1. INTRODUCTION

BACKGROUND & MOTIVATION

In every country, there are opportunities for more efficient energy management of the government's own facilities and operations. Improving efficiency at all levels of government can result in lower energy costs to public agencies, reduced demand on capacity-constrained electric utility systems, increased energy system reliability, and reduced emissions of greenhouse gases and local air pollutants. In addition, the government sector's buying power and visible leadership offer a powerful, non-regulatory means to stimulate market demand for energy-efficient products and services. Increased buyer demand for these products and services can trigger a positive response from domestic suppliers, encouraging them to introduce more energy-efficient products at competitive prices once the public sector has helped establish a reliable entry market.

Despite these benefits of government sector leadership in energy efficiency, many countries—particularly developing and transition economies—have only recently begun to focus on energy efficiency policies in this sector. Institutional barriers that historically have constrained public sector energy-efficiency efforts include a lack of awareness and technical expertise, bias toward buying lowest-first-cost products, budget constraints and disincentives, periodic changes of leadership, and competing policy priorities.

THE PROJECT

The project is to undertake Energy Audit of Assam Secretariat Building Complex, Dispur, Assam.

The basic objective of the Energy Audit was to study the operations/performance of both Electrical and Thermal energy intensive equipments/ systems for identification of potential areas wherein energy savings are practically feasible.

BUILDING PROFILE

The building complex is utilized as office of various ministries of Government of Assam including the Chief Minister of Assam along with different secretaries and their departmental staffs. The complex has total eleven numbers of buildings, of that four numbers are of five storied two numbers are four storied. In the middle CM block is there and by the side of it to numbers utility blocks G and H are built. Two ancillary blocks were built to house bank and security office. The complex is newly built, some portion is yet to be completed, and aesthetically designed with ample space and green lawns and plants at various places. The complex maintenance work is being looked after by Sri Sarat Kalita, Exe. Engineer, Sri Pradip Deka, Asst. Exe. Engineer, Sri Ingti, Jr. Engineer of PWD, Guwahati and other staffs.

The main sources of Energy being used are Electrical Power from M/s. ASEB Limited and HSD for DG set.

No electricity bill is generated for power consumption of the building complex. As per received in formation, a portion is kept aside in the budget for its electricity consumption.

PREVAILING RATES OF VARIOUS ENERGY SOURCES

- ❖ Purchased Power = Not available
- ❖ HSD = Rs.33.0/ Litre

TARIFF STRUCTURE

Charges on Billing Demand	Not available
Energy Charges	Not available
Contract Demand	No contract
Penalty on P.F. (below 0.85)	Not Measured
Billing Demand	Not available

SCOPE OF WORK

The study was aimed at identifying the potential for reduction of energy consumption in the following areas:

- **Electrical Distribution System**: Study and analysis of contract demand, power factor, performance of transformers, and suggestions to improve performance.
- **Illumination System**: Study of the lighting systems and measures for improvements wherever feasible.
- **Air Conditioning Systems**: Study and analysis of TR requirement, opportunity to reduce loss and need of air conditioning.
- **Motive Load**: The operations of Electric Motors/Pumps were studied to assess the Loading Pattern, Power Factor and other operational parameters.
- **DG set**: In addition to above, the study also covered the performance of DG set, to suggest measures for Energy Efficiency Improvements.

METHODOLOGY

The Methodology adopted for achieving the desired objectives viz: Assessment of the Current operational status and Energy savings included the following:

- Discussions at site with the concerned officials for **identification of major areas of focus** and other related systems;
- A team of engineers visited the institute and had discussions with the concerned officials/supervisors to collect data/ information on the operations and Load Distribution. The data was analyzed to arrive at a **base line** energy consumption pattern.
- **Measurements and monitoring** with the help of appropriate instruments including continuous and/ or time-lapse recording, as appropriate and visual observations were made to identify the energy usage pattern and losses in the system.
- Computation and **in-depth analysis** of the collected data, including

utilization of computerized analysis and other techniques as appropriate to draw inferences and to **evolve suitable energy conservation plans** for improvements/ reduction in specific energy consumption.

PARTICIPATION

Head and all other the working group members of Administrative Staff Training College, Khanapara co-ordinated and helped the Energy Audit Team during the site visits, these include amongst others the following:

- Sri Chisty, Administrative Officer
- Sri Pradip Deka, Asst Exe. Engineer

A team of PCRA engineers comprising of the following officials were involved in conducting the study.

- Sh. K.L. Bhutia, Deputy Director & SRO Guwahati
- Sh. S. Roychoudhury, Jt. Director
- Sh. Rabindranath Mandal, Jt. Director
- Sh. Amitava Chakraborty, Jt. Director

2. STUDY OF ELECTRICAL DISTRIBUTION SYSTEM

Assam Secretariat is importing power from Assam State Electricity Board through an 11.0 KV supply. The supply voltage is being stepped down to 433 volt by four numbers of 1000 KVA transformers.

ANALYSIS OF DEMAND

Monthly electricity bill

There is no electricity bill is generated for the building complex. Therefore, no measurement and accounting of the consumed power is carried out. This sort of practice is entirely against the philosophy of energy management / conservation. Unless we measure we can not control or conserve anything.

Observations

1) As there is no bill there is no observation on maximum demand, contract demand, power factor etc.

TRANSFORMER OPERATIONS

There are four numbers of transformers are installed and operated for the building complex. Two of them are installed in block-G another two are in block-H. Tap changing is carried out in summer season as the supply voltage some times comes down to 9.5 KVA in place of 11 KVA.

The ratings/ specifications of three nos. transformers are given below:

Transformer Details

Description	**Details**
Nos of Transformers	4
Located at	2 in Block G, 2 in Block H
Make	Kirloskar
Capacity	1000 KVA, each
HV	11000 Volt
LV	433 Volt
HV	49.99 Amp
LV	1333.37 Amp
Impedance Volts	5%
Total Wt.	3400 Kg
Oil Wt.	
Year Of Manufacture	2004 & 2005

Transformers are extremely efficient devices; however, since the entire power consumption of the building complex is through the transformers, some loss does take place. These losses are difficult to measure under site conditions as its magnitude in relation to the actual power consumption of the complex is very small.

Site testing of transformers is not possible without isolation of the transformers.

$$Transformer\ efficiency = \frac{kW}{kW + No\ load\ Losses + (\%loading)^2 \times Load\ losses}$$

Observations & Comments

Distribution transformers generally have full load efficiency around 98.5%. At lower loading levels, the efficiency increases, peaks at a value around 99.1% to 99.5% at about 50% kVA loading and then falls to around 98% to 98.5% at lower loading levels. If the transformer loading is very low i.e. below 10%, the efficiency deteriorates as then the fixed iron losses become the predominant loss.

Higher power factor at the load end helps reduce the current and the resistive losses in electrical distribution and generators.

Power measurements at Transformer down stream:

Transformer	Feeder to	Supply type	Vr	Vt	Vy	Ir	It	Iy	KWt	KW y	PFt	PFy
North, Block - G	Block - A	Normal	442	445	445	53	51	43	38.7	35.5	0.97	0.97
	Anci - II	Normal	442	445	445	18.5	10.6	20.6	10.3	14.5	0.95	1
	Block - A Main gate	Normal	444	444	443	4.25	7.83	3.85	4.5	3.11	0.98	1
	Block - C	Normal	440	443	443	14.7	15.3	13.5	11.4	10.5	0.99	0.98
	Block - A	Emergency	441	440	439	26.2	50	50	14.15	7.6	0.49	0.21
	Block - C	Emergency	440	439	438	44.7	46.3	43.9	32.8	32	0.975	0.96
South, Block - G	Block - B	Normal	440	440	439	23.2	19.9	21.05	15.3	15.1	1	0.97
	Block - G	Normal	442	442	442	3.99	0	2.8	1.47	2.41	0.97	0.92
	Block - CM	Normal	442	442	443	24.9	29	22.14	20.13	17.28	0.97	0.94
	Block -	Emergency	426	425	425	45.3	55.8	44.6	33.6	30.4	0.98	0.95

	CM											
	Block - B	Emergency	429	426	424	18.4	27.1	21.6	16.6	14.6	0.99	0.98
North, Block - H	Block - E	Normal	434	434	435	9.13	10.5	8.5	7.23	6.24	0.97	0.94
	Block - F	Normal	438	438	436	35.5	35.7	27	27.7	21.5	0.94	0.93
	Block - E	Emergency	437	437	437	15.23	23.4	20.4	14.4	12.8	0.98	0.96
	Block - F	Emergency	438	438	438	27.5	27.6	32.8	23.7	22	0.94	0.94
	Block - D	Emergency	439	439	439	21.34	24.2	16.5	16.7	8.3	0.97	0.54
South, Block - H	Block - H	Emergency	441	440	440	3.2	1.95	2.9	1.58	1.9	0.98	0.96
	Block - D	Normal	439	439	439	21.7	26.5	22.5	17.6	15.9	0.96	0.95
	Anci - I		N	O		L	O	A	D			
	Block - H	Normal	439	438	439	14.23	1.08	6.05	5.8	5.37	1	0.7

TECHNIQUES FOR IMPROVING EFFICIENCY OF EXISTING TRANSFORMERS

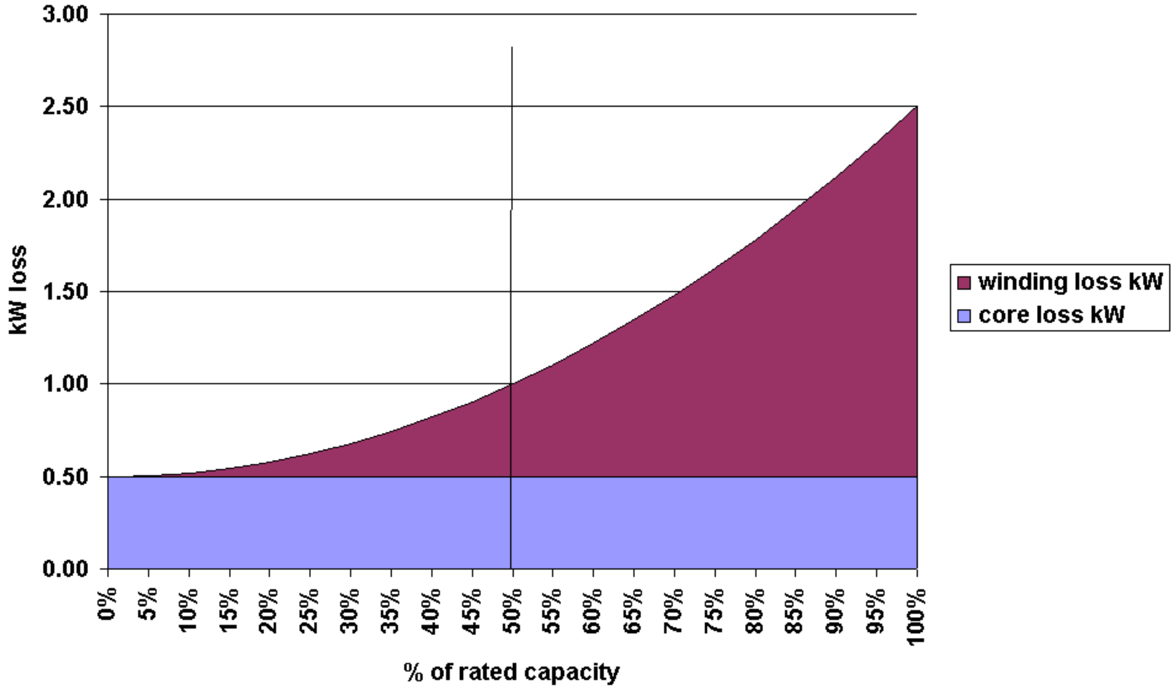
Reduction of Transformer Losses by Power Factor Improvement

Transformer load losses vary as square of the current. If the power factor is poor, for the same kW load, the current is higher leading to higher losses in transformers and cables; the transformers also reach their limits for kVA loading with smaller kW loads when the power factor is poor. If the power factor is maintained at unity the saving in load losses =

(Per unit loading as per kW)^2 x Load losses at full load x [(1/PF)^2 – 1]

At Assam Secretariat the power factor was measured as 0.96 and above except one feeder i.e. block–A emergency feeder which was 0.49 and 0.21. This can be checked and rectified accordingly.

Operation of Transformer close to 50% loading



The peak efficiency of distribution transformers generally occurs near 50% to 60% loading when the fixed losses (iron losses) are equal to the variable (copper losses). Academically speaking, efficiency can be improved by loading some of the transformers to about 50% level, wherever the electrical distribution system permits the same. However, since the electrical distribution of the institute is built on the concept of reliability and zero forced downtime, it is not advisable to attempt any such relocation of loads for the achieving the relatively minor energy savings.

Transformer Loading based on field measurement:

Transformer	KWt	KW y	PFt	PF y	KVA	KVA total	Transformer Loading (%)
North, Block - G	38.7	35.5	0.97	0.97	38.25	131.91	13.19
	10.3	14.5	0.95	1	12.67		
	4.5	3.11	0.98	1	3.85		
	11.4	10.5	0.99	0.98	11.11		
	14.15	7.6	0.49	0.21	32.53		
	32.8	32	0.975	0.96	33.49		
South, Block - G	15.3	15.1	1	0.97	15.43	86.04	8.60
	1.47	2.41	0.97	0.92	2.07		
	20.13	17.28	0.97	0.94	19.57		
	33.6	30.4	0.98	0.95	33.14		
	16.6	14.6	0.99	0.98	15.83		

North, Block - H	7.23	6.24	0.97	0.94	7.05	87.95	8.80
	27.7	21.5	0.94	0.93	26.29		
	14.4	12.8	0.98	0.96	14.01		
	23.7	22	0.94	0.94	24.31		
	16.7	8.3	0.97	0.54	16.29		
South, Block - H	1.58	1.9	0.98	0.96	1.80	26.07	2.61
	17.6	15.9	0.96	0.95	17.54		
	5.8	5.37	1	0.7	6.74		

It can be observed from above that all the four transformers are loaded very poorly. Therefore, it is recommended **to operate only one transformer each in each block** i.e. one in G-block and another in H-block and other two will be de-energized. The savings due to this can be estimated as below:

Description	**Details**
No load loss of a 1000kVa Transformer, KW	1.5
No load loss 4 nos Transformers, KW	6
Load loss of G-block North transformer, KW	0.21
Load loss of G-block South transformer, KW	0.09

Load loss of H-block North transformer, KW	0.09
Load loss of H-block South transformer, KW	0.01
Total loss, KW	6.39
After Switching off 2 nos transformers	
No load loss 2 nos Transformers, KW	3
Load loss of G-block North transformer, KW	0.14
Load loss of H-block North transformer, KW	0.04
Total loss, KW	3.18
Savings, KW	3.21
Annual Savings, KWH	**28149.15**
Annual Savings, Rs. (@5/- per KWH)	**140745.76**
Investment for modification, Rs	100000.00
Simple Pay Back, Yr.	0.71

Stopping Idle Operation of Transformers

Another important issue is that transformers, even when not loaded, will consume power i.e. no load losses (also called iron losses). To avoid the same, idle transformers will have to be switched off. Switching off transformers for prolonged periods, especially during periods of high humidity, can lead to deterioration of transformer oil, which makes it difficult to energise the transformer at short notice. Keeping in view the very high reliability requirements, we do not recommend any switching off of transformers in case of process plants, since the energy savings are relatively minor.

Amorphous Core Transformers

Amorphous core transformers, in comparison to the laminated core transformers, have lower iron losses, and can save energy (refer table below). The thickness of amorphous steel foils is about 0.03 mm compared to 0.18 to 0.23 mm for CRGO laminations, this reduces iron losses by about by about 75% (comparisons are given at a magnetic flux density of 1.5 Tesla). However, since magnetic flux densities in amorphous core transformers are likely to be lower, the volume of the core may be larger, leading to longer winding length and higher copper losses. Hence, at the time of transformer selection, comparison of total losses is preferred at the most probable loading level.

Evolution of Transformer Core Material with Reference to Core Losses

Year (Approx.)	Core Material	Thickness (Mm)	Loss (W/Kg At 50hz)
1910	Warm rolled FeSi	0.35	2 (1.5T)
1950	Cold rolled CRGO	0.35	1 (1.5T)
1960	Cold rolled CRGO	0.3	0.9 (1.5T)
1965	Cold rolled CRGO	0.27	0.84 (1.5T)
1975	Amorphous metal	0.03	0.2 (1.3T)
1980	Cold rolled CRGO	0.23	0.75 (1.5T)
1985	Cold rolled CRGO	0.18	0.67 (1.5T)

These transformers are available up to 2000 kVA rating in India. Considering energy savings and investments (about 40% higher than conventional transformers with laminations), it is not economically viable to replace existing transformers. However, these transformers can be considered for expansion. We suggest that these transformers can be installed for non-critical applications initially till sufficient confidence is gained by the electrical department in the new technology.

3. STUDY OF LIGHTING SYSTEMS

INSTALLED FITTINGS LUMINOUS EFFICACY AND LIFE

S. No.	Light Sources	Lamp Wattage (Watts)	Lumens	Efficiency (Lumens/ watt)	Choke Rating (watt)	Avg Service life (hrs)	Colour Rend. index
1	Incandescent lamps (GLS)	100	1360	14		1,000	100
2	Fluorescent tubes	40	2400	60	15	5,000	70
	Fluorescent tubes (super)	36	3250	90	2	14,000	70
3	T5 Fluorescent lamps	28	2700	96	2	18,000	70
4	Compact Fluorescent lamp	15	810	56		8,000	85
5	High pressure Mercury Vapor lamp	80	3400	43	9	5,000	45
		125	6300	50	12	5,000	45
		250	13000	52	16	5,000	45
		400	22000	55	25	5,000	45
6	Metal Halide	70	4200	84	26	10,000	70
		150	10500	70	20	10,000	70
		250	19000	76	25	10,000	70
		400	31000	76	60	10,000	70
7	Halogen	500	20000	22		2,000	100
8	High pressure Sodium Vapor lamp:	70	5600	80	13	15,000	25
		150	14000	93	20	15,000	25
		250	25000	100	20	15,000	25
		400	47000	118	40	15,000	25

ILLUMINATION SURVEY OF INSTITUTE & CAMPUS

Good lighting design is the key to minimize energy costs for lighting. Approximately 20% - 30% of the total energy cost in a building accounts from lighting. Besides incorporating efficient technology, effective lighting design should address users' priority for visual performance, comfort and ambience, incorporate natural lighting and provide the occupants flexibility in controlling light levels.

The seven blocks (A-F & CM's block) in Assam Sachivalaya building has about 3800 Nos. of Fluorescent tube lights (FTL) which are the conventional 40 W FTLs and also 380 Nos. of Compact Fluorescent Lamps (this number does not include lamps in passages/corridor, common areas, and utility rooms etc.).

Illumination study was carried by measuring the LUX level of the entire Building complex and was compared with standard level. The lux level measured at different locations is tabulated below. There are different types of light fittings in the building and a detailed inventory of the lights with type, area, wattage, measurement of LUX (Lumen/M^2) is shown in the table below.

All the switching arrangement is individual switching. However in office area, group switching helps in switching off the entire area during lunch period and off time. It was also observed that lights in many rooms were on in the evening when all office staff had left and also during lunch hour. This practice can only be rectified through general awareness of the staff and officers on energy conservation. The general house-keeping of the light fixtures and luminaries is good. It should be noted that dirty fixtures, broken or aged diffusers, old lamps in dilapidated condition reduces efficiency of lighting by about 40%.

The Blocks A, C, E and F have only FTLs installed where as Block D and Chief Minister's Block have CFLs installed. Block B has some FTLs along with mainly CFLs.

THE INSTALLED LOAD EFFICACY RATIO (ILER)

Lightning and Luminaries detail											
Sl. No.	Location	Fittings			Total Watt	Lux Measured	EAV M2	Rec. Lux	Lux/W /M2	ILER	Remarks
		NO	Type	Watt							
	Block-A										
1	Commisioner & Secy. Cultural Affairs Chamber	12	FTL	42	504	240,410,180, 400, 380, 260, 370, 460, 250, 260, 510, 480	350	300-700	33.56	0.78	Very Good
2	Assistants Hall	14	FTL	42	588	236,154,140, 180, 175, 186, 157, 225, 161, 170, 181, 234, 274, 256, 204	196	300-700	23.03	0.54	Good
3	Conference Room, Ministry of Forest & Environment	12	FTL	42	504	336, 308, 310, 342 327, 364, 348, 353, 351, 339, 343, 318, 311, 314, 308	328	300-700	26.60	0.67	Good
4	Chamber of Minister for Forest & Environment	12	FTL	42	504	224,241, 273, 205, 234, 303, 264, 224, 240, 232, 194, 244, 214, 236, 274	236	300-700	24.89	0.58	Good
5	Chamber of Secretary, Ministry of Forest & Envir.	12	FTL	42	504	194,189,204,188, 210, 224, 212, 190, 191, 174, 204, 325, 269, 220, 331	220	300-700	22.13	0.51	Good
6	Secretary's Chamber	10	FTL	42	420	239,241,234, 254, 243, 248, 295, 264, 319, 278, 253, 268	262	300-700	43.45	0.98	Good
7	Chamber of Commissioner & Secy. GAD, GD, Fishery	12	FTL	42	504	187,198,240, 237, 242, 264, 310, 324, 340, 355, 409, 395	292	300-700	31.00	0.72	Good
8	Conference Room, Ministry of	12	FTL	42	504	441,318, 402, 384, 409, 376, 368, 296,	375	300-700	36.51	0.85	Very Good

	Fishery										
9	Chamber of Addl. Secy. Dept. of Personnel	12	FTL	42	504	156,162,147, 149, 201, 220, 230, 256, 326, 365, 302, 268	232	300-700	20.70	0.52	Good
10	Chamber of Principal Secretary	12	FTL	42	504	203,280,254, 364, 270, 315, 284, 334, 198, 237, 244, 224	268	300-700	28.27	0.66	Good
	Block-B										Good
11	Chamber of Minister for Soil Cons. & Fishery	12	CFL	36	432	273,308, 394, 391, 384, 284, 330, 331, 251, 218	308	300-700	36.45	0.85	Very Good
12	Chamber of Minister for Urban Develop. & Housing	12	CFL	36	432	503,482, 488, 379, 348, 462, 451, 413	440	300-700	53.66	1.25	Very Good
13	PS to Minister for Urban Dev. & Housing	4	FTL	42	168	480,430, 488, 436, 478, 430, 454, 460	457	300-700	56.63	1.57	Very Good
14	Secretary's Chamber, PHE	14	CFL	36	504	476,508, 378, 253, 509, 471, 480, 491	446	300-700	42.76	0.99	Very Good
15	Chamber of Minister for PHE	12	CFL	36	432	305,275, 323, 360, 289, 274, 284, 298	301	300-700	34.17	0.79	Very Good
16	PHE Dept. Conference room	12	CFL	36	432	256,262,304, 437, 509, 407, 432, 363, 380, 304, 474, 379	376	300-700	39.13	0.98	Very Good
17	Chamber of Dy.Secy, (Est)	4	FTL	42	168	325,220, 305, 245, 278, 287, 272, 281	277	300-700	25.74	0.72	Good
18	Comm. & Spl. Secy.Chamber	12	CFL	36	432	368,418, 422, 378, 275, 248, 355, 344	351	300-700	39.26	0.91	Very Good
	Block-C										
19	Chamber of Minister of	9	FTL	42	378	225,166,205, 203, 151, 164, 159,	176	300-700	23.78	0.55	Good

	Power					148, 178, 164, 152, 190					
20	Pvt. Chamber of Power Minst.	4	FTL	42	168	248,168, 224, 157, 224, 157, 262, 294, 168, 174	212	300-700	13.71	0.38	Needs review
21	Minister's Conference Room	12	FTL	42	504	362,368,365, 343, 351, 290, 322, 295, 298, 336, 324, 330	298	300-700	26.58	0.66	Good
22	Computer Cell of Election Department	12	FTL	42	504	385,370,345, 354, 440, 342, 284, 340, 342, 442, 328, 318	358	300-700	29.03	0.73	Good
23	Jt.Secy, Election Dept.	12	FTL	42	504	444,405, 437, 482, 402, 418, 395, 398	423	300-700	40.56	0.94	Very Good
24	Conference Room, Election Department	16	FTL	42	672	382,374,405, 386, 392, 368, 375, 424, 430, 365	390	300-700	28.47	0.66	Very Good
25	Chief Secretary's Chamber	12	FTL	42	504	443,386, 400, 326, 286, 305, 394, 320	358	300-700	37.76	0.88	Very Good
26	PA to Chief Secretary	4	FTL	42	168	442,265, 453, 330, 320, 364, 296, 318	349	300-700	34.73	0.96	Very Good
27	Chief Secretary's Conference Room	12	FTL	42	504	380,371,369, 335, 352, 375, 350, 392, 424, 429, 402, 381, 349, 395	379	300-700	32.28	0.81	Very Good
29	Secy. & Commissioner, Industry & Commerce	12	FTL	42	504	403,264,391, 295, 233, 359, 284, 269, 256, 255, 273, 238	294	300-700	27.10	0.68	Good
	Block-D										
30	Chamber of Veterinary Minister	12	CFL	36	432	470,324, 370, 462, 364, 385, 380, 640, 544, 442, 462, 363	434	300-700	44.79	1.12	Very Good
31	Ante Chamber of Veterinary	4	CFL	36	144	350, 320, 280, 260	303	300-700	27.37	0.76	Good

	Minister										
32	Veterinary Conference Hall	12	CFL	36	432	412, 462, 520, 478, 468, 430, 428, 469	459	300-700	45.63	1.14	Very Good
33	PWD Minister's Room	12	CFL	36	432	320, 380, 304, 389, 346, 367, 375, 324, 265, 240, 365, 265, 285, 367	328	300-700	42.32	0.98	Very Good
34	PWD Minister's Conference Room	12	CFL	36	432	456, 450, 415, 495, 536, 531, 462, 429, 420, 425, 306, 265	433	300-700	40.96	1.02	Very Good
35	Ante Chamber of PWD Minister	4	CFL	36	144	273, 214, 256, 178, 293, 459	279	300-700	40.32	1.12	Good
36	Education Minister's Room	12	CFL	36	432	379, 316, 386, 389, 345, 317, 380, 242	344	300-700	42.31	0.98	Very Good
	Block-E										
37	Commissioner's Room	12	FTL	42	504	615,440,675 (daylight)	577	300-700	66.40	1.54	Very Good
38	Minister's Room	12	FTL	42	504	421,340,516,437, 558	455	300-700			Very Good
39	Secretary's Room (E3F3)	12	FTL	42	504	255,479,451,600, 580,500	478	300-700	35.25	0.88	Very Good
40	E3F3 Ante-Room	5	FTL	42	210	350,220,280,360, 350,370	322	300-700	30.78	0.86	Very Good
41	Room E1F3	12	FTL	42	504	315,518,736,602, 560,555	548	300-700	57.26	1.33	Very Good
42	Chief Minister's Conference Room	84	FTL	42	3528	413,357,380,460, 456,490,466,485, 497,400,475,448	444	300-700	22.45	0.47	Good
	Block-F										
43	Room of Minister for Health, S & T, Urban Dev	12	FTL	42	504	286, 205, 322, 312, 331, 301, 213, 271, 260, 244	275	300-700	26.78	0.62	Good
44	PRU Room	12	FTL	42	504	136,138,141,120,	151	300-700	16.65	0.39	Needs

						220					review
45	Computer Application Div	16	FTL	42	672	190,196,245,215, 202,260	218	300-700	21.17	0.49	Good
46	Addl. Dir., PC Division	8	FTL	42	336	227,273,267,262, 280,195	251	300-700	25.25	0.63	Good
47	P & D Dept. Conference Room	12	FTL	42	504	401, 382, 435, 402, 439, 403,368, 391, 378, 385	359	300-700	33.49	0.84	Very Good
48	Vice Chairman, Plan. Commission	12	FTL	42	504	169, 157, 178, 185, 176, 210, 220, 185	185	300-700	17.74	0.41	Good
49	Dy Secy., U/Secy, Finance Dept.	12	FTL	42	504	212,257,217,201, 225,227,167,287, 168,204,198,229	216	300-700	18.40	0.46	Good
	CM's Block										
50	Room of Minister for	12	CFL	36	468	368,376,362,387, 303,345	330	300-700	37.46	0.87	Very Good
	Transport, P&R Dev	2	CFL	18		276,372,236,302, 326,305					Good
51	OSD to Transport Min.	8	CFL	36	288	188, 226, 224, 204, 238, 233, 207, 274, 205, 240	224	300-700	23.41	0.65	Good
52	PS to Chief Minister	12	CFL	36	432	394, 390, 376, 391, 447, 260, 314, 245,260	342	300-700	39.72	0.92	Very Good
53	Ante-Room, Secy. To CM	6	CFL	36	216	482,439,452,421, 250,240	381	300-700	36.88	1.02	Very Good
	OUTSIDE AREA										
54	Outside Area – Front side	5	MHL	500	2500	30,32,36,39,40,42 ,41,43,33,36,38,4 3,47,46,31,32,38	38				
		2	CFL	9	18	51, 52, 54					

RECOMENDATIONS:

The Installed Load Efficacy Ratio (ILER) indicates how efficiently the installed luminaries are functioning. A low figure indicates that a review and action is required for improving. The improvement can be done through:

(i) By replacing the existing lamps by energy efficient luminaries- like replacing the conventional tube lights (slim 36 Watt & 40 Watt T/L) by T-5 tube lights, which consume only 28 watts. This can be done phase wise on failure replacement basis.

(ii) The color & reflectivity of wall and ceiling is to be bright to reduce the lighting requirement. For example, the cupboards and wooden paneling in some rooms are dark brown in color thereby reducing the overall illumination.

(iii) Effective use of daylight wherever possible should be made.

(iv) Sensitizing people to switch off lights and fans when they leave their work area for any long period.

OTHER MEASURES TO REDUCE LIGHTING LOAD ARE:

- Installing zone switching.
- Luminaries to be cleaned regularly to increase illumination. Normally 10-20 % light output reduces over a period of six months if not cleaned.
- Whenever replacing a burnt out lamp we should replace it with a more efficient lamp and replace the ordinary choke of T/L fitting with an electronic ballast fitting. This result in power savings as the electronic ballast consume only 2 to 6 Watts compared to the electromagnetic ballast, which consumes around 15 Watts of electrical energy.
- Use of time clocks or photocell control for outdoor lighting.
- During breaks the lights of the specific workplace should be switched OFF, for which individual switches at the worktable is helpful.
- Where it is possible the entire lighting load can be supplied through voltage stabilizer (AVR). On maintaining 190 V single-phase voltage tremendous scope of savings exists.

POTENTIAL SAVINGS IDENTIFIED:

Savings due to replacement of 36W FTL with T5 lamps:

Nos. of FTL	3800
Power consumption, Watt	42
Running hours	8
Expected Power consumption, Watt	28
Average nos. of day per year	250
Annual savings (50% light on), KWH	**53200**
Annual savings, Rs.	**266000**
Investment (@ Rs.125/- per T5, Salvage value Rs.100/-), Rs.	475000
Payback Period, Yr.	1.79

4. STUDY OF AIR CONDITIONERS

MEASURED AIR CONDITIONERS

Sl. No	Room	Location	Make	Model	Year of Instln.	Rated TR	Room Size
BLOCK -E							
1	Minister (A. Bora) room	LHS	LG	LSA-24XWASI	2008	2	24'x21'x10'
2		RHS	LG	LSA-24XWASI	2008	2	24'x21'x10'
3	E1 F2	LHS	LG	LSA-24XWASI	2008	2	20'x26'x10'
4		RHS	LG	LSA-24XWASI	2008	2	20'x26'x10'
5	E 2 F1	LHS	LG	LSA-24XWASI	2008	2	24'x22'x10'
6		RHS	LG	LSA-24XWASI	2008	2	24'x22'x10'
7	E3 F1	LHS	LG	LSA-24XWASI	2008	2	24'x20'x10
8		RHS	LG	LSA-24XWASI	2008	2	24'x20'x10
9	E3 F3	LHS	LG	LSA-24XWASI	2008	2	20'x20'x10'
10		RHS	LG	LSA-24XWASI	2008	2	20'x20'x10'
11	E1 F3	LHS	LG	LSA-24XWASI	2008	2	21'x27'x10'
12		RHS	LG	LSA-24XWASI	2008	2	21'x27'x10'
BLOCK -A							
13	Commisioner of Cultural Affair	LHS	Carrier			2	26'x20'x11
14	Conference Min. of Forest	RHS	Carrier			2	22'x20'x11
15	Min. of Forest & Env	RHS	Carrier			2	26'x22'x11
16		LHS	Carrier			2	
17	Min. of Forest & Env Conf. Room	Meeting Room	Carrier			2	
18	Min. of Forest & Env Secy. Room	LHS	Carrier			2	22'x26'x11
19	Min. of Forest & Env Secy. Room	RHS	Carrier			2	
20	Commissioner SAD, GD, Fisheries	RHS	Carrier			2	
21		RR	Carrier			2	
22	Conf. Room SAD, GD, Fisheries	Meeting Room	Carrier			2	
23	Addl.Secy Pers. Dept	RHS	Carrier			2	
24		RHS	Carrier			2	
25	Principal Secy. To Govt.	Split	Carrier			2	
BLOCK-D							
26	Min. of Veterinary	LHS	LG	LSB2451RAB1		2	10'x14'x10
27		RHS	LG	LSB2451RAB1	2005	2	
28	MoV rest room		LG	LSB2451RAB1	2005	2	
29	MoV conf. room		LG	LSB2451RAB1	2005	2	
30	MoPWD	LHS	LG	LSB2451RAB1	2005	2	

31		RHS	LG	LSB2451RAB1	2005	2	
32	MoPWD Conf room	LHS	LG	LSB2451RAB1	2005	2	
33		RHS	LG	LSB2451RAB1	2005	2	
34	MoPWD Rest room		LG	LSB2451RAB1	2005	2	
35	Min of Education		LG	LSB2451RAB1	2005	2	
BLOCK-F							
36	Min of Health & Urban Dev	RHS	LG	LSB2451RAB1	2004	2	
37	Conf room MoH&UD	LHS		LSB2451RAB1			
38	Pay research unit Office room	RHS	LG	LSB2451RAB1	2004	2	
39	Plan Coord. Research room	LHS	LG	LSB2451RAB1	2004	2	
40		RHS	LG	LSB2451RAB1	2004	2	
41	Addl PC division	RHS	LG	LSB2451RAB1	2004	2	
42	P & D Conf room	LHS	LG	LSB2451RAB1	2004	2	
43	VC State Planning Commision	RHS	LG	LSB2451RAB1	2004	2	
44		LHS	LG	LSB2451RAB1	2004	2	
45	Under secy Fin Dept	RHS	LG	LSB2451RAB1	2004	2	
46		LHS	LG	LSB2451RAB1	2004	2	
BLOCK-C							
47	Minister room (Mo Power)	RHS	LG	LSB2451RAB1	2004	2	25'x22'x10'
48		LHS	LG	LSB2451RAB1	2004	2	
49	Lunch room		LG	LSB2451RAB1	2004	2	
50	Conf room (MoPower)	LHS	LG	LSB2451RAB1	2004	2	22x22x10
51		RHS	LG	LSB2451RAB1	2004	2	
52	Election Dept Comp room	RHS	LG	LSB2451RAB1	2004	2	22x20x10
53	Jt. Secy Election	RHS	LG	LSB2451RAB1	2004	2	26x20x10
54	Ch. Secy Assam	RHS	LG	LSB2451RAB1	2004	2	26x22x10
55		LHS	LG	LSB2451RAB1	2004	2	
56	Ch Secy PS		LG	LSB2451RAB1	2004	2	15x12x10
57	Ch. Secy Conf	RHS	LG	LSB2451RAB1	2004	2	21x22x10
58	Ind Secy	RHS	LG	LSB2451RAB1	2004	2	25x20x10
BLOCK-B							
59	Min of Urb. Dev	LHS	LG	LSB2451RAB1	2004	2	25x22x10
60		RHS	LG	LSB2451RAB1	2004	2	25x22x10
61	MUD PS room		LG	LSB2451RAB1	2004	2	16x14x10
62	Secy PHE	RHS	LG	LSB2451RAB1	2004	2	26x20x10
63		LHS	LG	LSB2451RAB1	2004	2	26x20x10
64	Minister PHE	LHS	LG	LSB2451RAB1	2004	2	24x22x10
65		RHS	LG	LSB2451RAB1	2004	2	24x22x10
67	MoPHE Conf room	LHS	LG	LSB2451RAB1	2004	2	22x22x10
68		RHS	LG	LSB2451RAB1	2004	2	22x22x10
69	C & Spl Secy Dy Secy		LG	LSB2451RAB1	2004	2	12x14x10

70	Comm. & Spl Secy	LHS	LG	LSB2451RAB1	2004	2	12x14x10
CM-BLOCK							
71	Min of Tpt. & PRD	RHS	LG	LSB2451RAB1	2004	2	26x22x10
72		LHS	LG	LSB2451RAB1	2004	2	
73	Min of Tpt. & PRD	PS	LG	LSB2451RAB1	2004	2	14x18X10
74		OSD	LG	LSB2451RAB1	2004	2	18x18x10
75	CM PS room		LG	LSB2451RAB1	2004	2	20x27x10
76	Comm. & Secy to CM	Ante Room	LG	LSB2451RAB1	2004	2	25x9x10

CRITERIA

For Star Rating Analysis

Star Rating	EER (Wc / Wp)	
	Min	Max
1 Star *	2.30	2.49
2 Star **	2.60	2.69
3 Star ***	2.70	2.89
4 Star ****	2.90	3.09
5 Star *****	3.10	

MEASUREMENTS MADE AND ANALYSIS

Sl. No	Room	Location	Year of Instln.	Rated TR	Amps	Volts	KW	PF	EER Wc/Wp	Remarks
BLOCK -E										
1	Minister (A. Bora) room	LHS	2008	2	9.3	249	1.93	0.83	3.64	
2		RHS	2008	2	9.07	243	1.89	0.84	3.72	
3	E1 F2	LHS	2008	2	8.85	245	1.94	0.87	3.63	
4		RHS	2008	2	9.5	253	1.98	0.81	3.55	
5	E 2 F1	LHS	2008	2	9.76	255	2.05	0.82	3.43	
6		RHS	2008	2	9.47	249	2.03	0.87	3.46	
7	E3 F1	LHS	2008	2	9.51	252	1.95	0.81	3.61	
8		RHS	2008	2	8	250	1.07	0.56	6.57	Less Refrigerant
9	E3 F3	LHS	2008	2						
10		RHS	2008	2	9.8	250	1.97	0.8	3.57	
11	E1 F3	LHS	2008	2	4.6	251	0.95	0.81	7.40	Less Refrigerant
12		RHS	2008	2	9.78	252	1.95	0.8	3.61	
BLOCK -A										
13	Commisioner of Cultural Affair	LHS		2	7.6	248	1.84	0.97	3.82	
14	Conference Min. of Forest	RHS		2	7.7	247	1.85	0.97	3.80	
15	Min. of Forest	RHS		2	7.8	235	1.85	0.98	3.80	

16	& Env	LHS		2	8.2	239	1.9	0.98	3.70	
17	Min. of Forest & Env Conf. Room	Meeting Room		2	8.4	243	1.83	0.88	3.84	Less Refrigerant
18	Min. of Forest & Env Secy. Room	LHS		2	7.74	244	1.85	0.96	3.80	
19	Min. of Forest & Env Secy. Room	RHS		2			AC not working			
20	Commissioner SAD, GD, Fisheries	RHS		2	8.2	247	1.96	0.97	3.59	
21		RR		2	7.64	247	1.76	0.98	4.00	Less Refrigerant
22	Conf. Room SAD, GD, Fisheries	Meeting Room		2	7.16	248	1.7	0.96	4.14	Less Refrigerant
23	Addl.Secy Pers. Dept	RHS		2	7.2	247	1.78	0.96	3.95	Less Refrigerant
24		RHS		2	6.7	245	1.59	0.96	4.42	Less Refrigerant
25	Principal Secy. To Govt.	Split		2	8.13	249	2	0.97	3.52	
BLOCK-D										
26	Min. of Veterinary	LHS		2	9.98	252	2.09	0.85	3.36	
27		RHS	2005	2	9.92	250	2.15	0.86	3.27	
28	MoV rest room		2005	2	7.8	251	1.6	0.83	4.40	Less Refrigerant
29	MoV conf. room		2005	2	10.3	247	2.2	0.85	3.20	
30	MoPWD	LHS	2005	2	9.8	250	2.25	0.92	3.13	
31		RHS	2005	2	9.3	251	2.12	0.91	3.32	
32	MoPWD Conf room	LHS	2005	2	9.9	247	2.15	0.89	3.27	
33		RHS	2005	2	10.15	249	2.19	0.86	3.21	
34	MoPWD Rest room		2005	2	7.5	247	1.3	0.67	5.41	Less Refrigerant
35	Min of Education		2005	2	9.2	2.06	2.2	0.935	3.20	
BLOCK-F										
36	Min of Health & Urban Dev	RHS	2004	2	10.2	244	1.96	0.78	3.59	
37	Conf room MoH&UD	LHS								
38	Pay research unit Office room	RHS	2004	2	12.8	246	2.28	0.68	3.08	
39	Plan Coord. Research room	LHS	2004	2	6.7	245	1.5	0.914	4.69	Less Refrigerant
40		RHS	2004	2	12.67	247	2.23	0.71	3.15	
41	Addl PC division	RHS	2004	2	11.42	241	1.91	0.7	3.68	
42	P & D Conf room	LHS	2004	2	7.08	245	1.7	0.96	4.14	Less Refrigerant
43	VC State Planning Commision	RHS	2004	2	8.4	244	1.97	0.96	3.57	
44		LHS	2004	2	6.8	240	1.56	0.96	4.51	Less Refrigerant
45	Under secy Fin Dept	RHS	2004	2	6.5	242	1.8	0.96	3.91	Less Refrigerant
46		LHS	2004	2	11.3	239	1.99	0.15	3.53	
BLOCK-C										
47	Minister room (Mo Power)	RHS	2004	2	6.9	245	1.3	0.78	5.41	Less Refrigerant
48		LHS	2004	2	8.8	247	1.95	0.89	3.61	

49	Lunch room		2004	2	7.73	243	1.64	0.87	4.29	Less Refrigerant
50	Conf room (MoPower)	LHS	2004	2	7.63	245	1.67	0.85	4.21	Less Refrigerant
51		RHS	2004	2						
52	Election Dept Comp room	RHS	2004	2	8.7	244	2.02	0.93	3.48	
53	Jt. Secy Election	RHS	2004	2						
54	Ch. Secy Assam	RHS	2004	2	8.89	241	2.1	0.894	3.35	
55		LHS	2004	2	9.5	242	2.3	0.96	3.06	
56	Ch Secy PS		2004	2	10.45	240	1.97	0.79	3.57	
57	Ch. Secy Conf	RHS	2004	2	9.3	242	2.1	0.94	3.35	
58	Ind Secy	RHS	2004	2	8.93	241	1.95	0.92	3.61	
BLOCK-B										
59	Min of Urb. Dev	LHS	2004	2	11.01	247	2.16	0.8	3.26	
60		RHS	2004	2	10.71	246	2.06	0.78	3.41	
61	MUD PS room		2004	2	9.4	246	2.15	0.934	3.27	
62	Secy PHE	RHS	2004	2	8.5	247	1.87	0.905	3.76	
63		LHS	2004	2	7.35	252	1.72	0.92	4.09	Less Refrigerant
64	Minister PHE	LHS	2004	2	8.9	251	2.15	0.94	3.27	
65		RHS	2004	2	9.3	249	2.3	0.96	3.06	
67	MoPHE Conf room	LHS	2004	2	8.3	251	1.92	0.94	3.66	
68		RHS	2004	2	9.5	248	2.3	0.956	3.06	
69	C & Spl Secy Dy Secy		2004	2	9.85	230	2.05	0.903	3.43	
70	Comm. & Spl Secy	LHS	2004	2	9.98	230	2.1	0.88	3.35	
CM-BLOCK										
71	Min of Tpt. & PRD	RHS	2004	2	9.56	247	2.34	0.95	3.01	
72		LHS	2004	2	10.03	250	2.45	0.95	2.87	
73	Min of Tpt. & PRD	PS	2004	2	6.5	221	1.5	0.95	4.69	Less Refrigerant
74		OSD	2004	2	9.6	232	2	0.9	3.52	
75	CM PS room		2004	2	9.75	249	2.2	0.93	3.20	
76	Comm. & Secy to CM	Ante Room	2004	2	9.85	247	2.2	0.91	3.20	

The analysis has been carried out assuming:

[Air conditioners are delivering their rated TR of cooling

[Field electrical measurement

As the measurements have been taken in winter season it can be safely assumed that the performance of the machines will not be improved in summer, however, the same can deteriorate further. Due to inaccessibility air flow and temperature could not be measured and TR assessment of the air conditioners was not possible. Hence, actual TR delivered by the AC machines against KW drawn could not be ascertained. However, air conditioners with deviated performance (marked as less refrigerant) can be given for immediate maintenance.

The approximate thumb rule is that for every 1^oC higher temperature in the evaporator, the specific power consumption will decrease by about 2 to 3%. So, **maintain air conditioned room temperature at 25^{o}C instead of 22^{o}C.** In air conditioned spaces, use of circulation fans can provide *apparent comfort* and help raise the room temperature settings about 26^{o}C instead of 24^{o}C.

Savings due to higher setting of air conditioned space temperature:	
Total approximate TR	500
Present consumption, KW	600
Monthly usage, Hr	160
Fraction of TR utilized	0.75
Annual Power Savings, (@2% per deg C),KWH	**38880**
Annual Savings (@Rs.5/- per KW), Rs	**194400**
Investment, Rs.	Nil
Payback period, Yr.	Immediate

Room Air Conditioners

Air Conditioner is an appliance for controlling, especially lowering, the temperature and humidity of an enclosed space. It is designed to extract heat from an area via a refrigeration cycle. Its purpose is to provide comfort during either hot or cold weather. Air conditioner, once considered a luxury is now becoming a necessity. Air- Conditioning manufacturers have made them more affordable along with increasing their efficiency and improving components and technology. Air conditioning systems vary considerably in size and derive their energy from many different sources. Popularity of room air conditioners have increased dramatically with the advent of central air, a strategy that utilizes the ducting in a home for both heating and cooling.

The Efficiency of room air conditioners is rated only by EER (Energy Efficiency Ratio), which is cooling output divided by power consumption. The higher is the EER, the more efficient the air conditioner.

Tips for Saving Energy

- We can reduce air-conditioning energy use by as much as 40 percent by shading our home’s windows and walls. Plant trees and shrubs to keep the day's hottest sun off your house.

- One will use 3 to 5 percent less energy for each degree air conditioner is set above 22^0c (71.5^0F), so set the thermostat of room air conditioner on 25^0C (77^0F) to provide the most comfort at the least cost.
- Using ceiling or room fans allows you to set the thermostat higher because the air movement will cool the room.
- A good air conditioner will cool and dehumidify a room in about 30 minutes, so use a time and leave the unit off for some time.
- Keep doors to air- conditioned rooms closed as often as possible.
- Clean the air- conditioner filter regularly.

MAINTENANCE TIPS FOR SPLIT / WINDOW AC

- Make sure your AC doesn't get overloaded; check the fuse or circuit breaker if it doesn't operate.
- Remember to replace or clean the filter and have your mechanic clean the evaporator and condenser coils regularly, for the air conditioner to cool your home efficiently.
- Install a programmable thermostat, it will lead to 10-15% energy saving.
- Set your thermostat as high as possible comfortable.
- Set the fan speed on high except on very humid days, when humidity is high set the fan speed on low for more comfort.
- Install units in shade, it will lead to 10% saving in energy consumption.
- Use sun films on windows. That will cut heat entry by 70% of the building.
- If the AC makes noise it needs to be checked by the mechanic.

- Giving your air conditioning system a good electrostatic air filter is the best thing you can do for your air conditioner. A good air filter will extend the life of your air conditioner because the important parts, like the cooling coil, and other inner parts will stay cleaner, operate more efficiently and last longer.

- Avoid frequent opening of doors/windows. A door kept open can result in doubling the power consumption of your AC.

- Ensure direct sunlight (and heat) do not enter the air-conditioned space, particularly in the afternoons.

- Most people believe that a thermostat set to a lower temperature than desired, will force your air-conditioner to cool faster, not really, all it does, is make your air-conditioner operate for longer. Moreover, you will have an unnecessarily chilly room and wasted power. Every degree lower on the temperature setting results in an extra 3-4% of power consumed. Hence, once you've found yourself a comfortable temperature and set the thermostat at that level, avoid touching the thermostat thereafter.

- Once an air-conditioning system has been designed and installed avoid any major change in the heat-load on the AC. This will add to wasted power.

- Always ensure that whenever you install new unit, make sure its EER (12/(kW/TR)) should be between 9.5 to10.5.

- No gap should be left during installing units for cool air escape.

5. STUDY OF MOTORS & PUMPS

There are seventeen numbers of centrifugal water pumps, nine in G-block and eight in H-block pumping water from two numbers water tanks at grade level. These tanks are receiving water from PHE pumps outside the building complex.

Water Pump and Motor Data

Description	Details
Number of units	17
Type	MBK52
Make	Crompton Greavs
Size, MM	50X40
Insulation Class	B
RPM	2850
Poles	2
Current, A	8
Volt, +6% -15%	415
Phase	3
Connection	Delta
Motor KW	3.7

MEASUREMENTS

Electrical Measurement of Operating Motors

Location	No	Name plate details				Measured parameters						
		RPM	KW	FLC, A	Volt	KW	Ir	It	Vr	Vt	PF	Frequency
Block - G	B1	2880	3.7	8.2	415	4.63	6.97	7.01	431	430	0.88	49.3
	A1	2880	3.7	8.2	415	5.32	8.02	8.02	420	419	0.91	49.3
	C1	2880	3.7	8.2	415	3.45	5.6	5.23	421	420	0.87	49.3
	CM1	2880	3.7	8.2	415	4.86	7.3	7	422	420	0.93	49.3
	F1	2880	3.7	8.2	415	4.67	7.12	6.82	427	426	0.91	49.3
Block - H	D1	2850	3.7	8	415	4.59	7	6.6	428	428	0.91	49.3
	E1	2850	3.7	8	415	3.43	5.2	5.3	425	427	0.88	49.4
	H1	2850	3.7	8	415	3.96	6.1	5.8	427	424	0.9	49.4

Flow Measurement of Operating Pumps

Location	Service	No	Name plate details				Measured parameters	
			Capacity, lps	Head, m	Motor, kw	Efficiency	Flow, cu m / hr	Head, m
Block - G	Water	B1	5.0 / 2.0	33 / 51	3.7		12.01	No provision
	Water	A1	5.0 / 2.0	33 / 51	3.7		13.06	

	Water	C1	5.0 / 2.0	33 / 51	3.7		6.4	to check
	Water	CM1	5.0 / 2.0	33 / 51	3.7		11.32	
	Water	F1	5.0 / 2.0	33 / 51	3.7		9.95	
Block - H	Water	D1	5.2	34	3.7	43%	8.95	
	Water	E1	5.2	34	3.7	43%	4.5	
	Water	H1	5.2	34	3.7	43%	3.98	

ANALYSIS

CRITERIA

For Motor loading Analysis

- If % loading is > 100 : Overloaded
- If % loading is ≥ 50 and ≤ 100 : Satisfactory
- If % loading is < 50 : Under-loaded

Normally, under normal working conditions, motors should be loaded between 50 to 100% of their rated capacities.

For Power Factor Analysis

- If the operating Power Factor is > 0.7 : Satisfactory
- If the operating Power Factor is < 0.7 : Low

Operating power factor of 0.7 is satisfactory at the load centre, however, the overall plant power factor should be above 0.98.

Location	No	Rated	Measured parameters		% Loading	Loading Condition	Operating P.F
		KW	KW	PF			
Block - G	B1	3.7	4.63	0.88	110.49	Over loaded	Satisfactory
	A1	3.7	5.32	0.91	126.96	Over loaded	Satisfactory
	C1	3.7	3.45	0.87	82.33	Satisfactory	Satisfactory
	CM1	3.7	4.86	0.93	115.98	Over loaded	Satisfactory
	F1	3.7	4.67	0.91	111.45	Over loaded	Satisfactory
Block - H	D1	3.7	4.59	0.91	109.54	Over loaded	Satisfactory
	E1	3.7	3.43	0.88	81.86	Satisfactory	Satisfactory
	H1	3.7	3.96	0.9	94.50	Satisfactory	Satisfactory

OBSERVATIONS

Motors running in Over Loaded Conditions

Normally, motors can be loaded up to 125% of their rated capacity for short durations. However, if the over loading is continuous the installation can replace the over loaded motor with a higher capacity motor in order to avoid burnouts. For this building complex five out of eight checked motors found running overloaded.

Analysis of pump performance

Operating Efficiency of Pumps:

Location	No	Name plate details				Measured parameters			Hyd. Power, KW	Operating Eff
		Capacity, lps	Head, m	Motor KW	Efficiency	Flow, cu m / hr	Asmd. Head, m	Motor KW		
Block - G	B1	5.0 / 2.0	33 / 51	3.7		12.01	34.00	4.63	1.11	21%
	A1	5.0 / 2.0	33 / 51	3.7		13.06	34.00	5.32	1.21	20%
	C1	5.0 / 2.0	33 / 51	3.7		6.4	34.00	3.45	0.59	15%
	CM1	5.0 / 2.0	33 / 51	3.7		11.32	34.00	4.86	1.05	19%
	F1	5.0 / 2.0	33 / 51	3.7		9.95	34.00	4.67	0.92	17%
Block - H	D1	5.2	34	3.7	43%	8.95	34.00	4.59	0.83	16%
	E1	5.2	34	3.7	43%	4.5	34.00	3.43	0.42	11%
	H1	5.2	34	3.7	43%	3.98	34.00	3.96	0.37	8%

OBSERVATIONS

Pumps running with very poor efficiency

As observed from the table above all the pumps in Assam Secretariat Building Complex are running with a very poor efficiency. It seems the pumps are grossly over sized. And along with that system must also be imparting a very low efficiency in form of pinched down valves. Hence, it is recommended to replace all of them with suitably sized pumps while motors can be retained for the time being. The energy savings by replacing them can be estimated as below.

Location	No	Recommended New Pumps		Power in put to new pump (KW)	Power in put to existing pump (KW)	Savings (KW)
		Head, m	Flow, LPS			
Block - G	B1	21	3.5	1.37	4.63	3.26
	A1	25	3.5	1.63	5.32	3.69
	C1	25	2	0.93	3.45	2.52
	CM1	21	3.5	1.37	4.86	3.49
	F1	25	3	1.39	4.67	3.28
Block - H	D1	25	2.5	1.16	4.59	3.43
	E1	21	1.5	0.59	3.43	2.84
	H1	21	1.5	0.59	3.96	3.37

Total Savings, KW	25.90
Annual power savings, KWH	**23309.03**
Annual savings (@Rs.5/- KWH), Rs.	**116545.14**
Investment, Rs	160000.00
Simple Payback, Yr.	1.37

6. STUDY OF DG SET

INSTALLED DG SET

There is two numbers of DG sets catering the power requirement during grid failure.

DG Set Details	
No of DG sets	2
Make	Kirloskar Electric Company
Capacity	400 KVA
Engine	Kirloskar
Rpm	1500
Voltage	415
Amp	529
KW	320
P.F.	0.8
Frequency	50
Insulation	H
Rotation direction	CW

Observations

KWH generations and HSD consumptions are not noted in log book, there is no log book maintained.

Energy conservation in DG set

Generating efficiency of a DG set is measured by the nos. of units generated per litre of fuel consumed. As a rule, lower speed engines are more fuel efficient in larger sizes and less efficient in smaller sizes. While the engine speed is maintained constant within certain limits by means of governor of the engine, the load on the engine can vary from zero to full rated power and to a further 10% overload on the rated hp. The brake horse specific fuel consumption of an engine is characteristic of function of the bhp or load at any synchronous speed. It is seen that BSFC is at the minimum at approximately rated power increasing slightly at 10% overload and substantially at all lower loads. This situation arises due to the fact that the internal frictional horse power of the engine remains almost constant due to constant speed while the useful brake horse power taken from the engines decreases resulting in reduced mechanical efficiency of the engine and BSFC. It is recommended to load the sets at least 70% of the rated load, at all times. Action taken is to be based on the loading pattern. It may also be mentioned here that BSFC of air-cooled engines are lower than that of water-cooled engines, especially those water-cooled engines in which fans are driven by electric motors and not by the engine. In engine driven fan and water pump, there is a loss of 7 to 10% of engine bhp. Water-cooled engines having separate and independent cooling system that is cooling tower attached with fountain and heat exchangers have lower fuel consumption.

The way the unit was maintaining the logbook was quite adequate. It is very much essential for any unit to maintain proper logbook wherein all the data related to engine operation and performance should be recorded. The recorded data should also reflect the performance of various components like heat exchanger, etc. As discussed above, consumption will keep on varying with the change in load on the engine. It is therefore very important to take half-hourly or hourly reading of fuel consumption and energy produced, together which will give **specific fuel consumption (SFC)** in **KWH per Litre of fuel** consumed and a very good idea as to how to load the DG set judiciously and what is the load at a certain point of time. It is therefore recommended to maintain the SFCs. This will also indicate when the engine or its components need maintenance. This will help in scheduling the preventive maintenance of the DG set and thus reduce the down time and loss of production. The SFC will be reduced with the decrease in load and malfunction of any vital component of the engine. Although SFC varies with load, it is of utmost importance to conduct trial on all the sets to determine the actual SFC of each set. This will help in finding out the set or sets with low SFC. They have to be attended to immediately.

The following is the format recommended for any DG set logging:-

Date - Starting & Closing Time - kWh meter reading - AC Voltage - AC Amp - DC Voltage - DC Amp - Rpm - Frequency - kW - HSD Consumption in Litre (Physical measurement from the service tank and not by running hours) - SFC (KWH/Litre of HSD) - Lube Oil Pressure - Lube Oil Outlet Temperature - Total Running Hours - Total Lube Oil Consumption.

Engine room heats up during the DG set operation due to heat radiation from the hot exhaust pipes and due to the hot air from the radiator fan or from the exit of the air-cooled engines circulating inside the room. When the ambient temperature in the engine room goes up, fuel consumption increases due to decrease in the air fuel ratio due to lower density of available air. As the mixture becomes richer there is a decrease in the fuel efficiency. It has been seen that with the increase in the air intake temperature from 25^{o}C to 42^{o}C the air fuel ratio decreases by about 5% and this will result in higher BSFC in the range of 0.5 to 2% depending upon the engine design i.e. naturally aspirated or supercharged or inter-cooled. In other words, the engine output varies with the change in the intake temperature. It has been seen that for a rise of every 3^{o}C in intake temperature beyond 32^{o}C the engine output drops by about 1.2%. It is therefore essential to make arrangements for proper ventilation so that hot air is continuously removed by circulation of cool air. Using insulation lagging can reduce heat radiation from the exhaust pipe and manifold. The table given below gives the loss of heat from lagged and un-lagged pipes of different diameters at exhaust temperature of around 400^{o}C and ambient temperature of around 30^{o}C.

a) Diameter of exhaust pipe (mm)	150	200	300	400
b) Heat radiation in Kcal /hr. per meter of pipe length				
i) Base pipe	5800	7800	11600	15600
ii) Pipe with 50 mm thick lagging	235	350	520	630
iii) Pipe with 100 mm thick lagging	145	215	300	370

This will help to select the insulation thickness to reduce radiation heat. It is observed that all the exhaust pipes are un-insulated in the room, as a result when the DG sets are running the room temperature goes up.

Exhaust temperature of a DG set is an indication of the engine health and hence the fuel consumption. If the exhaust temperature is more than the recommended, the power generation is not proper and engine needs immediate attention before the situation worsens. Provision of measuring the cylinder temperature is very useful in identifying the damaged cylinder. So, it is recommended to incorporate the cylinder head temperature in the logbook to monitor the health of the DG set. Exhaust gas temperature should never be allowed to go beyond 450^{o}C. Overloading and air starvation are the major reasons for increased exhaust gas temperature, poor efficiency of heat exchanger also has a bearing.

While designing the engine room, factors like ambient temperature, relative humidity, whether the batteries are positioned inside the DG set room or not and whether the engine is air-cooled or water-cooled, whether the engine is naturally aspirated or supercharged should be taken into account.

Exhaust system should be properly designed for proper fuel and engine efficiency so that the exhaust backpressure is within the permissible limits. If the exhaust backpressure higher than the permitted value the scavenging of the engine will be adversely affected and there will be less oxygen in the cylinder during the subsequent compression stroke. The mechanical efficiency will reduce due to higher exhaust pumping losses. This will increase fuel consumption. The following steps are to be taken to maintain the exhaust backpressure within permissible limits: -

i) Small diameter pipes and large number of bends increase the backpressure.

ii) Pipe diameter should be such that exhaust backpressure is about 30 to 40 mm Hg for uncharged engines and about 20 to 30 mm Hg for turbocharged engines.

iii) Gas velocity should be below 33 m /sec for optimum exhaust backpressure.

iv) Number of bends should be minimum, and they should be smooth, not sharp. Radius of the bends should be at least 4 times the pipe diameter.

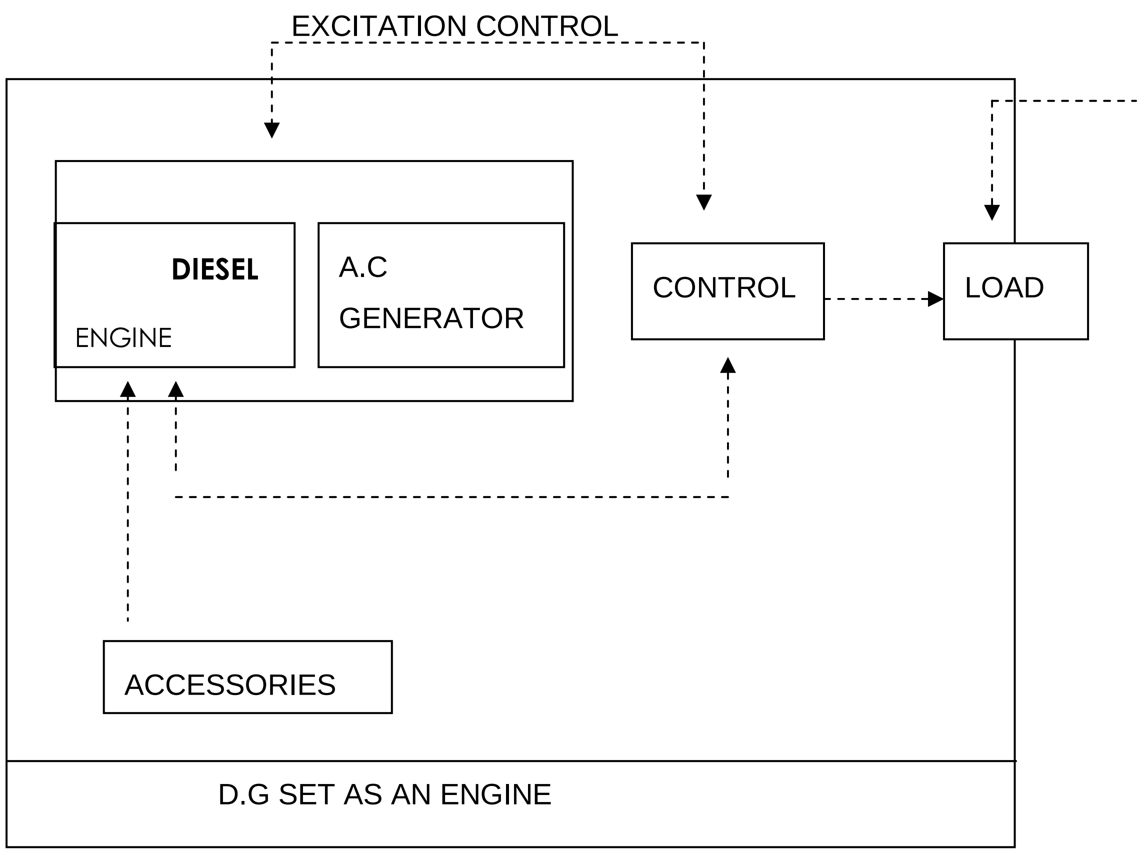
v) In case multiengine sets are connected to a single exhaust manifold the mean gas velocity should not exceed 15 m/sec.

Leakage even though they are of minor nature, should be avoided scrupulously as they are largely the major factor for higher fuel and lube consumption.

Monitor lubricant condition through regular sampling. Maintain proper cooling. Change oil on condition basis and not only on the rule of thumb as recommended by the Oil companies or engine manufacturers. In most of the cases it is found that the engine oil is discarded much before their life is over. This means wastage of oil and money. The parameters of oil change are sometimes ad hoc, bearing no relations to the actual state of oil in use. Many a time the extent of deterioration could be excessive resulting in damage to the equipment. Again, at times the deterioration may be mild and the oil may be in good condition and suitable for further use. Hence the condition-monitoring program is necessary.

3.12 Load Management:

A diesel generating set should be considered as a system since its successful functioning depends on the well-matched performance of its components namely:



1. The diesel engine and its accessories
2. The A.C. generators

3. The control system and switch
4. The foundation and power house civil works
5. The connected load with its own components like heating, motor drives lighting etc.

It is necessary to select the components with highest efficiency and operate them at their optimum efficiency levels to conserve energy in this system.

Energy conservation depends more on the management of the load connected to the D.G set than the performance of the D.G. set itself. Some of the aspects to be looked into are:

<u>Load Balancing</u>

There are a number of single-phase loads in the plant, which is fed through three-phase supply system. If the loads are not balanced the supply voltage will be heavily unbalanced though the D.G set can take up some degree of unbalanced loads. Such unbalanced supply for motors and other three phase loads will result in additional losses in the equipment and hence will make the system less efficient**. It may be noted that at no point of time the difference between maximum and minimum current in the R, Y and B phase should be more than 10%. It is necessary to distribute the loads judiciously or avoid single-phase loads in a three-phase system.**

<u>Non-linear/ Fluctuating loads</u>

Certain load causes serious output voltage variation and due to that the function of other voltage sensitive loads can be affected. For example, a thyrister converter driver or motor may malfunction if a flywheel rolling mill drive or a **compressor** is switched on. Hence it is necessary to provide a separate supply system for **such non-linear loads or at least isolate them through simple harmonic filters and transformers.**

<u>Optimum loading</u>

The efficiency curve of D.G set is almost flat above 60% load whereas below that load the fuel consumption increases drastically (Though the DG Set supplier mentions that at 25% load the f

7. CONCLUSIONS

LEADERSHIP AND EDUCATION

Leadership has to be displayed by the building complex management, to play a vital role in enhancing the energy conservation efforts. Since most of the savings can be achieved through simple measures adopted at the user level, getting support of the management in educating the user group on the simple methods of energy saving and the resulting positive impact were very important. Apart from the energy savings achieved, educating the users also brought about awareness and a sense of responsibility which contributed to the cost-effective approach to achieve energy and cost savings. To further promote energy conservation, leadership and education was also seen as an important element for the success of the project. Being an esteemed building complex, the energy conservation initiative has to be propagated at all levels of the organization. Aligned with the motto "**Electricity saved means Electricity generated**", education of every employee of the secretariat and awareness about electricity saving is a major component of the energy conservation drive. As a result, the motto for the project will result in a more responsible attitude on the part of the employees towards electricity savings. This type of behaviour would help reduce the acute power shortage that was prevalent in the State of Assam. Other means of spreading knowledge include distributing pamphlets and circulars to the head of all the different departments who will coordinate the conservation activity as well as to the intermediate and junior staff to educate and encourage their participation in conservation.

Besides the constant and complete support from the top management team, the maintenance staff of the departments of Estate Management should take the lead role and work extensively towards achieving the goal. Also, the awareness and the knowledge transfer regarding the importance of energy conservation has to spread through all the levels of management.

SUMMARY OF ENERGY CONSERVATION OPPORTUNITIES

Electrical Savings						
Recommendations	**Energy Savings**				**Estd. Investment**	**Simple Payback period**
	KWh	**Lac K.Cal**	**KL of oil equivalent**	**Rs Lacs**	**Rs Lacs**	**Years**
Switching off two transformers and operating only one in each block (G &H)	28145			1.4	1.0	0.7
Replacement of conventional tube lights (40w TFL) with energy efficient tube lights (28w T5)	53200			2.66	4.75	1.8
Higher setting (25^{o}C) of air conditioned space temperature	38880			1.94	Nil	Immediate
Replacement of 8 numbers water pumps	23309			1.16	1.6	1.4
Total – (A)	**143534**			**7.2**	**7.35**	