"Solutioning" in the Consultation/Training/Auditing

ENERGY AUDIT REPORT

AVMC
AARUPADAI VEEDU MEDICAL COLLEGE

SCHOOL OF PHYSIOTHERAPY, PUDUCHERRY

VINAYAKA MISSION'S
COLLEGE OF NURSING, PUDUCHERRY
(An Constituent College of Vinayaka Mission's Research Foundation)

SCHOOL OF ALLIED
HEALTH SCIENCES
VMRF - DU

Submitted By

TULASI EOHS CONSULTANCY SERVICES

Regd off: NO.18, SAKTHI NAGAR, LAKSHMI PURAM, WEST TAMBARAM, CHENNAI-600045
Mob: 9884624964, Email: chellamadhan@gmail.com, tulasieohsconsultancy@gmail.com

This is to certify that the following utilities were carried out Green audit in the month of

Details of Facilities Audited: Main college building including: Laboratories, Libraries, Hospitals, All departments and Hostel and college Canteen.

Authorized Signatory

For TULASI EOHS CONSULTANCY SERVICES

Date :

Place : Chennai

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Separately Enclosed- CD with soft copies of

1. **Data recorded during specific load combinations**

2. INTRODUCTION

An energy audit is an inspection, survey and analysis of energy flows, for energy conservation in a building, process or system to reduce the amount of energy input into the system without negatively affecting the output(s). In commercial and industrial real estate, an energy audit is the first step in identifying opportunities to reduce energy expense and carbon footprints.

The scope of an energy audit can comprise a detailed review of the energy performance of an organization, Significant Energy User(s), systems, energy-using processes and/or equipment. It is typically based on appropriate measurement and observation of actual energy performance for the defined energy audit scope.

Energy audit outputs typically include information on current energy consumption and energy performance, and they can be accompanied by a series of specific recommendations ranked by energy performance improvement or financial return on investment, based on analysis of specific site data and operating conditions

In the present study, the campus comprising of Medical college, Nursing college, School of Physiotherapy and School of Allied Health and Science, an electricity audit has been done. In this study Admin buildings, specialty services ,Operation theaters , Diagnostic service department, Clinical laboratories, Service areas viz. laundry, kitchen, Central sterile services department(CSSD), Backup power supply, AC plant, Manifold Rooms, Pharmacy services instrument, Fans, air conditioners, Computers facilities , IT infrastructures, Digital Libraries, Hostel facilities etc., were considered.. We have studied total budget of the Institution total economic investment of an Institution on the electricity and total electricity generated from the solar electricity generation unit. Also, we have studied total saving of electricity and the exact contribution of bulb, fans, computer, instruments etc in the total requirement of electricity. We

have studied all the above said parts of energy audit by collecting the exact details of the inputs through a survey.

3. SUMMARY STATEMENT

The IQAC Director, AarupadaiVeedu Medical College & Hospital situated on the Pondy – Cuddalore main road , Pondicherry requested to carry out Energy Audit at their campus comprising Medical college, Nursing college, School of Physiotherapy and School of Allied Health and Science. Energy and Power Quality Audit team had undertaken harmonic and other electrical parameter measurements on 3rd November 2020 at their institute of **1000 kVA capacity**.

The summary of the information are as follows:

The measurements were undertaken using **Model: 1735 Three-Phase Power Quality Logger**

The following parameters were recorded by the above instrument with 2 **minutes recording sample time over the 2 hours,**

(i) The following parameters were recorded

(a) 3 Phase voltage
(b) 3 Phase current
(c) Frequency
(d) % Voltage Unbalance
(e) % Current Unbalance
(f) Active Power in kW and reactive power in kVAR
(g) Power Factor
(h) % Voltage THD
(i) % Current THD

The parameters (a) to (i) are recorded every 2 minutes period by the meter and they are averaged (for convenience of handling)

*The definition of THD are provided at the end of this section

(ii) The trend recordings for various parameters (voltages, currents, powers and power factors) are also taken for the different periods of recording times.

(iii) This is followed by the report of the recordings for the various combinations of equipment in operation to cover possible operational modes with the time stamp. For these periods the recorded parameters are provided **without averaging but as the raw data** at 10 sec sample time records. The corresponding THD figures and the calculated TDD values with 4500 kVA as the base are also provided.

(iv) The scrutiny of the data presented for the THD. The voltage THD figures are also well within the stipulated 1.2% whereas the current THD is in the range between 2.07 % to 10.4% which is high as per the CEA.

(v) These values are not well within the IEEE 519-1992 stipulations which are internationally accepted values.

(vi) The extracts from IEEE regulations and CEA regulations are provided as annexure to this report.

(vii) **Definitions of THD and TDD:**

THD = Total Harmonic Distortion

The ratio of the root-mean-square of the harmonic **(voltage or current)** content to the root-mean-square of the fundamental quantity, expressed as a percent of fundamental. THD typically refers to instantaneous measurement of harmonic distortion at an individual piece of equipment or group of loads, based on the actual fundamental current that is flowing during the measurement. THD is the typical measurement made with a harmonic analyzing equipment which takes in 3 phase voltages and currents from which the same is extracted as per the following ratio.

$$THD = \sqrt{\frac{\text{sum of squares of amplitudes of all harmonics}}{\text{square of amplitude of fundamental}}} \quad 100\%$$

TDD = Total Demand Distortion

The total root-sum-square harmonic current distortion, in percent of the maximum demand load current (15- or 30-minute demand).

$$TDD = \sqrt{\frac{\text{sum of squares of amplitudes of all harmonics}}{\text{square of maximum demand load current}}} \; 100\%$$

When the point of common coupling (PCC) is considered at the service entrance or utility metering point, IEEE-519 recommends that the maximum demand load current (IL) be calculated as the average current of the maximum demand for the preceding 12 months. To calculate TDD for new construction, prior to installation of equipment, one may use good engineering judgments to estimate the expected maximum demand load current. A conservative approach is to use the summation of the FLA ratings of all motors**.**

4. MEASURING EQUIPMENT SPECIFICATION

Features of Power Quality Logger Make: Fluke Model: 1735

Fluke's 1735 Three-Phase power data logger is Fluke's most versatile multi-purpose power quality and energy analyzer on the market for the price and is the ideal power meter for conducting energy studies and basic power quality logging. Set the Power Logger up in seconds with the included flexible current probes and colour display. The power quality meter measures most electrical power parameters, harmonics, and captures voltage events.

Specifications		
General	Display	¼ VGA Graphic Color transmissive displays 320 x 240 Pixel with additional background lighting and adjustable contrast, text and graphics in color
	Quality	Developed, designed and manufactured according to DIN ISO 9001
	Memory	4 MB Flash memory, 3.5 MB for measuring data
	Interface	RS-232 SUB-D socket; 115.2 k Baud, 8 data bits, no parity, 1 stop bit, firmware updates are possible with the RS- 232 interface (9-pole extension cable)
	Sample rate	10.24 kHz
	Line frequency	50 Hz or 60 Hz, user-selectable, with automatic synchronization
	Power supply	NiMH battery-pack, with ac adapter (15 V to 20 V / 0.8 A)
	Operation time with battery	Typical > 12 hours without backlight and > 6 hours with backlight high
	Dimensions	240 x 180 x 110 mm
	Weight	1.7 kg, including battery

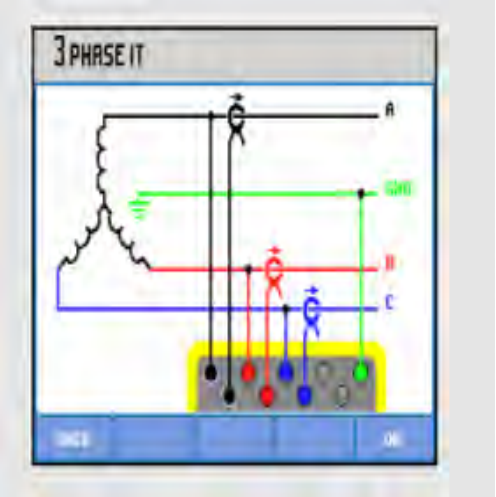
Ambient conditions	Working temperature range	-10°C to +50°C
	Storage temperature range	-20°C to +60°C
	Operating temperature range	0°C to +40°C
	Reference temperature range	23°C ±2°C
	The above terms are defined in European Standards. To calculate the specification at any point in the working temperature range, use the temperature coefficient below.	
	Temperature coefficient	±0.1% of the measured value per°C from the reference
	Intrinsic error	Refers to reference temperature, maximum deviation is guaranteed for two years
	Operating error	Refers to operating temperature range, maximum deviation is guaranteed for two years
	Climatic class	C1 (IEC 654-1) -5°C to +45°C, 5% to 95% RH, no dew
	Housing	Cycoloy shock and scratch proof thermoplast V0-type (non-flammable) with rubber protection holster
EMC	Emission	IEC/EN 61326-1:1997 class B
	Immunity	IEC/EN 61326-1:1997
Safety	Safety	IEC 61010-1 600 V CAT III, double or reinforced insulation, pollution degree 2
	Protection	IP65; EN60529 (refers only to the main housing without the battery compartment)
		RMS values are measured with a 20 ms resolution.

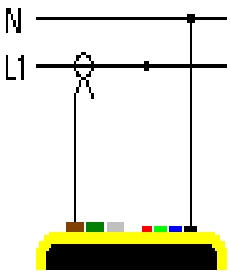
V-rms wye measurement	Measuring range	57 V/66 V/110 V/120 V/127 V/220 V/230 V/240 V/260 V/277 V/347 V/380 V/400 V/417 V/480 V AC
	Intrinsic error	±(0.2% of measured value + 5 digits)
	Operating error	±(0.5% of m. v. + 10 digit)
	Resolution	0.1 V
V-rms delta measurement	Measuring range	100 V/115 V/190 V/208 V/220 V/380 V/400 V/415 V/450 V/480 V/600 V/660 V/690 V/720 V/830 V AC
	Intrinsic error	±(0.2% of m. v. + 5 digit)
	Operating error	±(0.5% of m. v. + 10 digit)
	Resolution	0.1 V
A-rms measurement	Flexi set I ranges	15 A/150 A/3000 A rms (at sine)
	Current clamp ranges	1 A/10 A
	Resolution	0.01 A
	Ranges	150 A/3000 A and 1 A/10 A
	Intrinsic error	±(0.5% of m. v. + 10 digit)
	Operating error	±(1% of m. v. + 10 digit)
	Ranges	15 A
	Intrinsic error	±(0.5% of m. v. + 20 digit)
	Operating error	±(1% of m. v. + 20 digit)
		The errors of the current probes are not considered.

By using Flexi-set	Flexi Set measuring error	±(2% of m. v. + 10 digit)
	Position influence	±(3% of m. v. + 10 digit)
	CF (typical)	2.83
	When using Flexi Set please make sure to position the conductor opposite to the Flexi Set-lock	
Power measurement (P - Active, S - Apparent, Q- Reactive, D - Distorting	Measuring range	see V rms and A rms measurement
		Power errors are calculated by adding the errors of voltage and current
		Additional error due to power factor PF
		Specified error x (1-[PF])
		Maximum range with voltage range 830 V delta-connection and 3000 A current range is 2.490 MW, higher displayed values possible when using PTs and CTs with ratio feature
	Intrinsic error	±(0.7% of m.v. +15 digit)
	Resolution	1 kW
	Operating error	±(1.5% of m.v. + 20 digit)
		Typical range with voltage range 230 V wye connection and 150 A current range is 34.50 KW.
	Intrinsic error	±(0.7% of m.v. +15 digit)
	Resolution	1 W to 10 W
	Operating error	±(1.5% of m.v. + 20 digit)
		The errors of the current sensors themselves have not been considered.

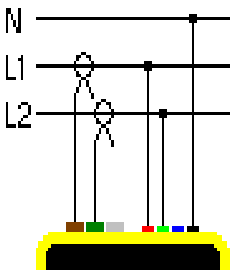
Energy measurement (kWh, KVAh, kVARh)	Intrinsic error	±(0.7% of m.v.+ F variation error* + 15 digit)
	Resolution	1 W to 10 W
	Operating error	±(1.5% of m.v. + F variation error[1] + 20 digit)
		1. Frequency variation error
PF (Power factor)	Range	0.000 to 1.000
	Resolution	0.001
	Accuracy	±1% of full scale
Frequency measurement	Measuring range	46 Hz to 54 Hz and 56 Hz to 64 Hz
	Intrinsic error	±(0.2% of m. v. + 5 digit)
	Operating error	±(0.5% of m. v.+ 10 digit)
	Resolution	0.01 Hz
Harmonics	Measuring range	To 50th harmonic (< 50% of nom)
Accuracy	Vm, Im, THDV, THDI	IEC 61000-4-7:2002, Class II
	Vm ≥ 3% Vn	±5% Vm
	Vm < 3% Vnom	±0.15% Vnom
	Im ≥ 10% Inom	±5% Im
	Im < 10% Inom	±0 5% Inom
	THDV	for THD < 3% ±0.15% at Vnom
		for THD ≥ 3% ±5% at Vnom
	THDI	for THD < 10% ±0.5% at Inom
		for THD ≥ 10% ±5% at Inom
	Vnom	Normal voltage range
	Inom	Nominal current range
		Vm and Im are measured values of harmonic m
Events		Detection of voltage dips, voltage swells and voltage interruptions with a 10 ms resolution and measuring error of the half period sine wave of rms.
	Intrinsic error	±(1% of m.v. + 10 digit)
	Operating error	±(2% of m.v. + 10 digit)
	Resolution	0.1 V

- **Equipment Connection Method**

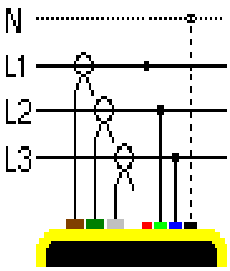




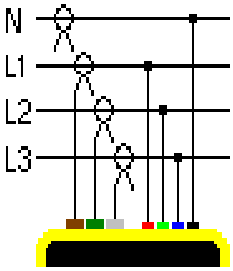
Single-phase



Two-phase



3-wire three-phase



4-wire three-phase

5. TOTAL AVERAGE RECORDINGS

5.1 Total Recordings for Seven Hours Averaged over 2 min

S.No	3Phase Voltage			3Phase Current			Frequency	% Voltage Unbalance	% Current Unbalance	Active Power in kW	Reactive power in kVAr	Power Factor	% Voltage THD	% Voltage THD	% Voltage THD	% Current THD	% Current THD	% Current THD
	L1	L2	L3	L1	L2	L3							V1	V2	V3	I1	I2	I3
1	571.64	673.77	646.50	571.64	673.77	646.50	50.05	0.85%	6.40%	418.63	80.23	0.98	1.2	1.2	1.2	6	5.3	5
2	517.64	639.55	596.86	517.64	639.55	596.86	50.04	0.77%	8.58%	388.09	76.94	0.98	1.2	1.2	1.1	6.5	5.2	5.2
3	524.73	624.82	585.82	524.73	624.82	585.82	50.07	0.78%	7.42%	385.82	70.28	0.98	1.1	1.1	1.1	5.9	4.9	4.7
4	521.32	601.50	566.59	521.32	601.50	566.59	50.06	0.79%	6.38%	375.13	69.71	0.98	1.2	1.1	1.1	6.1	5.2	5.2
5	532.23	605.86	587.86	532.23	605.86	587.86	50.09	0.82%	5.04%	383.55	73.07	0.98	1.1	1.1	1.1	6	5.2	4.9
6	530.73	614.73	618.14	530.73	614.73	618.14	50.12	0.86%	4.90%	391.90	76.31	0.98	1.1	1.1	1	6	5.1	4.7
7	523.91	594.14	580.09	523.91	594.14	580.09	50.11	0.83%	4.73%	377.52	75.80	0.98	1.1	1.1	1.1	5.8	5.2	4.8
8	558.00	603.68	585.14	558.00	603.68	585.14	50.09	0.85%	3.55%	389.46	74.83	0.98	1.1	1.2	1.1	5.7	5.3	4.9
9	546.14	606.41	574.91	546.14	606.41	574.91	50.06	0.80%	5.04%	385.02	73.98	0.98	1.2	1.2	1.1	6.3	5.7	5.6
10	525.14	614.59	567.14	525.14	614.59	567.14	50.06	0.76%	7.43%	379.17	73.70	0.98	1.2	1.2	1.1	6.5	5.6	5.6
11	535.50	630.68	544.09	535.50	630.68	544.09	50.05	0.70%	9.61%	379.62	76.99	0.98	1.1	1.1	1.1	6.2	5.3	5.9
12	520.09	620.18	535.23	520.09	620.18	535.23	50	0.69%	9.95%	371.43	78.24	0.97	1.2	1.2	1.2	6.6	5.5	6.1
13	564.82	644.59	530.46	564.82	644.59	530.46	50	0.66%	10.03%	387.41	75.97	0.98	1.1	1.1	1.1	5.7	5.1	6
14	518.05	604.50	525.96	518.05	604.50	525.96	50.03	0.68%	9.10%	367.51	69.32	0.98	1.1	1.1	1.1	5.9	5	5.5
15	505.36	595.36	535.64	505.36	595.36	535.64	50.03	0.71%	8.38%	365.63	65.45	0.98	1.1	1.1	1	6	5.1	5.3
16	489.14	606.14	513.68	489.14	606.14	513.68	50.01	0.68%	11.52%	358.75	67.95	0.98	1.1	1.1	1.1	6	4.8	5.5
17	502.77	595.36	507.27	502.77	595.36	507.27	50.02	0.70%	10.12%	357.90	68.24	0.98	1.1	1.2	1.1	6.8	5.8	6.5
18	517.91	569.46	500.59	517.91	569.46	500.59	50.03	0.71%	7.05%	354.94	66.64	0.98	1.1	1.2	1.2	6.9	6.5	6.8
19	514.91	555.82	534.00	514.91	555.82	534.00	50.01	0.75%	3.76%	358.92	66.25	0.98	1.1	1.2	1.1	6.3	6.1	5.9

20	514.36	565.50	515.18	514.36	565.50	515.18	50.01	0.72%	5.98%	357.67	62.10	0.98	1.1	1.1	1.1	5.6	5.2	5.5
21	449.05	522.55	472.91	449.05	522.55	472.91	50	0.72%	7.85%	324.58	54.87	0.98	1.1	1.1	1	6.5	5.8	5.9
22	440.73	531.27	468.00	440.73	531.27	468.00	50.01	0.69%	9.65%	323.33	58.29	0.98	1.1	1.1	1	6.9	6	6.2
23	444.14	531.55	462.14	444.14	531.55	462.14	50	0.68%	9.83%	322.36	60.05	0.98	1.1	1.2	1.1	7.7	6.8	7.1
24	438.55	565.91	489.41	438.55	565.91	489.41	49.99	0.69%	12.01%	334.59	63.06	0.98	1.1	1.1	1	7.7	6.1	6.4
25	425.86	561.55	482.05	425.86	561.55	482.05	49.95	0.68%	12.77%	329.35	60.10	0.98	1.1	1.1	1.1	7.2	5.6	5.9
26	403.09	479.18	481.77	403.09	479.18	481.77	49.96	0.76%	5.62%	305.87	58.85	0.98	1	1	0.9	7.4	6.3	5.5
27	381.41	415.77	424.50	381.41	415.77	424.50	49.97	0.74%	4.07%	273.63	53.45	0.98	1.1	1	1	7.2	6.5	5.6
28	355.09	413.46	388.09	355.09	413.46	388.09	49.99	0.67%	6.75%	260.38	44.98	0.98	1	1	1	8.1	6.8	6.4
29	315.96	401.32	376.50	315.96	401.32	376.50	50	0.65%	9.15%	247.58	36.56	0.99	1.1	1	1	9.2	6.9	6.4
30	323.59	404.59	371.59	323.59	404.59	371.59	50.01	0.63%	9.39%	248.32	38.44	0.98	1.1	1	1	9.2	7.1	6.8
31	341.05	424.64	397.36	341.05	424.64	397.36	50.02	0.66%	8.70%	262.08	42.36	0.98	1.1	1.1	1.1	9.7	7.6	7.3
32	349.36	450.14	417.41	349.36	450.14	417.41	50.02	0.64%	9.89%	274.20	45.04	0.98	1.2	1.1	1.1	9.5	7.1	6.9
33	335.46	445.09	402.14	335.46	445.09	402.14	50.04	0.62%	11.43%	266.86	43.16	0.98	1.1	1.1	1	10.1	7.5	7.4
34	335.05	431.59	377.32	335.05	431.59	377.32	50.04	0.57%	11.65%	258.16	40.43	0.98	1.2	1.1	1.1	10.2	7.8	8.1
35	295.91	349.77	321.41	295.91	349.77	321.41	50.05	0.57%	7.84%	217.79	37.30	0.98	1.2	1.1	1.1	10.4	8.5	8.2
36	280.50	337.77	312.68	280.50	337.77	312.68	50.05	0.56%	8.13%	210.34	33.38	0.98	1.2	1	1.1	10.2	8	7.8
37	310.50	368.18	336.14	310.50	368.18	336.14	50.07	0.59%	8.12%	228.88	38.61	0.98	1.1	1	1	9.2	7.5	7.4
38	282.55	345.27	333.27	282.55	345.27	333.27	50.05	0.59%	7.21%	218.13	28.60	0.988	1	1	0.9	8	7.1	6.4
39	241.50	304.77	278.46	241.50	304.77	278.46	50.02	0.55%	9.80%	188.45	19.50	0.994	0.7	0.7	0.6	3.3	3.5	4
40	276.55	328.77	290.46	276.55	328.77	290.46	49.98	0.57%	9.18%	204.31	21.67	0.993	0.7	0.7	0.6	3.2	3.2	4.1
41	272.59	343.50	299.59	272.59	343.50	299.59	49.97	0.56%	11.14%	209.26	20.64	0.993	0.7	0.7	0.7	3.1	3	4
42	267.82	329.59	300.68	267.82	329.59	300.68	49.94	0.53%	9.17%	204.42	24.74	0.992	0.7	0.6	0.6	2.9	2.9	3.8
43	250.77	307.36	282.27	250.77	307.36	282.27	49.95	0.52%	8.86%	190.78	27.64	0.989	0.7	0.7	0.6	3.2	3.1	3.8
44	273.82	324.68	269.46	273.82	324.68	269.46	49.98	0.50%	10.89%	197.83	24.51	0.991	0.7	0.7	0.6	3.1	2.9	3.9
45	296.05	330.96	275.32	296.05	330.96	275.32	49.99	0.51%	9.12%	205.68	24.05	0.992	0.7	0.7	0.7	3	2.8	3.9
46	302.05	338.73	292.09	302.05	338.73	292.09	50.02	0.52%	8.20%	213.18	20.58	0.994	0.7	0.6	0.7	3	2.7	3.9
47	307.09	329.86	301.23	307.09	329.86	301.23	50.02	0.54%	5.20%	213.47	28.32	0.991	0.7	0.6	0.6	3	2.8	3.7
48	296.46	336.27	310.91	296.46	336.27	310.91	50.01	0.53%	6.46%	214.89	25.42	0.992	0.6	0.6	0.6	3	2.8	3.6
49	288.96	351.82	317.86	288.96	351.82	317.86	49.97	0.54%	9.17%	218.07	26.27	0.992	0.6	0.6	0.6	3	2.7	3.5

50	284.86	331.64	307.91	284.86	331.64	307.91	49.96	0.54%	7.09%	208.80	36.22	0.984	0.7	0.6	0.6	3	2.8	3.3
51	312.27	329.18	300.68	312.27	329.18	300.68	50.02	0.57%	4.60%	213.01	38.78	0.983	0.6	0.6	0.6	2.8	3	3.4
52	426.00	456.82	415.50	426.00	456.82	415.50	50.05	0.58%	5.26%	290.97	63.40	0.975	1	1	1	6.1	6	5.9
53	528.68	554.86	516.14	528.68	554.86	516.14	50.03	0.67%	3.90%	356.02	84.44	0.97	1.2	1.2	1.1	6.3	6.2	6.1
54	549.68	598.09	574.36	549.68	598.09	574.36	50	0.71%	4.02%	386.16	79.61	0.977	1.1	1.1	1.1	5.9	5.5	5.4
55	574.91	630.27	589.64	574.91	630.27	589.64	50.01	0.74%	5.08%	403.90	75.23	0.98	1.1	1.1	1.1	5.6	5.1	5.3
56	580.23	606.68	562.50	580.23	606.68	562.50	49.98	0.71%	3.88%	393.95	73.01	0.981	1.1	1.1	1.1	5.5	5.4	5.7
57	551.32	602.18	524.32	551.32	602.18	524.32	49.97	0.66%	7.13%	378.88	67.84	0.982	1.1	1	1	5.2	4.8	5.4
58	516.27	594.96	554.05	516.27	594.96	554.05	49.96	0.70%	6.70%	375.75	71.42	0.98	1	1	1	5.6	4.9	5.1
59	523.23	583.77	563.46	523.23	583.77	563.46	49.97	0.74%	4.62%	378.26	66.81	0.982	1.1	1	1	5.4	4.9	4.8

6.Annexure

1. **EXTRACTS FROM IEEE 519-1992**
2. **CEA Regulations- Extracts**

   i. Technical Standards for Connectivity to the Grid
   ii. Central Electricity Authority (Grid Standards) Regulations 2010 [New]

1. EXTRACTS FROM IEEE 519-1992

Voltage Distortion Limits.

The recommended voltage distortion limits (see Table 11.1) are concerned with the follow indices:

THD: Table (RSS) Harmonic voltage distortion in percent of nominal fundamental frequency voltage.

The limits listed in Table 11.1 should be used as system design values for the "worst case" for normal operation (conditions lasting longer than one hour). For shorter periods, during start-ups or unusual conditions, the limits may be exceeded by 50%.

Voltage Distortion Limits

Bus voltage at PCC	Individual voltage Distortion (%)	Total voltage Distortion THD (%)
69 kV and below	3.0	5.0
69.001kV through 161kV	1.5	2.5
161.001 kV and above	1.0	1.5

Note: High-voltage systems can have up to 2.0% THD where the cause is an HVDC terminal that will attenuate by the time it is tapped for a user.

CURRENT DISTORTION LIMITS FOR GENERAL DISTRIBUTION SYSTEMS (120V THROUGH 69 000V)

Maximum Harmonic Current Distortion in Percent of I_1						
Individual Harmonic Order /odd Harmonics/						
I_{sc}/I_L	<11	11≤h<17	17≤h<23	23≤h<35	35≤h	TDD
<20	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

Current Distortion Limits for General Sub transmission Systems (69 001 V through 161 000 V)

Maximum Harmonic Current Distortion in Percent of I_L						
Individual Harmonic Order (odd Harmonics)						
I_{sc}/I_L	<11	11≤h<17	17≤h<23	23≤h<35	35≤h	TDD
<20	2.0	1.0	0.75	0.3	0.15	2.5
20<50	3.5	1.75	1.25	0.5	0.25	4.0
50<100	5.0	2.25	2.0	0.75	0.35	6.0
100<1000	6.0	2.75	2.5	1.0	0.5	7.5
>1000	7.5	3.5	3.0	1.25	0.7	10.0

Even harmonics are limited to 25% of the odd harmonic limits above.

Current distortions that result in a de offset, e.g., half-wave converters, are not allowed.

*All power generation equipment is limited to these values of current distortion, regardless of action I_{sc} / I_L

Where

I_{sc} = maximum short-circuit current at PCC. I_L = maximum demand load current (fundamental frequency component) at PCC.

These limits are recommended for low-voltage systems in which the notch area is easily measured on an oscilloscope. It should be noted that the total voltage distortion factor is related to the total notch area, A_N, by the equality given in Eq 8.20.

Fig 10.1 defines notch depth and area.

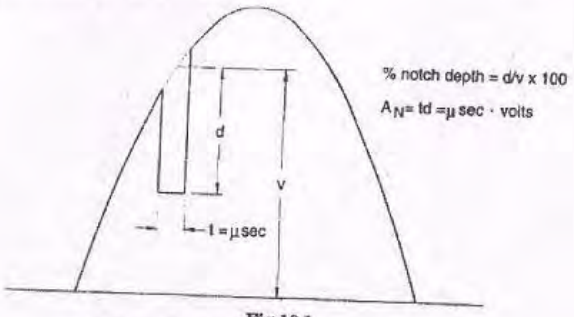


Fig 10.1
Definition of Notch Depth and Notch Area

10.4 **Current Distortion Limits.** Ideally, the harmonic distortion caused by a single consumer should be limited to an acceptable level at *any* point in the system; and the entire system should be operated without substantial harmonic distortion anywhere in the system. The harmonic distortion limits recommended here establish the maximum allowable current distortion for a consumer. The recommended current distortion limits are concerned with the following indice:

TDD: Total demand distortion (RSS), harmonic current distortion in % of maximum demand load current (15 or 30 min demand)

The limits listed in Tables 10.3, 10.4, and 10.5 should be used as system design values for the "worst case" for normal operation (conditions lasting longer than one hour). For shorter periods, during start-ups or unusual conditions, the limits may be exceeded by 50%.

These tables are applicable to six-pulse rectifiers and general distortion situations. However, when phase shift transformers or converters with pulse numbers (q) higher than six are used, the limits for the characteristic harmonic orders are increased by a factor equal to

$$\sqrt{\frac{q}{6}}$$

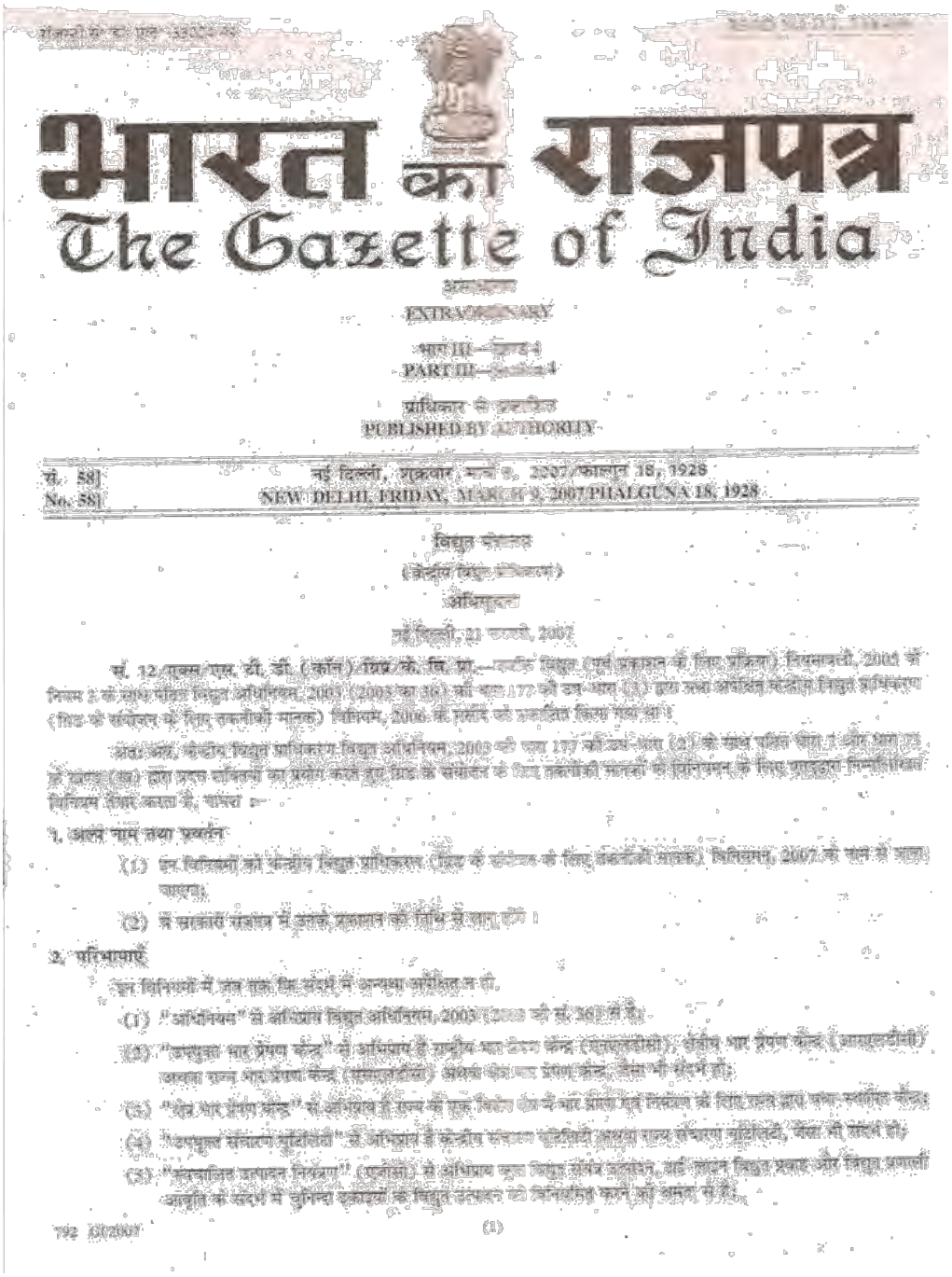
provided that the amplitudes of the noncharacteristic harmonic orders are less than 25% of the limits specified in the tables. See 13.1 for an example.

Table 10.3 lists the harmonic current limits based on the size of the load with respect to the size of the power system to which the load is connected. The ratio I_{sc}/I_L is the ratio of the short-circuit current available at the point of common coupling (PCC), to the maximum fundamental load current. It is recommended that the load current, I_L, be calculated as the average current of the maximum demand for the preceding 12 months. Thus, as the size of the user load decreases with respect to the size of the system, the percentage of harmonic current that the user is allowed to inject into the utility system increases. This protects other users on the same feeder as well as the utility, which is required to furnish a certain quality of voltage to its customers.

All generation, whether connected to the distribution, subtransmission, or transmission system, is treated like utility distribution and is therefore held to these recommended practices.

2. Extracts from CEA regulations

i. Technical Standards for Connectivity to the Grid



भारत का राजपत्र
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EXTRAORDINARY

PART III—

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विद्युत मंत्रालय

(केन्द्रीय विद्युत विनियामक आयोग)

अधिसूचना

नई दिल्ली, 21 फरवरी, 2007

सं. 12/सदस्य/एस. टी. डी. (कॉन)/सेंट्रेक/के. वि. प्रा.—केन्द्रीय विद्युत (पूर्व प्रकाशन के लिए प्रक्रिया) विनियमावली, 2005 के विनियम 2 के साथ पठित विद्युत अधिनियम, 2003 (2003 का 36) की धारा 177 की उप-धारा (1) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए केन्द्रीय विद्युत प्राधिकरण (ग्रिड के संचालन के लिए तकनीकी मानक) विनियम, 2006 के प्रतिस्थापन के प्रस्तावित किए गए थे ;

और, केन्द्रीय विद्युत प्राधिकरण विद्युत अधिनियम, 2003 की धारा 177 की उप-धारा (2) के खंड (क) के साथ पठित धारा 1 और धारा 178 के खण्ड (ख) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए ग्रिड के संचालन के लिए तकनीकी मानकों के विनियमन के लिए प्राधिकरण निम्नलिखित विनियम बनाना चाहता है, अर्थात :—

1. अल्प नाम तथा प्रवर्तन

(1) इन विनियमों को केन्द्रीय विद्युत प्राधिकरण (ग्रिड के संचालन के लिए तकनीकी मानक) विनियमन, 2007 के नाम से जाना जाएगा।

(2) ये सरकारी राजपत्र में उनके प्रकाशन की तिथि से लागू होंगे।

2. परिभाषाएं

इन विनियमों में जब तक कि संदर्भ में अन्यथा अपेक्षित न हो,

(1) "अधिनियम" से अभिप्राय विद्युत अधिनियम, 2003 (2003 की सं. 36) से है;

(2) "उपयुक्त भार प्रेषण केन्द्र" से अभिप्राय है राष्ट्रीय भार प्रेषण केन्द्र (एनएलडीसी), क्षेत्रीय भार प्रेषण केन्द्र (आरएलडीसी) अथवा राज्य भार प्रेषण केन्द्र (एसएलडीसी) अथवा पैरा भार प्रेषण केन्द्र, जैसा भी संदर्भ हो;

(3) "क्षेत्र भार प्रेषण केन्द्र" से अभिप्राय है राज्य या राज्य जिनके एक से अधिक भार प्रेषण केन्द्र नियंत्रण के लिए राज्य द्वारा पाया स्थापित किए गए हैं;

(4) "उपयुक्त संचारण यूटिलिटी" से अभिप्राय है केन्द्रीय संचारण यूटिलिटी अथवा राज्य संचारण यूटिलिटी, जैसा भी संदर्भ हो;

(5) "स्वचालित उत्पादन नियंत्रण" (एजीसी) से अभिप्राय कुल विद्युत संतुलन उपकरण, आवृत्ति लाइन विद्युत प्रवाह और विद्युत प्रणाली आवृत्ति के संदर्भ में चुनिन्दा स्टेशनों के विद्युत उत्पादन को विनियमित करने की क्षमता से है;

792 GI/2007 (1)

Part-II
Gird connectivity standards applicable to the generating Units

(2) The Short-Circuit Ratio (SCR) for generators shall be as per IEC-34.

(3) The generator transformer windings shall have delta connection on low voltage side and star connection on high voltage side. Star point of high voltage side shall be effectively (solidly) earthed so as to achieve the Earth Fault Factor of 1.4 or less.

(4) All generating machines irrespective of capacity shall have electronically controlled governing system with appropriate speed/load characteristics to regulate frequency. The governors of thermal generating units shall have a droop of 3 to 6% and those of hydro generating units 0 to 10%.

(5) The project of the requester shall not cause voltage and current harmonics on the grid which exceed the limits specified in Institute of Electrical and Electronics Engineers (IEEE) Standard 519.

(6) Generating Units located near load centre, shall be capable of operating at rated output for power factor varying between 0.85 lagging (over-excited) to 0.95 leading (under-excited) and Generating Units located far from load centres shall be capable of operating at rated output for power factor varying between 0.9 lagging (over-excited) to 0.95 leading (under-excited). The above performance shall also be achieved with voltage variation of ± 5% of nominal, frequency variation of +3% and –5% and combined voltage and frequency variation of ±5%. However, for gas turbines, the above performance shall be achieved for voltage variation of ±5%.

(7) The coal and lignite based thermal generating units shall be capable of generating up to 105% of Maximum Continuous Rating (subject to maximum load capability under Valve Wide Open Condition) for short duration to provide the frequency response.

(8) The hydro generating units shall be capable of generating up to 110% of rated capacity (subject to rated head being available) on continuous basis.

(9) Every generating unit shall have standard protections to protect the units not only from faults within the units and within the station but also from faults in transmission lines. For generating units having rated capacity greater than 100 MW, two independent sets of protections acting on two independent sets of trip coils fed from independent Direct Current (DC) supplies shall be provided. The protections shall include but not be limited to the Local Breaker Back-up (LBB) protection.

(10) Hydro generating units having rated capacity of 50 MW and above shall be capable of operation in synchronous condenser mode, wherever feasible.

(11) Bus bar protection shall be provided at the switchyard of all generating station.

(12) Automatic synchronisation facilities shall be provided in the requester's Project.

(13) The station auxiliary power requirement, including voltage and reactive requirements, shall not impose operating restrictions on the grid beyond those specified in the Grid Code or state Grid Code as the case may be.

(14) In case of hydro generating units, self-starting facility may be provided. The hydro generating station may also have a small diesel generator for meeting the station auxiliary requirements for black start.

(15) The standards in respect of the sub-stations associated with the generating stations shall be in accordance with the provisions specified in respect of 'Sub-stations' under Part III of these Standards.

2. Existing Units

For thermal generating units having rated capacity of 200 MW and above and hydro units having rated capacity of 100 MW and above, the following facilities would be provided at the time of renovation and modernization.

(1) Every generating unit shall have Automatic Voltage Regulator. Generators having rated capacity of 100 MW and above shall have Automatic Voltage Regulator with two separate channels having independent inputs and automatic changeover.

(2) Every generating unit of capacity having rated capacity higher than 100MW shall have Power System Stabilizer.

(3) All generating units shall have standard protections to protect the units not only from faults within the units and within the station but also from faults in transmission lines. The protections shall include but not limited to the Local Breaker Back-up (LBB) protection.

Part III
Grid Connectivity Standards applicable to the Transmission Line and Sub-Station

The transmission lines and sub-stations connected to the grid shall comply with the following additional requirements besides the general connectivity conditions under these regulations and General Standards for Connectivity to the Grid as specified in Part I of the Schedule.

(1) Bus bar protection shall be provided on all sub-stations at and above 220 kV levels for all new sub-stations. For existing sub-stations, this shall be implemented in a reasonable time frame.

(2) Local Breaker Back-up (LBB) protection shall be provided for all sub-stations of 220kV and above.

(3) Two main numerical Distance Protection Schemes shall be provided on all the transmission lines of 220 kV and above for all new sub-stations. For existing sub-stations, this shall be implemented in a reasonable time frame.

(4) Circuit breakers, isolators and all other current carrying equipment shall be capable of carrying normal and emergency load currents without damage. The equipment shall not become a limiting factor on the ability of transfer of power on the inter-state and intra-state transmission system.

(5) All circuit breakers and other fault interrupting devices shall be capable of safely interrupting fault currents for any fault that they are required to interrupt. The Circuit Breaker shall have this capability without the use of intentional time delay in clearing the fault. Minimum fault interrupting requirement need be specified by the Appropriate Transmission Utility. The Circuit Breaker shall be capable of performing all other required switching duties such as, but not limited to, capacitive current switching, load current switching and out-of-step switching. The Circuit Breaker shall perform all required duties without creating transient over-voltages that could damage the equipment provided elsewhere in the grid. The short circuit capacity of the circuit breaker shall be based on short-term and perspective transmission plans as finalized by the Authority.

(6) Power Supply to Sub-Station Auxiliaries, shall:

(a) for alternating current (AC) supply (Applicable to new sub-stations) :

220 kV and above: Two high tension (HT) supplies shall be arranged from independent sources. One of the two high tension supplies shall be standby to the other. In addition, an emergency supply from diesel generating (DG) source of suitable capacity shall also be provided.

66 kV and below 220 kV: There shall be one HT supply and one diesel generating source.

33 kV and below 66 kV: There shall be one HT supply.

(b) *for direct current (DC) Supply (Applicable to new sub-stations):* Sub-stations of transmission system *for 132 kV and above and sub-stations of all generating stations:* There shall be two sets of batteries, each equipped with its own charger.

For sub-stations below 132 kV: there shall be one set of battery and charger.

(7) Earth Fault Factor for an effectively earthed system shall be not more than 1.4.

Part IV

Grid Connectivity Standards applicable to the Distribution Systems and Bulk Consumers

The following additional requirements shall be complied with, besides the connectivity conditions in these regulations and general Standards for Connectivity to the Grid given in Part-I and those applicable to transmission lines and sub-stations in Part -III.

1. Under Frequency/df/dt Relays

Under frequency and df/dt (rate of change of frequency with time) relays shall be employed for automatic load control in a contingency to ensure grid security under conditions of falling grid frequency in accordance with the decision taken in the Regional Power Committee.

2. Reactive Power

The distribution licensees shall provide adequate reactive compensation to compensate the inductive reactive power requirement in their system so that they do not depend upon the grid for reactive power support. The power factor of the distribution system and bulk consumer shall not be less than 0.95.

3. Voltage and Current Harmonics

(1) The total harmonic distortion for voltage at the connection point shall not exceed 5% with no individual harmonic higher than 3%.

(2) The total harmonic distortion for current drawn from the transmission system at the connection point shall not exceed 8%.

(3) The limits prescribed in (1) and (2) shall be implemented in a phased manner so as to achieve complete compliance not later than five years from the date of publication of these regulations in the official Gazette.

4. Voltage Unbalance

The Voltage Unbalance at 33 kV and above shall not exceed 3.0%.

5. Voltage Fluctuations

(1) The permissible limit of voltage fluctuation for step changes which may occur repetitively is 1.5%.

(2) For occasional fluctuations other than step changes the maximum permissible limit is 3%.

(3) The limits prescribed in (1) and (2) above shall come into force not later than five years from the date of publication of these regulations in the Official Gazette.

6. Back-energization

The consumer shall not energize transmission or distribution system by injecting supply from his generators or any other source either by automatic controls or manually unless specifically requested by the Transmission or Distribution Licensee.

BIJOY KUMAR MISRA, Secy.

[ADVT-III/IV/Exty/187G/06]

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ii. Central Electricity Authority (Grid Standards) Regulations 2010 [New]

Table 5

S.No.	System Voltage (kV rms)	Total Harmonic Distortion (%)	Individual Harmonic of any Particular Frequency (%)
1	765	1.5	1.0
2	400	2.0	1.5
3	220	2.5	2.0
4	33 to 132	5.0	3.0

Provided that the standard on Harmonic Distortion shall come into force concurrently with clause 3 of Part IV of the Schedule to the Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007.

Explanation: For the purpose of this regulation, Total Harmonic Distortion (V_{THD}) expressed as percentage, shall be calculated as under,-

$$V_{THD} = \sqrt{\sum_{n=2}^{n=40} \frac{V_n^2}{V_1^2}} X 100$$

'1' refers to fundamental frequency (50 Hz)

'n' refers to the harmonic of n^{th} order (corresponding frequency is 50 x n Hz)

Operation Planning - The Regional Power Committee shall periodically review the performance of the grid for the past period and plan stable operation of the grid for the future, considering various parameters and occurrences such as frequency profile, voltage profile, line loading, grid incident, grid disturbance, performance of system protection schemes and protection coordination.

7. TOTAL POWER REQUIERMENT OF VARIOUS EQUIPMENT

Department/Infrastructure	Computer	Energy usage of LED Light	Energy usage of CFL	Energy usage of TUBE Light	Energy usage of FAN	Energy usage of AC	Refrigerator/ sterilizer/hot air oven/ refrigerator	Photocopier	Television	NVR / Camera	Other equipment
Full college/ Admin/ Hostel / other- Unit in numbers	334	2499	304	2383	1913	462	8	22	5	12	28
POWER CONSUMPTION(KWh) in units per annum	**6797546**	**134042.4**	**4471.6**	**258000**	**3783732**	**657043.2**	**214780.8**	**5368.6**	**1242**	**5457.6**	**8885.8**

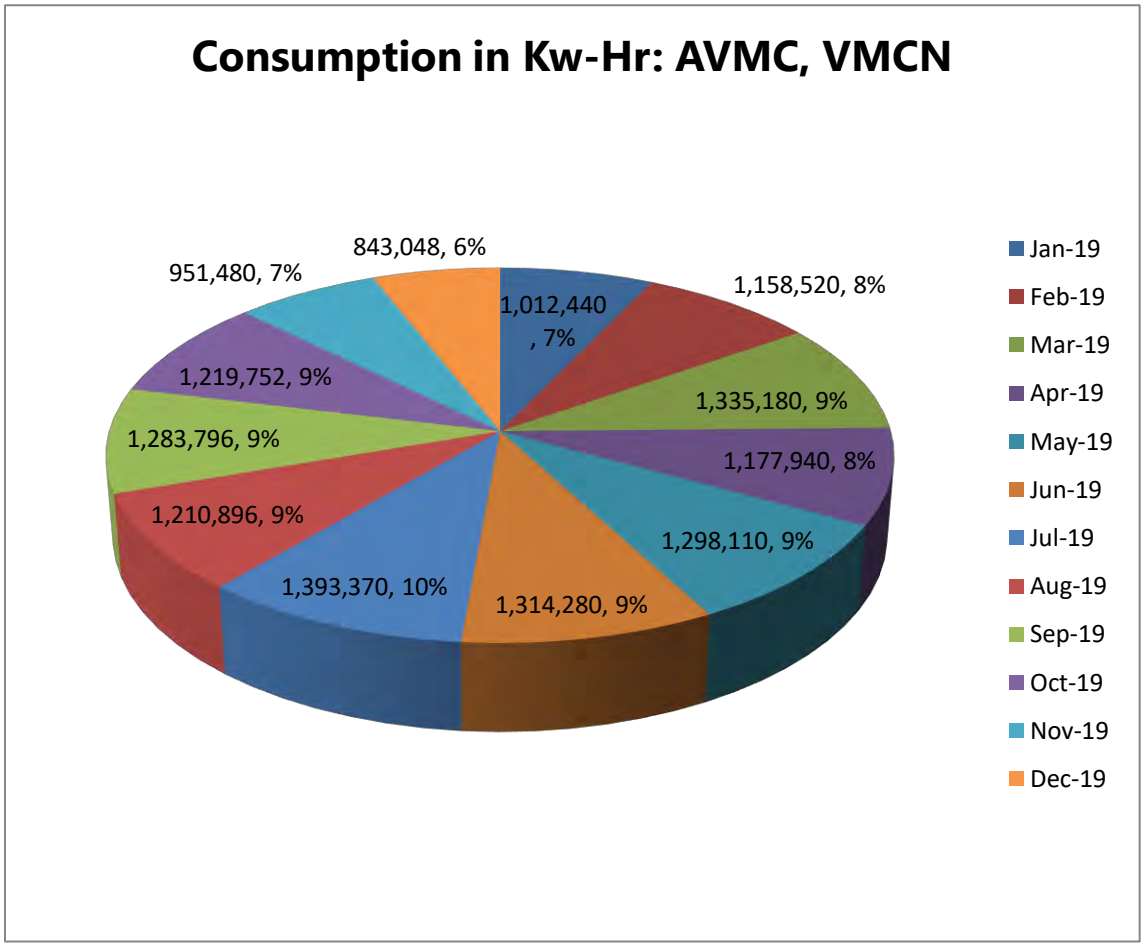
Electrical Power conserved through renewable energy sources

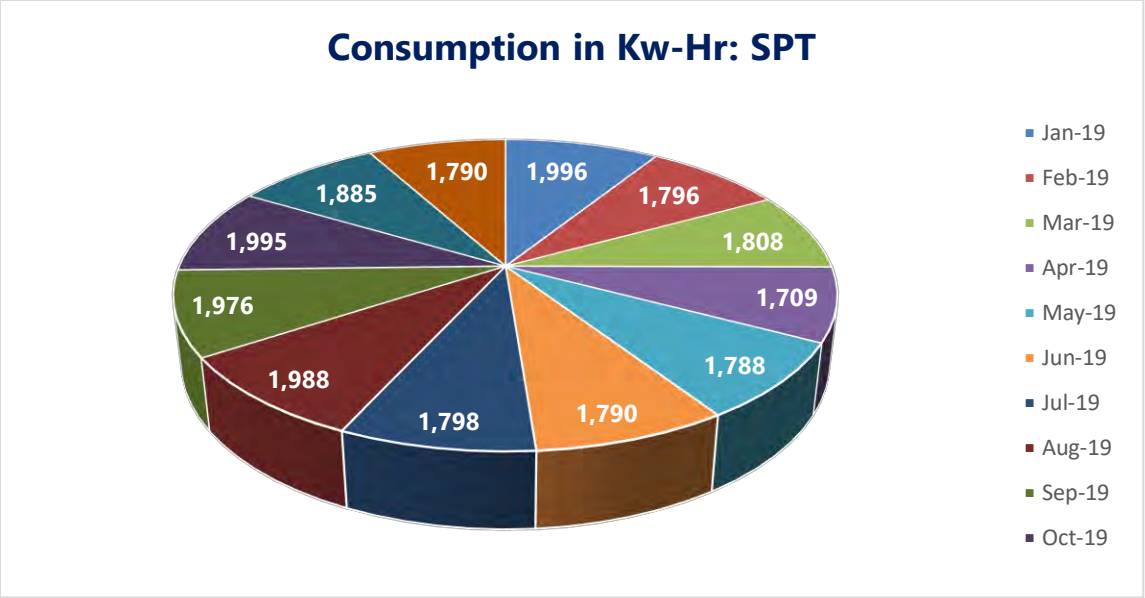
Type of renewable energy sources	Renewable energy source	Energy Conserved Per Year Considering 250 Days
Bio energy	-	-
Solar Energy	10.6 kw/solar water panel	654000 Watts
Wind Energy	-	-
Tidal Energy	-	-

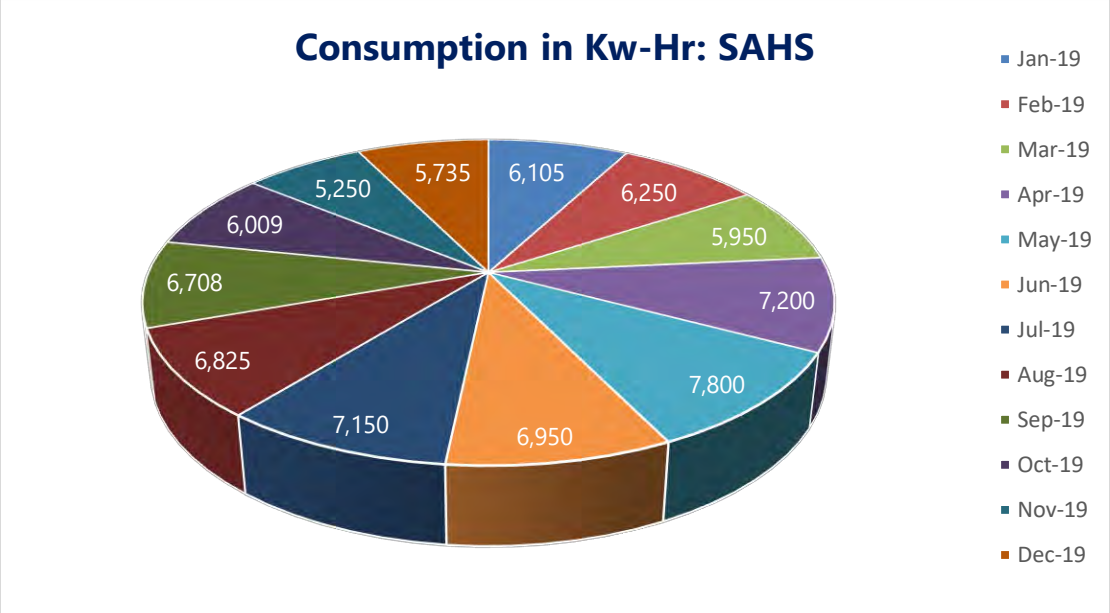
POWER CONSUMPITON OF EB- KW-hr

MONTH	AVMC, VMCN	SAHS	SPT
Jan-19	10,12,440	6,105	1,996
Feb-19	11,58,520	6,250	1,796
Mar-19	13,35,180	5,950	1,808
Apr-19	11,77,940	7,200	1,709
May-19	12,98,110	7,800	1,788
Jun-19	13,14,280	6,950	1,790
Jul-19	13,93,370	7,150	1,798
Aug-19	12,10,896	6,825	1,988
Sep-19	12,83,796	6,708	1,976
Oct-19	12,19,752	6,009	1,995
Nov-19	9,51,480	5,250	1,885
Dec-19	8,43,048	5,735	1,790

Total Power Consumption in Yearly in Kw-hr	**14198812**	**77,932**	**22,319**
Average power consumption in kW-hr	**1183234**	**11989**	**3433.7**







"The institution uses energy efficient lights of 2499 numbers, which consumed only 20 percentage of power compared to normal lights and fans. So savings is attained almost 80 percentages."

8. RECOMMENDATION/CONCLUSION

- Non inverter Air conditioners can be replaced by inverter based 5 Star rating for Eco friendly, Power consumption, Energy Savings, Sound, Longer life and fast cooling/heating.
- Library /Auditorium can have their own roof top panels to generate their power to meet their demand.
- Proximity/ Motion sensor can be introduced in the rest room and storage room.
- Small windmills can be established for pumping water at the bore well places.
- The HT Consumer VMMC has different Percentage current THD in each phase and it varies between 2.07 % to 10.4% , which is high as per CEA. To reduce, distribute the load equally in all phases and add Harmonic filters in the corresponding phases to reduce the Percentage current THD values Less than 8% .

Positive points:

Some of the positive points mentioned here which is already in practice, and shall recommend following the same.

- From the total average recordings, the power factor is maintained above 0.9 for different load conditions
- The Tungsten lights have been replaced with compact fluorescent lights/LED which conserves energy.
- During the day, lights are switched off to make use of daylight.
- All air conditioners are with local control and are used only when necessary. They are set to a comfortable 25 degrees.
- The use of renewable energy is highly recommended to sustain the same.