INVESTMENT GRADE ENERGY AUDIT REPORT

OF

North East Frontier Railway Head Quarter Building

Maligaon, Guwahati, Assam

Submitted by

Energy Management Cell

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FOR

Government of Assam

Inspectorate of Electricity

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BACKGROUND

Energy is a basic requirement for economic development in almost all major sectors of Indian economy i.e. agriculture, industry, transport, commercial, and residential (domestic). Consequently, consumption of energy in different forms of energy has been steadily rising all over the country, which has maintained a steady growth pattern in the past and the trend is likely to continue in future as well. This has increased the dependence of the state on fossil fuels and electricity.

Considering the vast potential of energy savings and benefits of energy efficiency, the Government of India enacted the Energy Conservation Act, 2001 in October 2001. The Energy Conservation Act, 2001 became effective from 1st March, 2002. The Act provides for institutionalizing and strengthening delivery mechanism for energy efficiency programs in the country and provides a framework for the much-needed coordination between various government entities.

As per the EC Act, Government of India established "**Bureau of Energy Efficiency" (BEE)** with the Mission to develop policy and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act (EC Act), 2001 with the primary objective of reducing energy intensity of the Indian economy. Among the key stakeholders are the "**State Designated Agencies" (SDAs)** established by State Governments in consultation with BEE with the responsibility to implement the Act within the state through various regulatory and promotional instruments.

"Office of the Chief Electrical Inspector-cum-Adviser, Government of Assam" has been declared as the State Designated Agency (SDA) to coordinate, regulate and enforce the Energy Conservation Act-2001 within the state of Assam. The role of Assam State Designated Agency **(ASDA)** is to create general awareness among masses about the importance and benefits of energy conservation measures and also to institutionalize the energy efficiency project implementation in the industry, govt. building & commercial buildings.

Besides these activities, a nationwide programme of "**Investment Grade Energy Audit" (IGEA)** of 500 Government Buildings is proposed by BEE to be completed during the financial year 2008-2009. Out of which 10 Government/Public Sector Buildings is in the state of Assam. Bureau of Energy efficiency is providing financial support for these audits through the SDAs.

It is expected that the owner of these buildings will implement energy efficiency measures recommended by this audit either from their own resources or through **"Energy Saving Companies"** (ESCO) route.

ACKNOWLEDGEMENT

We wish to place on records our thanks to Assam State Designated Agency (ASDA); Office of the Chief Electrical Inspector-cum-Adviser, Guwahati, Assam for offering M/s Blue Star Limited **"Investment Grade Energy Audit of 10 Government / Public Buildings"** in the state of Assam.

We also would like to thank the nodal officer/incharge: The Chief Engineer (E), Superintendent Engineer (E), NEF Railway, Maligaon, Guwahati and all the individuals who had involved themselves directly and indirectly in the smooth and successful completion of the Investment Grade Energy Audit Study at **"North East Frontier Railway Head Quarter Building, Maligaon, Guwahati".**

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1.0 EXECUTIVE SUMMARY

This Investment Grade Energy Audit was conducted for North East Frontier Railway Head Quarter Building, Maligaon, Guwahati. This report comes to you after a detailed study of existing system & their performance level study.

In totality findings of the study are summarised as follows:

- Annual energy consumption of the facility is around **20.64 Lacs of Units**.
- Annual energy bill of the facility is around **Rs. 94.78 Lacs.**
- Investment grade energy audit reveals various measures for Energy Conservation: Around **99,467 units** of electrical energy per annum can be saved.
- Around **Rs. 4.92 Lacs** of savings per annum with an investment of **16.33 Lacs**. Hence overall simple payback of **3.31 years**.
- Adopting many good engineering practices as suggested in Section-9.0 towards energy conservation in building.
- Incorporating Building Management System will allow monitoring and maintaining various operating parameters of equipment on an on-going real time basis. Further, this system allows access to all technical information; thereby enabling trained experts to take corrective measures remotely.
- The proposals identified are based on Investment Grade Energy Audit carried out with an objective of energy conservation and system up-gradation.

All the recommendations and proposals are summarized in table below, giving you a bird's eye view of annual savings expected, investment recommended and simple pay back for each proposal.

Table 1 : Investment Grade Energy Conservation Measures (ECM)

Sr.	Ref	Energy Conservation Measures (ECMs)	Annual Energy Consumption by identified segment (kWh)	Annual Energy Savings (kWh)	% Savings (kWh)	Annual Energy Cost Savings (Rs.)	Investment Required (Rs.)	Payback Period (Years)
1	7.1	Replacement of FTL to T5 lamps	2,25,436	91,447	40	4,57,236	15,33,750	3.4
2	7.2	Installation of LED based signage in place of FTL based signage	8,199	6,559	80	27,878	1,00,000	3.6
Total			**2,33,635**	**98,007**	**42**	**4,85,114**	**16,33,750**	**3.36**

Table 1 B : Without Investment Grade Energy Conservation Measures (ECM)

Sr.	Ref	Energy Saving Opportunities	Reduction in Energy Consumption	Cost reduction	Investment required	Pay Back Period
			kWh	Rs/annum	Rs.	Years
1	7.3	Reduction of no load losses by charging one transformer at main during the month November and March	1,460	7,300	Nil	Immediate
Total			**1,460**	**7,300**	**Nil**	**Immediate**

2.0 SCOPE OF WORK

2.1 Review of present electricity, fuel oil & estimation of energy consumption exploring the Energy Conservation Options (ENCON) in various load centers like lighting, Air Conditioning, Water Pumping etc.

2.2 Electrical Distribution System

2.2.1 Review of present electrical distribution like single line diagram, transformer loading, cable loading, normal & emergency loads, electricity distribution in various areas/floors etc.

2.2.2 Study of Reactive Power Management and option for power factor improvement.

2.2.3 Study of Power Quality like Harmonics, current unbalance, voltage unbalance etc.

2.2.4 Exploring energy conservation option in electrical distribution system.

2.3 Lighting System

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2.3.3 Detail lux level survey at various locations and comparison with acceptable standards.

2.3.4 Study of present lighting control system and recommended for improvement.

2.3.5 Analysis of lighting performance indices and comparison with norms of high rise buildings.

2.3.6 Exploring Energy Conservation options in lighting system.

2.4 Heating, Ventilation & Air-Conditioning (HVAC) System

2.4.1 Review of present HVAC system like central AC, window AC, split AC, package AC, water coolers and air heaters.

2.4.2 Performance assessment of window AC, split AC and packaged AC system.

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2.4.4 Analysis of HVAC performance like estimation of Energy Efficiency Ratio (EER) i.e. kW/TR, Specific Energy Consumption (SEC) of chilled water pumps, condenser water pumps, AHUs etc. and comparison of the operating data with design date.

2.4.5 Exploring Energy Conservation Option (ENCON) in HVAC system.

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2.6.1 Review of water pumping, storage and distribution systems.

2.6.2 Performance assessment of all water pumps i.e. power consumption vs flow delivered, estimation of pump efficiency etc.

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2.7.1 Performance assessment of hot water generators or Thermic fluid heaters like estimation of efficiency etc.

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2.8.1 Conducting the motor load survey of all drives to estimate the % loading.

2.8.2 Exploring ENCON options in electrical drive system.

2.9 Energy Monitoring & Accounting System

2.9.1 Detail review of present energy monitoring & accounting systems in terms of metering, record keeping, data logging, periodic performance analysis etc.

2.9.2 Recommendation for effective energy monitoring & accounting system.

2.10 Others

2.11 Review of present maintenance practice, replacement policies and building safety practices as applicable as applicable to high rise buildings and recommend for improvement.

3.0 METHODOLOGY ADOPTED FOR INVESTMENT GRADE ENERGY AUDIT (IGEA)

Step 1 - Interview with Key Facility Personnel

During the initial audit, a meeting is scheduled between the auditor and all key operating personnel to kick off the project. The meeting agenda focuses on: audit objectives and scope of work, facility rules and regulations, roles and responsibilities of project team members, and description of scheduled project activities.

In addition to the administrative issues, the discussion during this meeting seeks to establish: operating characteristics of the facility, energy system specifications, operating and maintenance procedures, preliminary areas of investigation, unusual operating constraints, anticipated future plant expansions or changes in product mix, and other concerns related to facility operations.

Step 2 - Facility Tour

After the initial meeting, a tour of the facility is arranged to observe the various operations first hand, focusing on the major energy consuming systems identified during the interview, including the architectural, lighting and power, mechanical, and process energy systems.

Step 3 - Document Review

During the initial visit and subsequent kick-off meeting, available facility documentation are reviewed with facility representatives. This documentation should include all facility operation and maintenance procedures and logs, and utility bills for the previous two or three years.

Step 4 - Facility Inspection

After a thorough review of the construction and operating documentation, the major energy consuming processes in the facility are further investigated. Where appropriate, field measurements are collected to substantiate operating parameters.

Step 5 - Utility Analysis

The utility analysis is a detailed review of energy bills from the previous 12 to 36 months. Billing data reviewed includes energy usage, energy demand and utility rate structure. The utility data is normalized for changes in climate and facility operation and used as a baseline to compute projected energy savings for evaluated ECM's.

Step 6 - Identify/Evaluate Feasible ECMs

Typically, an energy audit will uncover both major facility modifications requiring detailed economic analysis and minor operation modifications offering simple and/or quick paybacks. A list of major ECMs is developed for each of the major energy consuming systems (i.e., envelope, HVAC, lighting, power, and process). Based upon a final review of all information and data gathered about the facility, and based on the reactions obtained from the facility personnel at the conclusion of the field survey review, a finalized list of ECMs (energy conservation measures) is developed and reviewed with the facility manager.

Step 7 - Prepare a Report Summarizing Audit Findings

The results of our findings and recommendations are summarized in a final report. The report includes a description of the facilities and their operation, a discussion of all major energy consuming systems, a description of all recommended ECMs with their specific energy impact, implementation costs, benefits and payback. The report incorporates a summary of all the activities and effort performed throughout the project with specific conclusions and recommendations. The recommendations that are presented in the report will be discussed with ASDA/Facility Owners in order to help them in making a decision on which ECMs to be implemented.

ECMs – Energy Conservation Measures

4.0 BUILDING DESCRIPTION

North East Frontier Railway Head Quarter is a Complex consisting of several buildings. The following Tables show the basic information about the buildings and the utilities.

Table 2: Basic Information about the Buildings

Basic Building Data			Unit
No.	**Item**		**Value**
1	Connected Load (kW) or Contract Demand (kVA)		600 kW
2	Installed capacity: DG/ GG Sets (kVA or kW)		1140 kVA
3	a) Annual Electricity Consumption, purchased from Utilities (kWh)		2064340 kWh
	b) Annual Electricity Consumption, through Diesel Generating (DG) Set (kWh)		63648 kWh
	c) Total Annual Electricity Consumption, Utilities + DG Sets (kWh)		2127988 kWh
4	a) Annual Cost of Electricity, purchased from Utilities (Rs.)		9478127 Rs.
	b) Annual Cost of Electricity generated through DG/GG Sets (Rs.)		486286 Rs.
	c) Total Annual Electricity Cost, Utilities + DG/GG Sets (Rs.)		9964413 Rs.
5	Area of the building (exclude parking, lawn, roads, etc.)	Built Up Area (sq. ft. or sq.m.)	20215 sq.m
		o Conditioned Area	4005 sq.m
		o Non Conditioned Area	16000 sq. m
6	No. of Buildings inside the Complex : Canteen, Central Control, CSC Office, CPO Main, FA & CO Building, GM Building, CMD Building and CEE Office		
7	Working hours (e.g. day working /24 hour working)		9 hours
8	Working days/week (e.g. 5/6/7 days per week)		5 Days
9	Installed capacity of Air Conditioning System	a) Centralized AC Plant (TR)	NA
		b) Window ACs (TR)	319.5 TR
		c) Split ACs (TR)	81 TR
		d) Total AC Load (TR)	400.5 TR
10	Installed lighting load (kW)		100 kW
11	Water consumption in the building	Water consumption per month (exclude consumption for garden, lawn, etc.) (kilo liters)	52000 KL
12	Whether sub-metering of electricity consumption for Air Conditioning, Lighting, Plug Loads, etc. done: Yes/No		No

5.0 PRESENT ENERGY SCENARIO

5.1 Review of Present Electricity, Fuel Oil & Estimation of Energy Consumption in various Load Centres

At present the overall energy consumption is catered by the Electricity supply from **A**ssam **S**tate **E**lectricity **B**oard. Electricity is received at 11 KV and step-down to 0.433 KV with the help of four nos. 11 / 0.433 KV distribution transformer of capacity 500 kVA each located outskirts of the building.

5.1.1 Electrical Energy Consumption

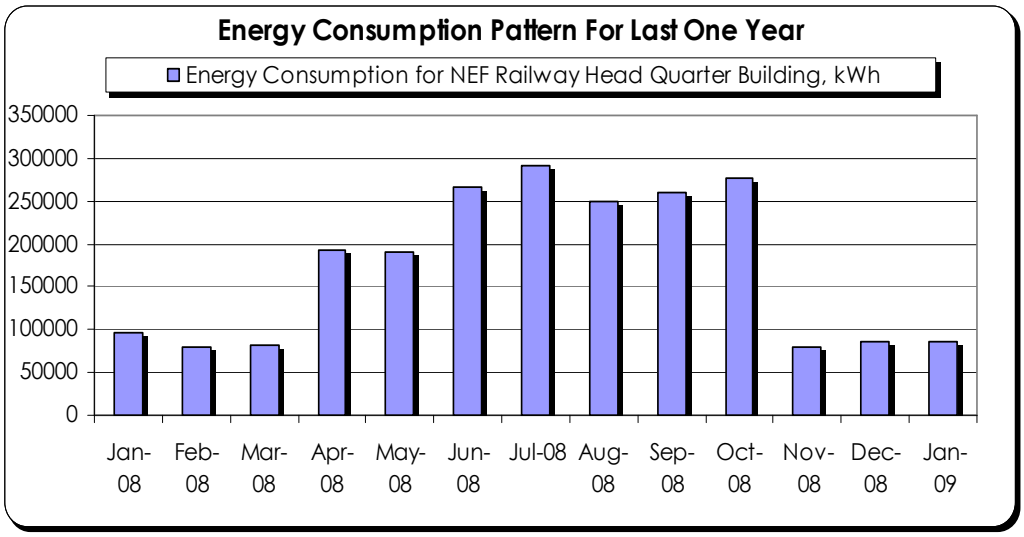
Total sanction load from Electricity Board is 600 kW. Energy Bill to the building is monthly. Details of the Energy Bill are shown in Annexure-1. Summary of the Energy Bill from Month of January-2008 to January -2009 is shown in Table-3.

Table 3: Summary of Energy Bills:

S. No	Description	Value	Units
1	Monthly Average Consumption	1,72,028	kWh/month
2	Monthly Average Energy Cost	7,89,843	Rs/month
3	Annual Average Energy Consumption	20,64,340	kWh/annum
4	Annual Average Energy Bill EB only	94,78,127	Rs/annum
6	Contract Demand	600	kW
7	Average P.F maintained	Above 0.9	

Note: The above values are based on average energy consumption from Month of January-2008 to January-2009 Electricity Bill. The variation in energy consumption is shown in Fig-1.

Fig 1: Variation in Energy Consumption over a period of one Year



The above figure shows the trend of monthly energy consumption of NF Railway Head Quarter Building starting from January-08 to January-09. There is sharp rise in the energy consumption between April and October. This pattern is observed because the Air Conditioners are switched off during the winter, from November to March.

5.1.2 Thermal Energy Consumption

Not Applicable.

5.1.3 Energy Consumption in various Load Centres

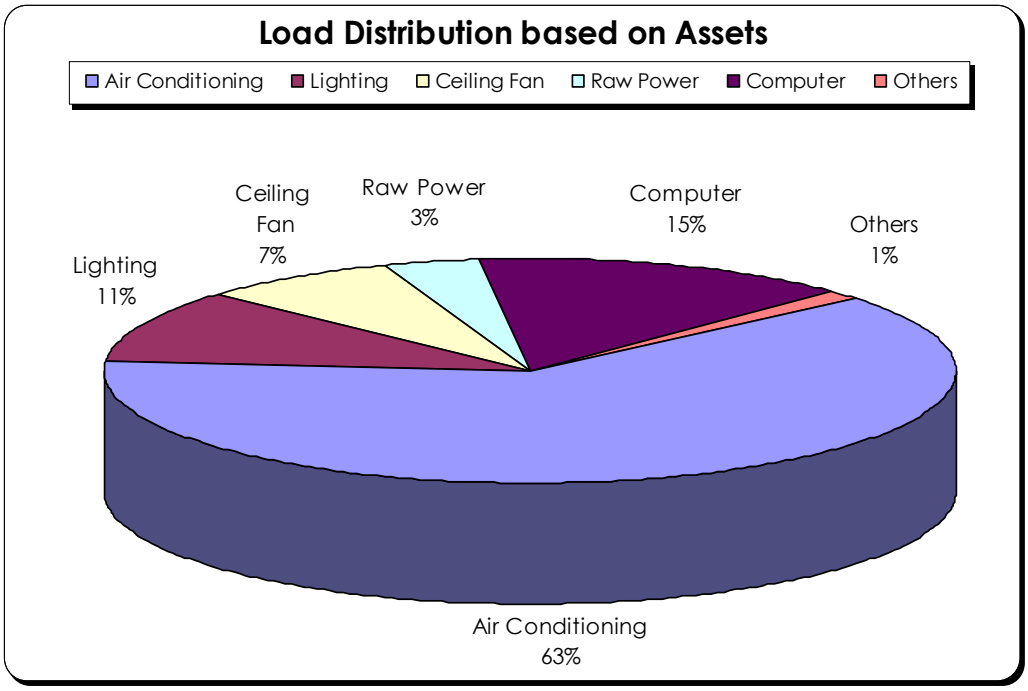
The major energy consuming equipments available in the building are

- Air Conditioners- Window and Split Units
- Lighting System- General and Campus Lighting System
- Water pumps
- Ceiling Fans

- Other Electrical Equipments such as Refrigerators, Television, Computers, Printers, Water coolers and photo copying machines etc.

During the investment grade energy audit, power measurements were carried out building/block/circle wise. Details are shown in Annexure-2. The break-up for Load distribution is shown in Fig-2.

Fig-2: Load Distribution at NF Railway Head Quarter Building, Guwahati



Note: Raw Power is the total consumption of Refrigerators, Televisions, Computers, Printers, Water coolers and photo copying machines etc.

6.0 PERFORMANCE EVALUATION, OBSERVATION AND ANALYSIS

6.1 ELECTRICAL DISTRIBUTION SYSTEM

There are four transformers of capacity 500 kVA each supplying power to entire campus. Three separate power distribution lines from three transformers cater the electrical energy requirement for the essential load and separate distribution line from a single transformer caters the electrical energy requirement for non-essential load.

6.1.1 Performance Evaluation of Transformer

Transformers have very high efficiencies (98% and above), as their losses are very low. Higher size transformers have low percentage losses and hence they are more efficient. Study of Transformer Load (Voltage, current, Power & P.F.), of all Transformers inside the Building has been carried out during the Investment Grade energy Audit with the help of power analyzer.

Observations:

- Present loading on Trnasformer-1 is 33.3%, Transformer-2 is 17.8% and Transformer-4 is 16.5%.
- The supply from the secondary of Transformer-3 was disconnected during the Investment Grade Energy Audit.

Comments:

- Disconnecting Transformer-3 from 11 kV main during the period November to February will save the no load loss.

6.1.2 Study of Reactive Power Management

Power Factor plays an important role in the fixation of Monthly Electricity Bill. Higher Power Factor reduces the system I^2R losses, KVA demand and increases the voltage level. Additionally maintaining higher power factor tends to rebate on energy charges and vice versa.

Observations:

- Average Power factor maintained at NEF railway Head Quarter Building is above 0.9.

Comments:

- Present Actual Power Factor can be increased to unity in order to get Maximum Demand Reduction, System Loss Reduction and gain rebate on energy charges.

6.1.3 Study of Power Quality

Study of Power Quality Parameters i.e. Instantaneous Total Harmonics Distortion and Voltage unbalance at main incomer (Transformer Secondary) are measured with the help of 3-phase power quality analyzer. The summary of the detailed measurements are shown in Table-4.

Table-4: Measured Power Quality Parameters

Sr.	Description	Value	Limit
1	Total Voltage Harmonics Distortion (Vthd)*	1.10%	5%
2	Voltage Unbalancing**	0.05%	<1 %

*** * Recommended Limits by IEEE-519-1992**

Observations:

- Total Voltage Harmonics Distortion (Vthd) is 1.1%.
- Voltage unbalance was found 0.05%.

Comments:

- Total Voltage Harmonics Distortion is within the limit.
- Total Voltage unbalance is within the limit.

6.2 LIGHTING SYSTEM

6.2.1 Review of Present Lighting System

Lighting contributes about 11% of energy consumption of the building. The building is mainly consisting of 36/40W Fluorescent Tube Lights (FTLs) and CFLs to illuminate the workplace. Campus lighting consists of 38 nos. of CFL based street lighting (24Wx4 nos.) each. The details of the lighting fixtures are shown in Table-5.

Table-5: Lighting Fixtures available at Bijuli Bhawan

Equipment	No's	Rating	Ballast
Fluorescent lamps	1045	40 W	Magnetic
	1000	40 W	Electronic
CFL	106	15 W	
CFL based street Light	38	96 W	

6.2.2 Estimation of Lighting Load

Lighting contributes about 11% of energy consumption of the building.

6.2.3 Lux Level Survey

Location/Floor wise Lux (Lumens/sq. met) level was measured and the details are shown in Annexure-3.

Observations:

- Illuminance levels of all the areas are within recommended limit.
- During our audit we observed that there is adequate day lighting, especially in office areas.

Comments:

- Switching off lights during the day time may not possible due to the nature of working environment , however to inculcate discipline and sense of participation in the energy conservation movement, any unnecessary lighting during day period should be avoided.

6.2.4 Lighting Control System

At present lighting control is manual. According to the requirement, the lighting systems of all floors/cabins/offices/conference hall/multipurpose hall are switching on/off.

Observations:

- Office lights are on at morning 10 AM and off at evening 5 PM.

Comments:

- Installation of occupancy sensors so that the lighting systems are controlled by this occupancy sensor. As and when there is no executive inside the cabin, the occupancy sensor will switch off all the lights inside the cabin thus eliminating human intervention in doing so.

6.2.5 Lighting Performance Indices

Lux (Lumens/sq. mt.) and Lighting Power Density (Watt/Sq. Ft) are the performance indicators for assessment of lighting system.

Observations:

- Lux level of all areas is within recommended limit.
- Overall Lighting Power Density (Watt/Sq.ft) is within specified limit (<1).

Comments:

- Replacement of present installed Fluorescent Tube Lights with T-5 Lamps will reduce the lighting energy consumption without affecting the present lux level.

6.3 STUDY OF HEATING, VENTILATION & AIR CONDITIONING SYSTEM

6.3.1 Review of Present HVAC System

Air conditioning requirement at NEF Railway Head Quarter Building, Guwahati is catered by 213 nos. of Window Air Conditioner of capacity 1.5 TR Each, 33 nos. of Split Air Conditioner of capacity 2 TR each and 5 nos. of Cassette Air Conditioner of capacity 3 TR each. These air conditioners contribute 63% of the total average annual energy consumption.

6.3.1 Performance Assessment of Window & Split Air Conditioning System:

Measurements were carried out to determine the present TR delivered and the specific energy consumption (**kW/TR**) of the Air Conditioning Units.

DBT/WBT of discharge air and return air were measured, and so was the suction airflow rate. These measurements were taken at various point of time. Based on these measurements, the actual TR delivered was calculated. The corresponding power consumption by the unit was then measured to ascertain the specific energy consumption. Performance measurements of Window units are given in Annexure-4.

Observations:

- The specific Energy consumption (kW/TR) of the Window AC units is in between 1.12 to 1.7 except a couple of Window & Split AC units.
- Return air filters are choked in few Window and Split Air Conditioners.

Comments:

- The specific Energy Consumption (kW/TR) is quiet acceptable by considering the age and condition of the air conditioning units.
- As a replacement policy, replacing the window/split air conditioning units more than 10 years old with four/five star rated AC units will reduce the present energy consumption for ACs.

6.4 DIESEL GENERATOR (DG) SET

6.4.1 Review of DG Set Operation

There are three nos. of D.G Set of capacity 380 kVA each installed at NEF Railway Head Quarter Building. D.G Sets are in operation during power failure and supplies to the specific areas. Measurements were carried out in order to find out the present specific power generation ratio (kWh/Lit). The detailed performance analysis is shown in Annexure-5.

Observations:

- The specific power generation ratio for the DG Set-1(Old) is 2.21 kWh/Lit.
- The specific power generation ratio for the DG Set-3 is 3.33 (New) kWh/Lit.
- The specific power generation ratio for the DG Set-3 (New) is 3.26 kWh/Lit.

Comments:

- By considering the age and percentage loading of the DG; performance is quiet ok.

6.5 WATER PUMPING SYSTEM

Not Applicable.

6.6 THERMIC FLUID HEATERS/BOILERS

Not applicable.

6.7 MOTOR LOAD SURVEY

Not applicable.

6.8 ENERGY MONITORING & ACCOUNTING SYSTEM

6.8.1 Review of Present Energy Monitoring and Accounting System:

Observations:

- Electrical maintenance team at NEF Railway Head Quarter Building is maintaining a practice to record the total monthly energy consumption from the energy meter installed at LT side for electricity billing purpose.

Comments:

- Adoption of Building Management System (BMS) will bring the operation of the entire facility in a single window. Benefits of BMS system is shown in Section -10.
- We recommend the Building maintenance team to install energy meters at following locations and monitor them regularly which are shown in Table-7.

Table-7: Recommended Energy Meters to be installed

Sr.	Location	No of Meters to be installed	Parameters to be Monitored	Frequency of Monitoring
1	Lighting Panel (Building Wise)	7	kWh,kVA,kW, p.f, Voltage and Current	Every day at 11AM and 6 PM
2	LT side (Building Wise)	7	kWh,kVA,kW, p.f, Voltage and Current	Every day at 11:00 AM and 6:00 PM
4	Transformer Secondary Panel	4	kWh,kVA,kW, p.f, Voltage and Current	Every day at 11:00 AM and 6:00 PM

6.9 Others

6.9.1 Review of Present Maintenance Practice, Replacement Policies & Building Safety Practices

Observations:

- Maintenance Team at NEF Railway Head Quarter Building is following a standard maintenance practice for the electrical utilities.

Comments:

- It is advised to follow a regular maintenance practice for all the utilities like window/split air conditioners, pumping system, lighting system, control devices etc on quarterly/half yearly basis. The details of maintenance practices are shown in Sention-9.
- Maintenance team should make a standard policy for the replacement/ up gradation of the existing technology for the utilities with energy efficient system.

7.0 ENERGY CONSERVATION MEASURES:

7.1 Replacement of 40 Watt Fluorescent Tube Light with T5 Tube Lights

Background:

The lighting requirement at NEF railway Head Quarter is met by fluorescent light of 40W with magnetic ballast and electronic ballast, CFL Lamps and very few nos. of GLS Lamps. The lighting is contributing about 11% of the total building energy consumption.

Recommendation:

At present T5 lamps are available which gives 10 to 15% more lumens/Watt than standard FTL. The energy saving that can be expected by replacing the existing FTL with T5 lamps are given in Table-8.

Table-8: Energy saving calculation for Section 7.1

Description	Quantity	Unit
Present Wattage of single Fluorescent Tube Light with magnetic ballast	50	W
Proposed T5 Tube Light Wattage with Electronic ballast	28	W
Present Total Lighting energy consumption is 11% of total energy consumption of building	2,25,436	kWh/annum
Expected savings in Lighting after replacing 2045 no FTLs (40W Tube with magnetic & electronic ballast) with T5 Tube lights(28W T5 Tubes with inbuilt electronic choke)	91,447	kWh/annum
Expected reduction in energy cost after replacing with T5 lights considering overall energy cost Rs. 5.0 per unit, 260 working days per annum and 9 hours operation per day	4,57,236	Rs/annum
Investment required for replacing existing fitting with T5 fitting	15,33,750	Rs.
Simple payback period	3.4	Years

7.2 Installation of LED Based Signage in place of FTL based Signage

Background:

NF Railway Head Quarter Building has Fluorescent Tube Lights for their signage. These are lighting up from 6:00 PM to 6: 00 AM. NEF Railway Head Quarter Building has three numbers of signage: one in English, second one is in Assamee and third one is in Hindi displaying North East Frontier Railway during Night hours.

Recommendation:

Light Emitting Diodes (LEDs) are new type of lighting technology which is far more efficient than FTL lighting especially for signage purpose. The energy saving that can be expected is between 80 and 90% of energy consumed by FTLs. Cost benefit analysis of this proposal is shown in Table-9.

Table-9: Energy saving calculation for Section-7.2

Description	Value	Unit
Present Power consumption of FTL Lamps for three signage board	1.872	kW
Expected power savings by installing LED Lamps	80%	%
Expected power savings	1.497	kW
Hours of operation per day 6 PM to 6 AM	12	Hours
Days of operation	365	Days
Expected energy savings	6,559	kWh/annum
Expected cost reduction per annum	27,878	Rs/annum
Investment required	100,000	Rs.
Simple payback period	3.6	Years

7.3 Reduction in no load loss by charging one Transformer at Main

Background:

At present one transformer (No-3) of 500 kVA is dedicated for non-essential load i.e. for Air Conditioning. During the month November to February; the secondary is disconnected from the main control panel of the non-essential load and again connected for rest of the months. During the month November to February; this transformer is in charging condition in spite of secondary is disconnected.

Recommendations:

We recommend to disconnect the supply from the 11 kV main and switched off the transformer-3 for the mentioned months November to February which will tend to save the no load loss of the transformer itself. The energy saving calculation is shown in Table-10.

Table-10: Energy saving calculation for Section-7.3

Description	Value	Unit
Present no load loss for Transformer-3 of capacity 500 kVA	400	Watt
Annual Energy loss(no load) of Transformer-3 considering 24 hours a day and 365 days in a year of charging which is dedicated for Air Conditioning Load	3,504	kWh
Annual Energy saving by disconnecting Tranformer-3 from main 11 kV supply between the month November to February	1,460	kWh
Annual Energy cost saving by disconnecting Tranformer-3 from main 11 kV supply between the month November to February	7,300	Rs
Expected investment	Minor	
Payback period	Immidiate	

8.0 SUMMARY

8.1 Outcome of the Study

- Three Proposals have been identified for possible energy savings; out of which two proposals required investment and last proposal is without investment.
- Energy saving potential of about **99,467 kWh**/ year can be realised by implementing the proposals 7.1, 7.2 & 7.3 which will save approximately **Rs. 4, 92, 414**per Annum.
- The implementation would require an one time investment of about **Rs. 16, 33, 750** to reap the benefits and will get pay back in **about 3.3 Years.**

8.2 Approach to Energy Conservation

- Each energy conservation proposal should be given a top priority to achieve energy savings.
- All the implemented proposals are to be monitored on a proposal-by-proposal basis for quantifying the actual achievement of savings obtained on a monthly basis.

8.3 Specific Action Plan

- Specific target date for implementation for the proposals shall be made at the earliest after the submission of this report.
- The identified proposals shall be prioritized in a phased manner based on investment, payback period and other benefits.
- Low Cost Measures can be implemented immediately followed by other proposals.

Note:

While carrying out the Economics of the Energy Conservation Proposals care has been taken to estimate the monetary savings as near realistic as possible. However, the likely investment mentioned in the economic valuation are only indicative in nature as it involves many extraneous factors like quality, price fluctuation, brand name, availability etc.

9.0 GOOD ENGINEERING PRACTICES

9.1 GUIDELINES FOR ENERGY MANAGEMENT IN COMMERCIAL BUILDINGS:

9.1.1 Illumination:

- Natural light should be used as far as possible. Especially artificial light is not required in staircases during daytime. Use of blinders to block the sunlight should be minimized. This will allow utilization of day light without causing significant glare.
- Whenever design requires, single tube-lights should be used instead of using twin tube fittings everywhere.
- While designing the illumination system, care should be taken so as the lights in each area can be switched off partially when not in use. (e.g. The illumination level required for working on computers is 200 - 300 lux, but when the area is not used for work illumination level of 150 lux is sufficient. (This can be achieved by switching off some of the lights.)
- Also proper naming or numbering of the switches will facilitate the use of them by occupants or security staff.

9.1.2 Use of Efficient Lighting Technology

- In most of the area 40-watt old tube-lights are used, while replacing them more efficient tube-lights should be used. These tube-lights have efficacy of more than 90 lumens/watt as compared to 65-70 lumens/watt of the existing tube-lights.
- Replacing the existing conventional chokes either by low loss chokes or electronic ballast can reduce the ballast losses from 10-12 watts to 3-7 watts. Before selecting the electronic ballast, following factors should be considered.
- Effect of harmonics, ability of ballast to suppress harmonics or surges.
- Ability of twin tube ballast to work with single tube-lights is essential, so that even in case of failure of single tube ballast should work with single tube.

- Losses of the ballast. Although some manufacturers claim of having ballast losses of 2-3 watts, a testing certificate should be asked to produce before purchasing.

9.1.3 Heat Load on Air-Conditioning

- Reduce the load by minimizing the thermal conduction & air infiltration.
- To reduce the heat load on AC system due to the solar heat gain through windows, double glazed windows should be used for future applications & present windows should be retrofitted with a good quality sun protection film.
- Some additional load reduction strategies can be used like window shedding or tree planting outside the office buildings. For new buildings, under construction use of hollow concrete bricks should be done to maximize the insulation of walls. Special care should be taken for providing insulation for roof. This will reduce the solar heat load considerably.
- Best of the windows have less ability to block solar gain as compared to worst of the walls, so if the designer & interior decorator are not planning to utilize the daylight, then window area can be reduced. This will certainly help in reducing total heat load.
- Any leaks in the building envelope should be sealed. E.g. cracks in windows or weather striping.
- Air ducts should have proper insulation, dead ends should be eliminated.
- Keeping doors and windows closed can reduce A/C power consumption. Use of air curtains or lobbies at the entrances, will also help in reducing A/C power consumption.

9.1.4 Electricity Bill Reduction

- To reduce the peak demand of power supply, scheduling of the non-critical tasks (e.g. running of water pumps) to off peak hours is advisable. The maximum demand has a direct impact on the billing.

The State Electricity Boards charges tariffs, by taking into account the power demand. Thus reducing the peak demand will help in reducing monthly charges.

- Due to addition of new loads, the PF (Power factor) may drop. Precautionary steps should be taken to maintain power factor above 0.95 in order to reduce the maximum demand.
- Where the power supply quality is not good & there are too many power cuts, then possibility of having a DG set for power supply can be evaluated. Also due to the government promotional efforts solar energy may also turn out to be a feasible alternative.

9.1.5 Preventive Maintenance

- Inspect & monitor equipment operations. Maintain regular operation & maintenance log for major equipment.
- Fix minor problems before they result in major repairs. For this regular inspection of all equipment by trained staff is necessary.
- If necessary maintenance shutdown should be taken at least once in 6 months. During this wiring, contacts & other components should be thoroughly inspected for voltage imbalance, loose connections or self-heating.
- If major repairs are required, evaluate the economic benefit of replacing the old equipment with more efficient and compact equipment before doing the repairs. Such study should be done well in advance, so that in case of breakdown a decision can be taken quickly.
- Adjust schedules to keep all equipment on only when necessary.
- Adjust temperature & humidity set points for AC within comfort zones seasonally.
- Use night setback temperature during unoccupied hours.
- Thermostats should be calibrated after regular interval & replace inaccurate gauges & thermometers.
- Ducting arrangement for A/C should be checked periodically for leakage & it should be cleaned. Filters, condenser tubes, cooling

towers should be regularly cleaned, so that the system can work at the designed efficiency.

- A bimonthly cleaning schedule for lighting fittings (lamps & reflectors) should be prepared, so that the lumen loss due to dirt accumulation & environmental impact can be avoided. In addition, this information should be provided to the illumination designer, to enable him to consider a higher maintenance factor while designing the lighting system.
- As a thumb rule for fluorescent lamps, group replacement of lamps can be used to keep the system operating near peak o/p & efficiency. It is proved that the economic replacement can be done at 70% - 80% of the lamps rated life. The replacement interval in years can be calculated by dividing useful operating life in hours by annual operating hours.

9.1.6 Training & Awareness

- Maintenance & operating staff should be trained / informed about the energy management issues & procedures.
- To implement an effective preventive maintenance program, the operational staff must be given comprehensive training on each type of equipment, regarding system fundamentals, use of reference material & manuals, maintenance procedures, service guidelines & warranty information.
- Proper maintenance schedules could be supplied to them for different equipment.

9.1.7 Other Savings

- New computers available in the market offer built in power saving modes. These monitors are called as Energy Star compliant monitors. However, it was found that most of the users are not aware of this facility. Therefore, steps should be taken to inform every one of this & any such future options.

- This example emphasizes the fact that proper employee training or awareness is necessary for success of any energy management initiative.
- Switches for computers should be made more accessible, so that employee can turn off their terminals when not in use.
- If found economical, then meters should be installed to monitor energy use. This will help in preventive maintenance, in identifying energy management opportunities. Proper metering also helps to allocate energy costs to various cost centers.

10.0 BUILDING MANAGEMENT SYSTEM

Automation is the buzzword in today's technically advanced and progressive which will bring the operation of entire facility through single window. It allows you to monitor and maintain various operating parameters of your equipment on an on-going real time basis. Further, this system allows access to all technical information; thereby enabling trained experts to take corrective measures remotely. This facility prevents expensive and unforeseen breakdown and enhance the performance, helping you get the best from your air conditioning system. This facility will also pave the way for energy savings.

Benefits:

- Centralized control of equipment located anywhere.
- Operation by trained personnel.
- Data analysis and condition monitoring
- Performance enhancements resulting in energy savings.
- Required report generation.
- Looks after the air conditioning system on 24x7 basis.
- Predictive maintenance.
- Reduction of down time and lower life cycle costs.

Annexure 1A – Energy Bill (Jan-08 to Jan-09)

Month	Energy Consumption for Total NEF Railway, kWh	Energy Consumption for NEF Railway Head Quarter Building, kWh
Jan-08	1908727	95436
Feb-08	1598227	79911
Mar-08	1655669	82783
Apr-08	1926368	192637
May-08	1901440	190144
Jun-08	2224214	266906
Jul-08	2423937	290872
Aug-08	2069868	248384
Sep-08	2171783	260614
Oct-08	2311493	277379
Nov-08	1597031	79852
Dec-08	1715283	85764
Jan-09	1713711	85686

Annexure 2: Power Measurement

Sr.	Description	Phase	V	I	PF	kW	Total kW
1	Transformer no-2	R	403	137	0.94	89.9	80.0
		Y	400	123	0.89	75.8	
		B	401	115	0.93	74.3	
2	Transformer no-1	R	409	211	0.93	139.0	150.1
		Y	407	257	0.91	164.9	
		B	408	238	0.87	146.3	
3	Transformer no-4	R	427	160	0.89	105.3	74.4
		Y	428	119	0.82	72.3	
		B	422	71.4	0.87	45.4	
4	Transformer no-3	R	During the Audit; Transformer was charged but secondary was disconnected from the supply control panel.				
		Y					
		B					
5	CPO Main	R	229	87.5	0.93	18.6	59.9
		Y	229	103	0.96	22.6	
		B	228	90.7	0.9	18.6	
6	BG Construction	R	230	34.2	0.92	7.2	18.5
		Y	233	33.4	0.9	7.0	
		B	232	19.5	0.95	4.3	
7	GM Building Main	R	237	66.1	0.92	14.4	31.4
		Y	236	44.5	0.88	9.2	
		B	236	35.1	0.94	7.8	

Sr.	Description	Phase	V	I	PF	kW	Total kW
8	SBI/COMD/PSTE/DYCE	R	237	35	0.95	7.9	33.9
		Y	236	71.6	0.89	15.0	
		B	236	48.6	0.96	11.0	
9	SBI ATM	R	237	3.9	1	0.9	2.5
		Y	237	0	0	0.0	
		B	236	7.53	0.9	1.6	
10	CEE/COS/CE/CME/CSTE	R	237	81.8	0.94	18.2	66.4
		Y	237	111	0.91	23.9	
		B	236	121	0.85	24.3	
11	Central Control	R	237	7.84	0.8	1.5	11.9
		Y	236	38.1	0.81	7.3	
		B	237	18.5	0.71	3.1	
12	Canteen	R	236	0	0	0.0	3.1
		Y	236	6.15	0.81	1.2	
		B	236	9.83	0.83	1.9	
13	Sr DEN/MLG/ADE/MLG	R	237	16.2	0.64	2.5	5.5
		Y	236	9	0.85	1.8	
		B	237	6.36	0.83	1.3	
14	Data Center	R	244	16.3	0.93	3.7	12.6
		Y	244	25.4	0.89	5.5	
		B	249	13.9	0.97	3.4	
15	IBM	R	244	25.2	0.77	4.7	9.3
		Y	244	14.7	0.86	3.1	

Sr.	Description	Phase	V	I	PF	kW	Total kW
		B	250	7.33	0.81	1.5	
16	FA & CAO Office	R	243	91	0.81	17.9	32.5
		Y	244	59.9	0.76	11.1	
		B	248	18.7	0.75	3.5	
17	Non Essential Load	R	244	11.7	0.77	2.2	3.4
		Y	244	7.48	0.67	1.2	
		B	248	0	0	0.0	

Annexure-3 Lux Level Measurement

Sr.	Description	Average Lux Level (Lumens/m2)
A	**Railway Canteen**	
1	Canteen-1	126
2	Canteen-2	118
B	**Central Control**	
1	OFC Control	146
2	Railnet	155
3	Datacom	154
4	Digital Electronic	149
5	004A	129
6	003A	134
7	001A	126
8	IPS	143
9	PSICC	115
10	Central Control Room	175
11	Central Committee Room	166
C	**CSC Office**	
1	CSC Office	162
2	Personal Office	171
3	S.K. Barik	140
4	Crime Inteligence Branch	138
D	**CPO**	
	Ground Floor	
1	CPO Hall	161
2	APO/LC	155
3	CPO Office	157
	1st Floor	
1	Room 112	163
	Gzetab	144
	111C	150
	111B	151
	111A	149
	Hall	167
	NFR SA Office	164
E	**FA & CO West Building**	
	Grounf Floor	

Sr.	Description	Average Lux Level (Lumens/m2)
1	Chief Cahairman Office	127
2	Principal Director Audit	120
3	Private Secretary	147
4	Senior Audit Officer	124
5	Deputy Director	158
6	Hall	128
7	Admin Section	122
8	Audit Office	117
9	Prncipal Director Office	133
	First Floor	
1	FA & CO Office Hall	165
2	Computer Room	182
3	Dy. FA	154
4	Dy. CAO	133
5	Sr. AFA PEN & NPS	165
6	Sr. AFA Stores	155
7	Asst. FA Goods & SI	104
8	AFA/EFFA	187
9	Sr. AFA Co-ord	173
10	Dy FA & COA-1	185
11	Dy. CAO-G	169
12	Dy FA-Stores & Workshop	196
	Second Floor	
1	FA & COA Office	134
2	Sr. AFA Budget	177
3	Sr. AFA Books	167
4	Sr. AFA/F (W)	180
5	EU/ACS/BR Hall	147
6	Computer Cell	129
7	AFA(W)	180
8	AFA Finance	199
9	Asst. Finance Advisor	186
10	Sr. AFA/T-1/MLG	178
F	**GM Building**	
	Ground Floor	
1	PF Section	157
2	Law Section	165
3	Chief Public Relation Officer	167

Sr.	Description	Average Lux Level (Lumens/m2)
4	CPTM/MLG	177
5	PA to CPTM	186
6	CA to DSM	146
7	Chief Freight Transport Manager	204
8	J.D.Goswami	170
9	Chief Safety Officer	180
10	Chief Transportation PLG Manager	174
11	General Manager	176
12	Confidential Section	183
	1st Floor	
1	Asst. Sec to Addl. GM	231
2	Add. General Manager	171
3	Principal Private Sec GM	150
4	GM's Secret Cell	168
5	Protocol Officer	162
6	Dy. GM	189
7	GM	245
G	**CMD Building**	
1	Chief Medical Director	191
2	Dr. N.Deka	189
3	Asst. Pharmacy Officer	184
4	Dr. S.K. Brahinea	179
5	Dr. H.S. Mina	187
H	**CEE Office**	
	Grounfd Floor	
1	Chief Electrical Engineer office Hall	133
2	Room 13	155
3	Room 12	140
4	Room 11	137
5	Room 10	133
5	Room 9	135
6	Room 8	147
7	Room 7	122
8	Room 6	144
9	Room 5	154
10	Room 4	147
11	Room 3 (Chief Electrical Engineer)	221
12	Room 1	157

Sr.	Description	Average Lux Level (Lumens/m2)
13	Controller of Stores Office Hall	113
14	Controller of Stores	147
15	PS to COS	165
16	Chief Material Manager-Mechanical	178
17	Chief Material Manager-Sales	152
18	Dy. Chief Material Manager-Sales	174
19	Dy. Chief Material Manager-Diesel	172
20	Dy. Chief Material Manager-Computation	143
21	Dy. Chief Material Manager-E&G	146
22	Dy. Chief Material Manager-C&W	126
23	Dy. Chief Material Manager-IC	108
24	Asst. Material Manager-E&G	128
25	Asst. Material Manager-Diesel	136
26	Asst. Material Manager-IC	114
27	Sr. Material Manager-IC	114
28	Sr. Material Manager-HQ	144
29	Sr. Material Manager-Diesel	130
30	Computer Room	257
	1st Floor	
1	Chief Mechanical Engineer	231
2	Chief Signal & Telecom Engineer	127
3	Dy. CSTE	135
4	Chief signal Engineer	123
5	CSTE/PLG/NFR	152
6	CSTE/HQ	128
7	Chief Signal/Telecom	129
8	SSTE Work	115
9	ASTE	128
10	CME	156
11	CME-WS	141
12	ASSTE-ME	151
13	Sinour Mech. Engineer (Fuel)	125
14	AST ME (Diesel)	136
15	AST ME(C&W)	173
16	Dy. Chief ME (O&P)	142
17	Chief ME (Diesel)	122
18	Dy. CME (C&W)	125

Sr.	Description	Average Lux Level (Lumens/m2)
19	Chief ME (O&P)	153
20	Chief Motive Power Engineer	143
21	Chief ralling Stock Engineer	132
22	Chief workshop Engineer	139
23	CME Confidential Section	179
	Second Floor	
1	Room No-2	125
2	Room No-3	122
3	Room No-4	126
4	Room No-5	165
5	Room No-6	146
6	Room No-7	135
7	Room No-8	120
8	Room No-9	132
9	Room No-10	125
10	Room No-11	120
11	Room No-12	140
12	Room No-13	117
13	Hall	130
14	Room No-14	124
15	Room No-15	130
16	Room No-16	133
17	Room No-17	136
18	Room No-18	132
19	Room No-19	124
20	Room No-20	137
21	Room No-21	152
22	Room No-22	122
23	Room No-23	128
24	Room No-24	141
25	Room No-25	126
26	Room No-26	122
27	Room No-27	125
28	Computer Room	189

Annexure 4: Performance of Window/Split Air- Conditioning Units

Sr.	Description	Flow		Supply		Return		Rated Capacity	Power Consumption	Actual Cooling	Sp. Energy Consumption
		CFM	m3/hr	DBT (oC)	RH (%)	DBT (oC)	RH (%)	TR	kW	TR	kW/TR
1	GM Building 1st Floor(Window AC-1 GM Room)	350.00	594.65	10.9	67.1	23.9	56.8	1.5	1.7	1.44	1.18
2	GM Building 1st Floor(Window AC-2 GM Room)	378.00	642.22	11	70	24	55	1.5	1.7	1.47	1.17
3	GM Building Conference Room AC-1	559.00	949.74	11.6	76	21.9	48.9	1.5	1.63	1.28	1.27
4	GM Building Conference Room AC-2	367.00	623.53	7.6	87.2	22.8	53.6	1.5	1.53	1.43	1.07
5	Digital Telephone Exchange AC-1	339.00	575.96	8.8	76.3	24.1	54.5	1.5	1.66	1.49	1.12

Sr.	Description	Flow		Supply		Return		Rated Capacity	Power Consumption	Actual Cooling	Sp. Energy Consumption
6	Digital Telephone Exchange AC-2	437.00	742.46	11.2	77.8	20.2	60.3	1.5	1.66	1.07	1.56
7	FA & COA's Office-Principal Director's Room AC	235.70	400.45	12.7	72.8	21.9	62.8	1.5	1.70	0.7	2.43
8	FA & COA's Office-Principal Dy. Director's Room AC	249.00	423.05	8.6	75.8	20.8	62.2	1.5	1.5	0.92	1.63
9	Computer Cell	334.00	567.47	8	87	23.6	54	1.5	1.72	1.37	1.26
10	Chief Finance Adviser Room AC	620.00	1053.38	12.2	71.8	24.2	56.2	1.5	1.72	1.29	1.33
11	Dy. FA-II Room AC	435.00	739.07	7	88.1	15.5	74.1	1.5	1.70	1.08	1.58
12	Dy. CAO Room AC	457.00	776.44	12.3	73	20.9	61.1	1.5	1.63	1.18	1.38

Sr.	Description	Flow		Supply		Return		Rated Capacity	Power Consumption	Actual Cooling	Sp. Energy Consumption
13	Dy. FA-CAO/Store/Workshop Room AC	393.00	667.71	11.4	70.2	22.8	60.9	1.5	1.63	1.43	1.14
14	Dy. CAO-G Room AC	328.00	557.27	12.4	69	19.7	61	1.5	1.70	0.73	2.33
15	Dy. FA-CAO/I Room AC	248.00	421.35	12.2	71.1	26.7	56.2	1.5	1.53	1.16	1.32
16	Dy. FA-CAO-Worhshop Room AC	273.00	463.83	10.1	80.7	20.2	62	1.5	1.63	0.77	2.11
17	Computer Cell Budget Section AC	303.00	514.80	11.6	75.2	20.7	60	1.5	1.70	0.8	2.13
18	Data Center Cassete AC-1	932.00	1583.47	12.6	68.1	23.6	53	3	3.38	2.94	1.15
19	Data Center Split AC-1	367.00	623.53	9.2	86.1	24.1	54.1	1.5	1.66	1.45	1.15
20	Data Center Multisplit AC	640.00	1087.36	12.6	72.1	25.4	53.5	3	3.22	2.4	1.34

Sr.	Description	Flow		Supply		Return		Rated Capacity	Power Consumption	Actual Cooling	Sp. Energy Consumption
21	CMD Building-Chief Health Director Room AC	400.00	679.60	11.6	75	22.3	61	1.5	1.72	1.32	1.30
22	Chief Medical Director Room Split AC	320.48	544.50	10.5	78.4	21.9	62.8	1.5	1.83	1.12	1.64
23	CPO Office 1st Floor	358.00	608.24	10.3	83.2	24.1	54	1.5	1.53	1.31	1.17
24	Dy. CPO Head Quarter Office AC	321.00	545.38	11.8	76.2	22.1	63.8	1.5	1.72	1.06	1.62
25	Chief Personal Officer Room AC	373.00	633.73	11.8	73.9	28.7	51.8	1.5	1.63	1.47	1.11
26	Chief Security Commissioner	412.17	700.28	11.2	76.1	23.2	56.1	1.5	1.53	1.4	1.10
27	Central Control Room	335.56	570.12	10.9	70	24.2	55	1.5	1.53	1.34	1.14
28	Central Control Room Hall	341.00	579.36	11.9	76.1	24.3	55	1.5	1.53	1.2	1.28

Sr.	Description	Flow		Supply		Return		Rated Capacity	Power Consumption	Actual Cooling	Sp. Energy Consumption
29	Controller of Store Room split AC	274.00	465.53	10.2	81.9	24.6	56.1	1.5	1.66	1.12	1.49
30	Dy. CMM- C&W Room AC	260.00	441.74	10.3	80.6	28.3	50.5	1.5	1.72	1.34	1.28
31	Chief Electrical Engineer Room AC	330.30	561.18	10	81.8	22.2	60.6	1.5	1.63	1.16	1.40
32	Dy. Chief Electrical Engineer Room AC	313.64	532.87	10.4	80.1	25.8	51.7	1.5	1.74	1.32	1.32
33	CME Office Room AC	304.76	517.79	13.5	78.6	23.4	65.3	1.5	1.72	1	1.72
34	Chief Ralling Stock Engineer Room AC	339.73	577.20	12.6	72.3	24.7	54.1	1.5	1.72	1.19	1.45
35	Chief Communication Engineer Room AC	349.72	594.17	11.5	79.6	26.1	53.8	1.5	1.81	1.46	1.24

Sr.	Description	Flow		Supply		Return		Rated Capacity	Power Consumption	Actual Cooling	Sp. Energy Consumption
36	Chief Signal Engineer Room AC	359.71	611.15	12.5	76.6	23.6	55.9	1.5	1.72	1.11	1.55
37	Conference Room Split AC-1	366.43	622.56	10.1	85.2	24.7	54.7	1.5	1.72	1.45	1.19
38	Conference Room Split AC-1	370.2	628.97	9.2	86.7	23.7	57.1	1.5	1.72	1.48	1.16
39	Room No-20 Window AC	355	603.15	10.9	78.7	24.1	51.9	1.5	1.72	1.22	1.41
40	Room No-18 Window AC	349.72	594.17	11.7	76.9	23.2	56.1	1.5	1.72	1.12	1.54

Annexure 5: DG Performance Evaluation

Description	Quantity	Unit
DG No-4		
Initial Tank level	430	Lit
Final Tank Level	385	Lit
Initial kWh Reading	0	kWh
Final kWh Reading	146.66	kWh
Start time	02:35	PM
End time	03:35	PM
Total hours of operation	1	Hour
Total kWh generated	146.66	kWh
Total Diesel Consumption	45	Lit
Specific Energy Generation Ratio	3.26	kWh/L

Description	Quantity	Unit
DG No-3		
Initial Tank level	625	Lit
Final Tank Level	575	Lit
Initial kWh Reading	0	kWh
Final kWh Reading	166.66	kWh
Start time	03:00	PM
End time	04:00	PM
Total hours of operation	1	Hour
Total kWh generated	166.66	kWh
Total Diesel Consumption	50	Lit
Specific Energy Generation Ratio	3.33	kWh/L

Description	Quantity	Unit
DG No-1		
Initial Tank level	380	Lit
Final Tank Level	345	Lit
Initial kWh Reading	0	kWh
Final kWh Reading	80	kWh
Start time	11:10	AM
End time	11:40	AM
Total hours of operation	30	Min
Total kWh generated	80	kWh
Total Diesel Consumption	35	Lit
Specific Energy Generation Ratio	2.29	kWh/L

Annexure 6: List of Suppliers

(A) List of the CFL & T-5 Lamp Manufacturers/Traders

M/s Osram India Pvt Ltd	Signature Towers ,11 th Floor , Tower -B,South City -1,Gurgaon -122001	Mr Chandan Bhattacharjee Divisional Manager (Display Optics,OEM&UR-IR)	Phone No :0124-4081581 Fax :0124-4081577 c.bhattacharjee@osram.co.in
M/s Asian Electronics Ltd	Surya Plaza ,First Floor , K-185/1,Sarai Jullena, (Near New Friends Colony) New Delhi -110025	Mr DS Bedi General Manager	Mobile No : 9312628768 aeldel@spectranet.com
M/s Havells India Ltd	E-1 ,Sector 59 ,Noida -201307 UP India	Mr Sunil Sikka Sr VicePresident	Phone No : 0120-2477777 Fax : 0120-2477666 sunilsikka@havells.com
M/s Surya Roshini Ltd	Padma Tower-1 ,2 nd Floor , Rajender Place ,New Delhi -110008	Mr B.B Pradhan President	Phone No :011-25759051 Fax :01125789560 export @sroshini.com
M/s Phillips Electronics India Ltd	Motorola Excellence Centre, 5 th floor ,415/2,MehauriGurgaon Road, Sector -14,Gurgaon -122001	Mr R.Nandakishore Sr .GM sales and marketing Lalit Srivastava - Area Manager – TPF	Phone No :0124-4091900 Fax : 0124-4091993 r.nandakishore@phillips.com
M/s Wipro Consumer Care &Lighting	Doddakanelli ,Sarjapur Road Banglore -5600035 , India	Shri Sanjay Gupta Vice President Sales	Landline :080-28440011 Fax :08028440054

(B) List of LED Signage Supplier

Marc Signage	20A, Lake View Road Kolkata - 700029	Tel. 033-24659543
Philips Electronics India Limited	Temple Towers,5th Floor, Old No. 476, New No. 672 Annasalai, Nandanam Chennai – 600035	Phone: +91-44-66501000 +91-44-66501155
OSRAM	Contact Type Distributor Name Avnet Asia 2nd Floor, The Estate 121 Dickenson Road Bangalore Bangalore 560 042 Country India	Phone +91 80 5550228 Fax +91 80 5588146