	5	40		13	3	60		50	1	45
40		Ward No. 29,30,25		20		7	24	40		13	19	60		50	1	45
41		Ward No. 26,27		20		7	9	40		13	5	60		50	1	45
	First Floor Blood Bank	Pasage		20		7		40	16	13		60		50		45
	Location	**Section**	**LED Tube**	**Watt**	**LED Bulb**	**Watt**	**FTL-T12**	**Watt**	**CFL**	**Watt**	**Ceiling Fan**	**Watt**	**Wall Fan**	**Watt**	**Exhaust Fan**	**Watt**
		Blood bank		20		7	6	40	38	13	4	60		50	1	45
	PSM			20		7	2	40		13	1	60		50		45
	First Floor Opration Theatre	OT		20		7	51	40		13	21	60		50		45
		Endoscopy		20		7	18	40		13	7	60		50		45
		Surgery		20	6	7	6	40		13	4	60		50		45
		Outdoor rooms		20		7	26	40		13	20	60		50		45
	Anaesthesia Dept.			20		7	4	40		13	1	60		50		45
Total Qty			**42**		**94**		**735**		**75**		**711**		**0**		**30**	
kW			**0.84**		**0.658**		**29.4**		**0.975**		**42.66**		**0**		**1.35**	
Total kW			**75.883**													

Table 4.9: OPD building Lighting chart																
Sr. No.	**Location / Section**		**Type of Lighting Load**													
	Location	**Section**	**LED Tube**	**Watt**	**LED Bulb**	**Watt**	**FTL-T12**	**Watt**	**CFL**	**Watt**	**Ceiling Fan**	**Watt**	**Wall Fan**	**Watt**	**Exhaust Fan**	**Watt**
1	Outdoor	Passage		20	1	7		40		13		60		50		45
2		Waiting Hall		20		7	4	40		13		60		50		45
3	Medical	Passage		20		7	5	40		13	1	60		50		45
4		Medical		20		7	4	40		13	8	60		50		45
5	Section-9	Registration Room		20		7	22	40		13	3	60		50		45
6	Section-8	Eye section		20		7	16	40		13	9	60		50		45
7		Outdoor		20		7	3	40		13	17	60		50		45
8	Section-7			20		7	11	40		13	12	60		50		45
9	Section-6	Gaynec OPD		20		7	15	40	2	13	11	60	5	50		45
10	Section-5	Orthopedic		20		7	15	40		13	8	60		50	1	45
11	Section-4			20		7	11	40		13	14	60		50		45
12	Section-3			20		7	20	40		13	16	60		50		45
13	Section-2			20		7	7	40	1	13	6	60		50		45
14	Section-10			20		7	4	40		13	3	60		50		45
15	Section-1			20		7	4	40		13	3	60	1	50		45
16	Section-12			20		7	1	40		13	1	60		50		45
17		RNTCP		20		7	1	40		13	1	60		50		45
18	First Floor OPD	Medicine		20		7	2	40	1	13	2	60		50		45
	Location	**Section**	**LED Tube**	**Watt**	**LED Bulb**	**Watt**	**FTL-T12**	**Watt**	**CFL**	**Watt**	**Ceiling Fan**	**Watt**	**Wall Fan**	**Watt**	**Exhaust Fan**	**Watt**
19		Dental OPD		20		7	6	40		13	6	60		50		45
20		Child OPD		20		7	6	40		13	7	60		50		45
21		OPD		20		7	15	40		13	10	60		50		45
22		Skin OPD		20		7	2	40		13	2	60		50		45
23		Respiratory section		20		7	2	40		13	2	60		50		45
24		Medical		20		7	2	40		13	2	60		50		45
25		Pediatrics Office		20		7	2	40		13	1	60		50		45
Total			0		1		180		4		145		6		1	
kW			0		0.007		7.2		0.052		8.7		0.3		0.045	
Total kW			**16.304**													

Table 4.10: Medical college building Lighting chart

SN	Location / Section		Type of Lighting Load													
	Location	Section	LED Tube	Watt	LED Bulb	Watt	FTL-T12	Watt	CFL	Watt	Ceiling Fan	Watt	Wall Fan	Watt	Exhaust Fan	Watt
1	Ground Floor Front Side	Office		20		7	4	40		13	2	60		50		45
2		Students Lab		20		7	15	40		13	10	60		50		45
3		Research Lab		20		7	7	40		13	4	60		50	2	45
4		Tutor Room		20		7	4	40		13	2	60		50		45
5		Microbiology Dept.		20		7	8	40		13	4	60		50		45
6		Demonstration Room		20		7	4	40		13	2	60		50		45
7		Museum		20		7	6	40		13	4	60		50		45
8		Parasitology		20		7	16	40		13	10	60		50		45
9		Mycology		20		7	15	40		13	7	60		50	2	45
10		Meeting Hall		20	17	7	4	40		13	10	60		50		45
11		Admin Office		20		7	2	40	1	13	1	60		50	1	45
12		Registration office		20		7	14	40		13	12	60		50	1	45
13	Ground Floor Back Side (Anatomy 7 Biochemistry Department)	Asst. Professor		20		7	2	40		13	1	60		50		45
14		Demonstration Room-1		20		7	2	40		13	1	60		50		45
15		HOD Cabin		20	1	7	2	40		13	1	60		50		45
16		Office-1		20	1	7	6	40		13	3	60		50		45
17		Histology Lab.		20		7	17	40		13	12	60		50		45
	Location	**Section**	**LED Tube**	**Watt**	**LED Bulb**	**Watt**	**FTL-T12**	**Watt**	**CFL**	**Watt**	**Ceiling Fan**	**Watt**	**Wall Fan**	**Watt**	**Exhaust Fan**	**Watt**
18		Library cum seminar Room-1		20		7	3	40		13	2	60		50		45
19		Research Lab-1		20		7	2	40		13	2	60		50		45
20		Demonstration Room-2		20		7	2	40		13	2	60		50		45
21		Museum		20	8	7	10	40		13	10	60		50		45
22		Demonstration Room-3		20		7	6	40		13	4	60		50		45
23		Library cum seminar Room-2		20	1	7	2	40		13	2	60		50		45
24		Demonstration Room-4		20		7	6	40		13	4	60		50		45
25		Office-2		20		7	2	40		13	1	60		50		45
26		Room-1		20		7	1	40		13	1	60		50		45
27		Room-2		20		7	2	40		13	1	60		50		45
28		Room-3		20		7	2	40		13	2	60		50		45

29		Office-3		20	1	7	2	40		13	1	60		50		45
30		Own teaching staff		20		7	2	40		13	2	60		50		45
31		Research Lab-2		20		7	2	40		13	2	60		50		45
32		Clinical biochemistry Lab		20		7	9	40		13	6	60		50		45
33		Students Lab	23	20		7	17	40	1	13	6	60		50		45
34		Outdoor		20		7	12	40		13		60		50		45
35	First Floor Psychology Department & Lecture Theatre (Backside)	Departmental Lib.	2	20		7		40		13	2	60		50		45
36		Laboratory-1	17	20		7		40		13	9	60		50		45
37		Office	6	20		7		40		13	4	60		50		45
38		Demonstration Room-1	4	20		7		40		13	2	60		50		45
39		Research Lab.	6	20		7		40		13	3	60		50	1	45
40		Demonstration Room-2	2	20		7		40		13	1	60		50		45
41		Chemical Pharmacology	15	20		7		40		13	10	60		50	4	45
		Museum-1	8	20		7		40		13	6	60		50		45
		Dept. of Forensic medicine	7	20		7		40		13	4	60		50		45
42		Museum-2	12	20		7		40		13	11	60		50	2	45
43		F.P.M.T. Room	15	20		7		40		13	10	60		50		45
44		Demontion Room	4	20		7		40		13	1	60		50		45
45		Library	4	20		7		40		13	2	60		50		45
	Location	**Section**	**LED Tube**	**Watt**	**LED Bulb**	**Watt**	**FTL-T12**	**Watt**	**CFL**	**Watt**	**Ceiling Fan**	**Watt**	**Wall Fan**	**Watt**	**Exhaust Fan**	**Watt**
46		Hematology Lab.-1	14	20		7		40		13	1	60	3	50		45
47		Laboratory-2	4	20		7		40		13	5	60	1	50		45
48		Amphibian Lab	15	20		7		40		13	11	60	2	50		45
		Clinical Psychology Lab	4	20		7		40		13	4	60	2	50		45
		Seminar Room	2	20		7		40		13	2	60		50		45
		HOD Cabin	11	20		7		40		13	7	60		50		45
		Reserve Lab	4	20		7		40		13	4	60		50		45
		Guyton Lecture Hall	33	20		7		40		13	16	60		50		45
		Officer In charge	2	20		7		40		13	2	60		50		45
		Department of Sports	3	20		7		40		13	5	60		50		45
		Outdoor	14	20		7		40		13		60		50		45
		Hall	29	20		7		40		13	29	60		50		45

Total Qty	**260**	**29**	**210**	**2**	**285**	**8**	**13**
kW	**5.2**	**0.203**	**8.4**	**0.026**	**17.1**	**0.4**	**0.585**
Total kW	**31.914**						

Table 4.11: Outdoor Street lighting chart

Location	Streetlights (Mercury vapor lamps)	Watt	Streetlights (LED)	Watt
Streets	46	200	41	100
Total Qty	**46**		**41**	
kW	**9.20**		**4.10**	
Total kW	**13.30**			

This chart provides overall picture of lighting system in the premises.

Table 4.12: Total Lighting load assessment chart

Sr. No.			Type of Lighting Load					
	Location	**Qty / kW / kWh**	**LED Tube**	**LED Bulb**	**FTL-T12**	**CFL**	**Street Light focus**	**LED street Light**
1	Wards & Hospital building	Qty	42	94	735	75	0	0
		kW	0.84	0.658	29.4	0.975	0	0
		kWh/annum	1839.6	1441.02	64386	2135.25	0	0
2	OPD building	Qty	0	1	180	4	0	0
		kW	0	0.007	7.2	0.052	0	0
		kWh/annum	0	15.33	15768	113.88	0	0
3	Medical college building (300 days considered)	Qty	260	29	210	2	0	0
		kW	5.2	0.2	8.4	0.026	0	0
		kWh/annum	9360	360	15120	46.8	0	0
4	Street lighting	Qty	0	0	0	0	46	41

		kW	0	0	0	0	9.2	4.1
		kWh/annum	0	0	0	0	20148	8979
Item-wise Total		**Qty**	**302**	**124**	**1125**	**81**	**46**	**41**
		kW	**6.04**	**0.865**	**45**	**1.053**	**9.2**	**4.1**
		kWh/annum	**11199.6**	**1816.35**	**95274**	**2295.93**	**20148**	**8979**
Total quantity of lighting fixtures		**Nos.**	**1719**					
Total connected lighting load		**kW**	**66.258**					
Total energy consumed by lighting system		**kWh/annum**	**139712.88**					

4.6.1 ECO-6: REPLACING ALL 1125 NOS. OF FLUORESCENT TUBES (FTL T-12) OF 40W WITH 20W LED TUBES.

Table 4.13: Saving calculation for ECO-6		
	UoM	
A. Existing system	:	1125 Nos. of Fluorescent tubes (FTL T-12) of 40W are fitted in the campus. That alone accounts for 68% of connected lighting load.
B. Upgraded system	:	Replacing all 1025 Nos. of fluorescent tubes (FTL T-12) of 40W with 20W LED tubes.
C. Energy savings Calculations		
Total connected load of 40W tubes	kW	45.00
Energy consumption of 40W tubes per annum	kWh/annum	95274
Cost of energy consumed by 40W tubes	Rs. /annum	924,157.80

Total connected load of 20W LED tubes	kW	22.50
Energy consumption of 20W LED tubes per annum	kWh/annum	47637
Cost of energy consumed by 20W LED tubes	Rs. /annum	462,078.90
Total energy savings	kWh/annum	47637
Total cost saving	Rs. /annum	4,62,078.9
Investment (Purchase of retrofit LED tubes that can be fitted in existing tube brackets)	Rs.	3,65,625

4.6.2 ECO-7: REPLACING ALL 46 NOS. OF STREETLIGHTS OF 200W WITH 100W LED STREETLIGHTS.

Table 4.14: Saving calculation for ECO-7		
	UoM	
A. Existing system	:	46 Nos. of streetlights of 200W are fitted in the campus.
B. Upgraded system	:	Replacing all 46 Nos. of streetlights of 200W with 100W LED streetlights.
C. Energy savings Calculations		
Total connected load of 200W streetlights	kW	9.20
Energy consumption of 200W tubes per annum	kWh/annum	40296
Cost of energy consumed by 200W streetlights	Rs./annum	390,871.20

Total connected load of 100W LED streetlights	kW	4.60
Energy consumption of 100W LED streetlights per annum	kWh/annum	20148
Cost of energy consumed by 100W LED streetlights	Rs./annum	195,435.60
Total energy savings	kWh/annum	20148
Total cost saving	Rs./annum	195,435.60
Investment (Purchase of retrofit LED tubes that can be fitted in existing tube brackets)	Rs.	230,000.00

4.7 ENERGY CONSUMPTION OF FANS

The facility is having around 1199 numbers of ceiling fans of 71.15 kW. Following table shows the Building-wise annual energy consumption of these fans.

Table 4.15: Wards & Hospital Fans chart

Sr. No.	Section/Location		Type of Lighting Load					
	Location	Section	Ceiling Fan	Watt	Wall Fan	Watt	Exhaust Fan	Watt
1	Electric Room/Dept.		5	60		50	3	45
2	Wards	Ward No. 16 & 17	39	60		50	2	45
3		Ward No.11	29	60		50		45
4		Ward No.2	37	60		50	2	45
5		Ward No.3 & 4	64	60		50	2	45
6		Ward No. 5 & 6	48	60		50	2	45
7		Ward No. 7 & 8	18	60		50	6	45
8		TF (Offices)	32	60		50		45
9		Ward No. 14 & 15	39	60		50		45
10		Ward No. 20 & 21	43	60		50	2	45
11		Ward No. 18 & 19	49	60		50		45
12		Ward No. 12 & 13	49	60		50	2	45
13	First Floor	Gynec ICU	10	60		50		45
14		SICU	13	60		50		45
15		Medical	2	60		50		45
16		Hall, Rooms		60		50		45
17	Second Floor	ICCU	10	60		50		45
18		ICU	10	60		50		45
19		Medicine Dept.	16	60		50		45
20		Outdoor	1	60		50		45
21		Ward No. 9 & 10	38	60		50		45
22		Outdoor	2	60		50		45
23		Rooms	2	60		50		45

24		PICU	4	60		50		45
25		NICU	5	60		50		45
26	Ward No.1	Ward no.1(Male)	7	60		50	2	45
	Location	**Section**	**Ceiling Fan**	**Watt**	**Wall Fan**	**Watt**	**Exhaust Fan**	**Watt**
27		Ward no.1(Female)	7	60		50	2	45
28		Outdoor		60		50		45
29		Rooms	7	60		50	1	45
	Ward No.22	MRI Room		60		50		45
30		Sonography Section	2	60		50		45
31		X-ray rooms	7	60		50		45
32		Registration room	1	60		50		45
33		Corridor	4	60		50		45
34	Ground Floor	Account Section	1	60		50		45
35		Corridor		60		50		45
36		Office (mahatma Phule)	3	60		50		45
37		Emergency Section	16	60		50		45
38		Emergency Sect. ICU	6	60		50		45
39		Medical	3	60		50	1	45
40		Ward No. 29,30,25	19	60		50	1	45
41		Ward No. 26,27	5	60		50	1	45
42	First Floor Blood Bank	Passage		60		50		45
43		Blood bank	4	60		50	1	45
44	PSM		1	60		50		45
45	First Floor Operation Theatre	OT	21	60		50		45
46		Endoscopy	7	60		50		45
47		Surgery	4	60		50		45
48		Outdoor rooms	20	60		50		45
49	Anesthesia Dept.		1	60		50		45

Total Qty	711		0		30	
kW	42.66		0		1.35	

Table 4.16: OPD fan chart

Sr. No.	Section/Location-OPD		Type of Lighting Load					
	Location	**Section**	**Ceiling Fan**	**Watt**	**Wall Fan**	**Watt**	**Exhaust Fan**	**Watt**
1	Outdoor	Passage		60		50		45
2		Waiting Hall		60		50		45
3	Medical	Passage	1	60		50		45
4		Medical	8	60		50		45
5	Section-9	Registration Room	3	60		50		45
6	Section-8	Eye section	9	60		50		45
7		Outdoor	17	60		50		45
8	Section-7		12	60		50		45
9	Section-6	Gynec OPD	11	60	5	50		45
10	Section-5	Orthopedic	8	60		50	1	45
11	Section-4		14	60		50		45
12	Section-3		16	60		50		45
13	Section-2		6	60		50		45
14	Section-10		3	60		50		45
15	Section-1		3	60	1	50		45
16	Section-12		1	60		50		45
17		RNTCP	1	60		50		45
18	First Floor OPD	Medicine	2	60		50		45
19		Dental OPD	6	60		50		45
20		Child OPD	7	60		50		45
21		OPD	10	60		50		45
22		Skin OPD	2	60		50		45
23		Respiratory section	2	60		50		45
24		Medical	2	60		50		45
25		Pediatric Office	1	60		50		45
26	**Total**		145		6		1	

27	**kW**	8.7	0.3	0.045

Table 4.17: Medical college Fan chart

Sr. No.	Section/Location-Medical College		Type of Lighting Load					
	Location	Section	Ceiling Fan	Watt	Wall Fan	Watt	Exhaust Fan	Watt
1	Ground Floor Front Side	Office	2	60		50		45
2		Students Lab	10	60		50		45
3		Research Lab	4	60		50	2	45
4		Tutor Room	2	60		50		45
5		Microbiology Dept.	4	60		50		45
6		Demonstration Room	2	60		50		45
7		Museum	4	60		50		45
8		Parasitology	10	60		50		45
9		Mycology	7	60		50	2	45
10		Meeting Hall	10	60		50		45
11		Admin Office	1	60		50	1	45
12		Registration office	12	60		50	1	45
13	Ground Floor Back Side (Anatomy 7 Biochemistry Department)	Asst. Professor	1	60		50		45
14		Demonstration Room-1	1	60		50		45
15		HOD Cabin	1	60		50		45
16		Office-1	3	60		50		45
17		Histology Lab.	12	60		50		45
18		Library cum seminar Room-1	2	60		50		45
19		Research Lab-1	2	60		50		45
20		Demonstration Room-2	2	60		50		45
21		Museum	10	60		50		45
22		Demonstration Room-3	4	60		50		45
23		Library cum seminar Room-2	2	60		50		45

24		Demonstration Room-4	4	60		50		45
25		Office-2	1	60		50		45
	Location	**Section**	**Ceiling Fan**	**Watt**	**Wall Fan**	**Watt**	**Exhaust Fan**	**Watt**
26		Room-1	1	60		50		45
27		Room-2	1	60		50		45
28		Room-3	2	60		50		45
29		Office-3	1	60		50		45
30		Own teaching staff	2	60		50		45
31		Research Lab-2	2	60		50		45
32		Clinical biochemistry Lab	6	60		50		45
33		Students Lab	6	60		50		45
34		Outdoor		60		50		45
35	First Floor Psychology Department & Lecture Theatre (Backside)	Departmental Lib.	2	60		50		45
36		Laboratory-1	9	60		50		45
37		Office	4	60		50		45
38		Demonstration Room-1	2	60		50		45
39		Research Lab.	3	60		50	1	45
40		Demonstration Room-2	1	60		50		45
41		Chemical Pharmacology	10	60		50	4	45
		Museum-1	6	60		50		45
		Dept. of Forensic medicine	4	60		50		45
42		Museum-2	11	60		50	2	45
43		F.P.M.T. Room	10	60		50		45
44		Demonstration Room	1	60		50		45
45		Library	2	60		50		45
46		Hematology Lab.-1	1	60	3	50		45

47		Laboratory-2	5	60	1	50		45
48		Amphibian Lab	11	60	2	50		45
	Location	**Section**	**Ceiling Fan**	**Watt**	**Wall Fan**	**Watt**	**Exhaust Fan**	**Watt**
49		Clinical Psychology Lab	4	60	2	50		45
50		Seminar Room	2	60		50		45
51		HOD Cabin	7	60		50		45
52		Reserve Lab	4	60		50		45
53		Guyton Lecture Hall	16	60		50		45
54		Officer In charge	2	60		50		45
55		Department of Sports	5	60		50		45
56		Outdoor		60		50		45
57		Hall	29	60		50		45
Total Qty			**285**		**8**		**13**	
kW			**17.1**		**0.4**		**0.59**	
Total kW			**58.514**					

This chart shows consolidated analysis of all types of fans installed at the premises.

Table 4.18: Energy consumption chart for fan load					
Sr. No.			**Type of fan Load**		
	Location	**Qty / kW / kWh**	**Ceiling Fan**	**Wall Fan**	**Exaust Fan**
1	Wards & Hospital building	Qty	711	0	30
		kW	42.66	0	1.35
		kWh/annum	62710.2	0	3942
2	OPD building	Qty	145	6	1
		kW	8.7	0.3	0.045
		kWh/annum	12789	441	98.55
3	Medical college building (300 days considered)	Qty	285	8	13
		kW	17.1	0.4	0.59
		kWh/annum	25137	588	1292.1
Item-wise Total		**Qty**	**1141**	**14**	**44**
		kW	**68.46**	**0.7**	**1.985**
		kWh/annum	**100636.2**	**1029**	**5332.65**
Total quantity of fans		**Nos.**	**1199**		
Total connected fan load		**kW**	**71.145**		
Total energy consumed by fans		**kWh/annum**	**106,997.85**		

4.8 PERFORMANCE EVALUATION OF SPIT & WINDOW AIR CONDITIONERS

Facility has around 110 window & split Air conditioners. Measurements has been taken for all the installed ACs in the premises. The chart presents some of AC units. Measurement of various HVAC parameters reveal the following status of the ACs.

SN	Location	Window / Split	Volume flow (m3 / h)	Flow velocity (m / s)	Dry bulb temp. (^{0}C)	Wet bulb temp. (^{0}C)	Relative humidity (%)	Dew point (^{0}C)	Star rating	Status
1	Central Research Lab	Split	2073	2.8	26.9	20.5	56.5	17.5	NO	Satisfactory but Needs to change with at least 3-star split AC
2	Hematology lab	Split	2073	2.8	26.9	20.5	56.5	17.5	NO	Satisfactory but Needs to change with at least 3-star split AC
3	Casualty ICU	Split	2073	2.8	26.9	20.5	56.5	17.5	NO	Satisfactory but Needs to change with at least 3-star split AC
4	ICU	Split	1488	2	28.8	25.9	79.7	25	NO	Needs to clean filter area
5	ICU	Split	2946	3.9	28.5	25.5	79.3	24.5	NO	Satisfactory but Needs to change with at least 3-star split AC
6	ICU	Split	2946	3.9	28.5	25.5	79.3	24.5	NO	Satisfactory but Needs to change with at least 3-star split AC
7	OPD Section 2 EEG	Split	2121	2.8	27.8	25.6	84.2	24.9	2	Satisfactory but Needs to change with at least 3-star split AC

8	Dialysis center	Window	874	1.2	28.7	25.3	76.5	24.2	NO	Needs to change with at least 3-star split AC
9	Blood bank	Split	2227	3	27.1	24.1	78.6	23.1	3	Satisfactory
10	Blood Bank section-Refreshment room	Split	3566	4.7	27.1	24.7	82.8	23.9	2	Satisfactory but Needs to change with at least 3-star split AC
11	ICCU	Split	1128	1.5	27.5	23.3	70.8	21.7	2	Needs to change with at least 3-star split AC
12	NICU	Split	1332	1.8	27.9	23.9	72.2	22.4	3	Needs to clean filter area
13	PICU	Split	1847	2.5	27.6	23.6	71.7	22	2	Needs to change with at least 3-star split AC
14	OT II	Split	2304	3.1	27.7	23.9	73.4	22.5	3	Satisfactory
15	OT II	Split	2287	3	27.6	24.2	76.1	23	3	Satisfactory
16	OT II	Split	2355	3.1	27.2	22.4	67	20.5	3	Satisfactory
17	OT I ENT	Window	1173	1.6	27.9	23.6	69.8	21.9	NO	Needs to change with at least 3-star split AC
18	OT I EYE	Split	1789	2.4	27.6	24.8	80.2	23.9	3	Needs to clean filter area
19	OT I Gynacology	Split	2099	2.8	27.8	23.9	72.7	22.4	2	Satisfactory but Needs to change with at least 3-star split AC
20	OT I Gynacology minor	Split	3676	4.9	28	24.7	76.5	23.7	NO	Satisfactory but Needs to change with at least 3-star split AC
21	Dean office	Split	1883	2.5	29.4	25.7	74.6	24.4	3	Satisfactory
22	Dean office	Split	3280	4.4	28.6	25.8	80.2	24.8	3	Satisfactory
23	Meeting hall in medical college	Split	2883	3.8	29.3	26	78	25	3	Satisfactory

24	Research lab	Window	1381	1.8	28.6	24.9	74.2	23.6	NO	Needs to change with at least 3-star split AC
25	Medical college-Histo	Split	2934	3.9	26	21.6	68.2	19.7	NO	Satisfactory
26	Histo lab AC-2	Split	1659	2.2	26.5	22.2	69.4	20.4	3	Needs to clean filter area
27	CBR lab	Split	1691	2.2	27.9	24.6	76.5	23.4	NO	Needs to change with at least 3-star split AC

Table No 4.20 Performance evaluation of window/split ACs

Table No 4.21 Performance evaluation of medical equipmentTable No 4.20 Performance evaluation of window/split ACs

Observations & recommendations:

a) Almost 50% of ACs are Non star rated and 2-star rated. It is recommended that, all Non star or 2-star rated ACs shall be replaced with minimum 3-Star ACs with inverter technology to save energy significantly.
b) Some 3-star rated ACs have found with lower volume flow than specified on nameplate of the ACs. Cleaning of evaporator and condenser filters and periodical maintenance would provide optimum volume flow.
c) Intelligent AC controllers provide a precise control over the temperature and optimizes the sub-cooling and super-heating of refrigerant. It is recommended to install these controllers on every split AC. This controller can save energy up to 30%. On the conservative side the savings have been considered around 15% of annual energy consumption of HVAC system.

4.9 PERFORMANCE EVALUATION OF VARIOUS MEDICAL EQUIPMENT

SN	Equipment	Phase	Line voltages (Volts)			Line current (Amps)			PF	Neutral current	Working hours / day	Power drawn (kW)
1	MRI machine	3	413	408	411	36.2	44.9	45.5	0.955	5.8	12	31.08
2	CT scan machine (out of service due to failure of ACT)	3	NA	NA	NA	NA	NA	NA	NA	NA	12	40
3	X-ray machine (C-arm)	1	233			4.3					12	0.96
4	X-ray machine (C-arm)	1	229			3.2					12	0.70
5	X-ray machine	1	231			4.9					12	1.08
6	Ventilator	1	231			0.0002					24	0.05
7	Ventilator	1	231			0.0002					24	0.05
8	Ventilator	1	231			0.0002					24	0.05
9	Ventilator	1	231			0.0002					24	0.05
10	Ventilator	1	231			0.0002					24	0.05
11	Ventilator	1	231			0.0002					24	0.05
12	Neo-natal warmers	1	231			0.002					24	0.6
13	Dialysis machine	1	230			8.69					4	2
14	Sonography machine	1	230			0.0013						0.3
Total kW												77.02

Table No 4.21 Performance evaluation of medical equipment

Table No 4.22 Performance evaluation of vacuum pumpTable No 4.21 Performance evaluation of medical equipment

Observations & recommendations:

d) Out of the all medical equipment, MRI and CT scan machines consume maximum energy.

e) These equipment are sensitive to switching, lightning surges and voltage fluctuation. Proper care shall be taken to protect them from earth fault, surges and voltage fluctuations.

4.10 PERFORMANCE EVALUATION OF THE ACB PANEL

Table 4.22: ACB panel- 400A

SN	Parameters	Phase values			Line values			Total
		R	Y	B	RY	YB	BR	
1	Voltage	237.7	244.4	237.3	412	416.8	416	
2	Current	60.09	32.23	66.77				
3	Active power	13.95	6.9	15.15				36.05
4	Reactive power (Inductive)	2.211	3.129	4.095				9.436
5	Apparent power	14.13	7.646	15.7				42.25
6	Power factor (Inductive)	0.9871	0.9042	0.9642				0.9427
7	Neutral current							37.78
8	Current Imbalance							39%
9	Voltage imbalance							1.92%
10	Frequency							50.1

- **Observations & recommendations:** Permissible current imbalance is 10%. Measured value is greater than the permissible imbalance. Load on the three phases shall be balanced to reduce power loss on the system.

4.11 PERFORMANCE EVALUATION OF VACUUM PUMP

Table No 4.22 Performance evaluation of vacuum pump

SN	Parameters	Unit	Vacuum pump
Nameplate data			
1	Location of compressor		near medical store
2	Service locations		Emergency ICU, Casualty OT, PICU, NICU, Gaynec ICU, Obstetrics ICU
3	Type of compressor		Reciprocating
4	Motor rating	HP/kW	2/1.50
5	No. of cylinders	Nos.	2
6	Maximum flow rate	CFM	34.6
7	Reciever tank capacity	Ltrs	150
8	Cylinder bore size	inches	4
9	Stroke length	inches	2.75
10	Maximum vacuum measurement limit	inchHg	29
11	Piston displacement	CFM & Ltr/min	34.60 & 980
12	Control strategy employed		Automatic On/Off control
Test data			
13	Load pressure [Gauge]	inchHg	22
14	Unload pressure [gauge]	inchHg	21.5
15	Load kW	kW	2.34
16	Unload kW	kW	0
17	Load time	minutes	0.70
18	Unload time	minutes	28.00
21	Ambient temperature	Deg. Cel	34.4
22	Energy consumption	kWh/h	2.34

- **Observations:** Performance of vacuum pump was satisfactory.

4.12 PERFORMANCE EVALUATION OF VRV SYTEM

At the time of measurement, load on the VRV system was low. Thus, only one VRV system was ON out of two.

Table No 4.23 Performance evaluation of VRV system			
SN	**Parameters**	**Unit**	**Value**
Nameplate data			
1	compressor capacity	kW	44.00
2	Rated compressor input	kW	12.71
3	Maximum pressure	kg/cm2	42.31
4	Refrigerant		R410A
Test data			
5	Voltage	Volts	413
6	Current	Amps	21.4
7	PF		0.864
8	No. of compressors	Nos.	1.00
9	Total power drawn by compressors	kW	13.23
10	Hot water temperature- Compressor-1	Deg. Celcius	37.90
11	Chilled water temperature- Compressor-1	Deg. Celcius	21.30
15	Average air velocity (across suction side filter)	m/s	4.60
16	Cross section area	sq.meter	0.57
17	Air flow rate	cubic meter/s	2.622
18	Air flow rate per hour	cubic meter/h	9439.2
19	Dry bulb temperature	Deg. Celcius	31.7
20	Wet bulb temperature	Deg. Celcius	27.1
21	Enthalpy (h in)	kcal/kg	20.43
22	Dry bulb temperature	Deg. Celcius	21.05
23	Wet bulb temperature	Deg. Celcius	15.22
24	Enthalpy (h out)	kcal/kg	10.17
25	Density of air	kg/cubic meter	1.225
26	Total TR delivered	TR	39.23
27	Total cooling effect delivered	kW	137.70
28	EER	W/W	11.57
29	Specific power consuption	kW/TR	0.30

4.13 PERFORMANCE OF LIFT

Table 4.24 Lift- Qty-1								
SN	**Parameters**	**Phase values**			**Line values**			**Total**
		R	Y	B	RY	YB	BR	
1	Voltage	248	237	243	419	417	423	
2	Current	6.6	6.3	6.3				
3	Active power (kW)	2.53	2.31	2.37				5.24
4	Apparent power (kVA)	14.13	7.646	15.7				5.8236
5	Power factor (Inductive)	0.785	0.799	0.8				0.9427
6	Neutral current (Amps)							0.1
7	Current Imbalance (%)							3%
8	Voltage imbalance (%)							2.34%
9	Frequency							50.1
10	Motor speed (rpm)							477
11	Displacement torque (Nm)							> 295

4.14 UNINTERRUPTED POWER SUPPLIES AND THEIR DETAILS

Table 4.25: UPS & Inverters									
SN	**Location of inverter/UPS**	**Capacity (kVA)**	**Make**	**Readings**					
				Vdc	Vac	Vout	No of batteries	AH capacity of each battery	Battery combination
1	C-arm machine	3	Microtek	81.4	247	230	6	42	series
2	Blood bank (Apherisis room)	2	Microtek	78.7	248	230	6	35	series
3	Blood bank	2	Microtek	82.1	248.8	230	6	100	series
4	Haematology	2	Microtek	82.1	248	230	6	100	series
5	OT	3	Microtek	81.9	250	230	6	100	series
6	Central research lab	3	Microtek	81.8	234	230	6	100	series
7	Central research lab	3	Microtek	82.1	233	230	6	42	series
8	Medical college-Research lab	3	Microtek	83.2	213	230	6	100	series

9	MRI machine	60	Eaton	539	241	232	44	100	series

5. BEST PRACTICES

5.1 SPACE COOLING & HEATING

5.1.1 ELIMINATE ENERGY WASTE DOES NOT HAVE TO COMPROMISE PATIENT'S COMFORT

Most managers recognized the importance of having and effective cooling and heating system to keep the patients and staff comfortable. It is often possible to reduce the energy wastage while improving internal comfort conditions at the same time. Setting appropriate temperatures, ensuring that cooling and heating equipment and controls are operated and managed correctly can help reduce cost. It is possible in many hospitals to save up to 15% on cooling and heating cost through the implementation of energy saving measures.

5.1.2 OBTAIN FEEDBACK

Encourage staff to report any areas that are too hot, cold or draughty. Investigating problem areas can help to identify maintenance issues. If these issues are addressed, staff and patients are less likely to adjust the temperatures by opening windows whilst heating or cooling is on, or bringing in portable electric heaters or fans. Therefore, in order to maintain appropriate internal temperatures, the temperature settings should be in accordance to the activity taking place in the area. A good starting point is to know NBC (2005) recommended temperatures for specific areas in hospital.

5.2 HOT WATER

Water cost within a hospital can be considerable and this is made worse when hot water is wasted, as the energy used to heat the water has been wasted too. However, water is a metered and controllable resource and it is possible to save a significant amount of water simply by implementing some inexpensive efficiency measures. Conservation of water also reduces the pumping requirement, which saves energy.

Use solar water heaters in place of geysers for water heating.

5.3 LIGHTING

5.3.1. LABELING LIGHT SWITCHES

5.3.2. SWITCH OFF POLICY

6. NEXT STEPS

Step 1. Understand your energy use

Look at your hospital and identify the major areas of energy consumption. Check the condition and operation of equipment and monitor the power consumption over one week to obtain a base figure against which energy improvements can be measured.

Step 2. Identify your opportunities

Compile an energy checklist. Walk round your building and complete the checklist at different times of day and night to identify where energy savings can be made.

Step 3. Prioritize your actions

Draw up an action plan detailing a schedule of improvements that need to be made and when, along with who will be responsible for them.

Step 4. Seek specialist help

It may be possible to implement some energy saving measures in-house but others may require specialist help. Discuss the more complex or expensive options with a qualified technician.

Step 5. Make the changes and measure the savings

Implement your energy saving actions and measure against original consumption figures. This will assist future management decisions regarding your energy priorities.

Step 6. Continue managing your business for energy efficiency

Enforce policies, systems and procedures to ensure that your business operates efficiently and that

1 UNIT SAVED IS 3 UNITS GENERATED

----------CONTACT US----------

Registered Office: 14, Rana Nagar, Congress Nagar Road, Amravati – 444606

Email: omgbpt@groundzerosols.com; Mobile: 7020535401

GROUND ZERO ENERGY SOLUTIONS
CHARTERED ELECTRICAL ENGINEERS & CONSULTANTS
AMRAVATI

Arvind B. Bhalerao
BEE Certified Energy Auditor
CEA - 4144