A

Seminar report

On

ENERGY AUDIT

Submitted in partial fulfillment of the requirement for the award of degree of CIVIL

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Acknowledgement

I would like to thank respected Mr…….. and Mr. ……..for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

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Last but clearly not the least, I would thank The Almighty for giving me strength to complete my report on time.

Preface

I have made this report file on the topic **ENERGY AUDIT**; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to …………..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

CONTENTS

EXECUTIVE SUMMARY OF SAVINGS IN RAIL BHAVAN

The Bureau of Energy Efficiency [BEE] has entrusted to consortium of energy auditors for conduct energy audit at Rail Bhavan. Consortium of Energy auditors conducted the study during Nov. 2002-Jan. 2003. Following are the major energy saving potential, identified during the study.

1.0 Lighting system

The present energy consumption in the lighting system at Rail Bhavan is 4,56,000 kWh/Year which translates to Rs. 29.05 lakhs per annum. The anticipated energy saving due to the recommended measures are 1,50,484 kWh/year (replacement with electronic ballast & high lumen tubes and de-lamping), which translates to a saving of Rs 9.59 lakhs per annum. About 33 % saving are envisaged in the annual cost of the energy used for lighting systems.

2.0 Canteen

Presently about 360 LPG cylinders (14 kg capacity each) are used only for water heating and 27,216 kWh of electrical energy for water heating requirement in the canteen/Annum. It is proposed to replace this LPG and electrical heater with solar water heating system, of capacity 4,500 LPD. This will lead to a savings of 2.97 lakhs per year [1.23 lakhs from LPG Heating and 1.74 Lakhs from electrical heating]. The investment on the solar water heating system will be around Rs. 8.0 lakhs and the pay back period is 2.7 years.

3.0 Pumping system

The present energy consumption for the pumping system at Rail Bhavan is 24,000 kWh/Year which translates to Rs. 1.53 lakhs per annum. The anticipated energy saving due to the recommended measure is 5,093 kWh/year (replacement with a new monoblock pump set, having a system efficiency of 60 %), which translates to a saving of Rs 0.32 lakhs per annum.

4.0 HVAC system

The present energy consumption HVAC system at Rail Bhavan is 9,36,000 kWh/Year which translates to Rs. 59.62 lakhs per annum. The anticipated energy saving due to the recommended measures are 4,16,000 kWh/year (introduction of central AC system & room heating, through hot water generated from LDO), which translates to a saving of Rs 26.5 lakhs per annum. About 44 % saving are envisaged in the annual cost of the energy used for HVAC systems.

The summary of overall saving is given as a Table below.

Summary of Energy Saving

Sl. No	Area	Saving potential / Year			Capital investment, Rs. Lakhs	Simp pe
		kWh	Rs. Lakhs	%		
1	Lighting	1,50,484	9.59	33	24.85	
2	Pumping system	5,093	0.32	19	0.30	
3	Canteen LPG heating	5,040 kg of LPG	1.23	25	8.0	
4	Canteen electrical heating	27,261	1.74	57		
5	HVAC system	4,16,000	26.50 [a]	44	130.0	
6	**Total**	**5,98,838 & 5,040 kg of LPG**	**39.38**	**25**	**163.15**	

[a]: Annual running cost for LDO (16,998 kg/year) & electricity are deducted.
Note: Energy cost Rs. 6.37/kWh & LPG cost Rs. 24.5/kg.

By optimizing the loading pattern & operational time of various loads, about 10-12 % yearly energy consumption can be reduced/controlled.

1.0 PREAMBLE

During August 2002, honourable Prime Minister has announced in one of the meeting (organised in New Delhi) that all Govt. Organisations should bring down their energy consumption by 30 % and private organisations by 20 %, over a period of next 5 years, by conducting comprehensive energy audit studies in their premises and followed by implementation of the suggestions/recommendations arising out of the study.

As a first step towards implementing the above, Bureau of Energy Efficiency (BEE), New Delhi was given the task of identifying and executing the above study in 10-13 Govt. buildings and also high security buildings. In this connection, BEE has formed no. of teams, consisting of energy auditors and Energy service companies (ESCOs) to conduct the comprehensive energy audit study simultaneously in the above buildings. Rail Bhavan is one of the building identified for the study.

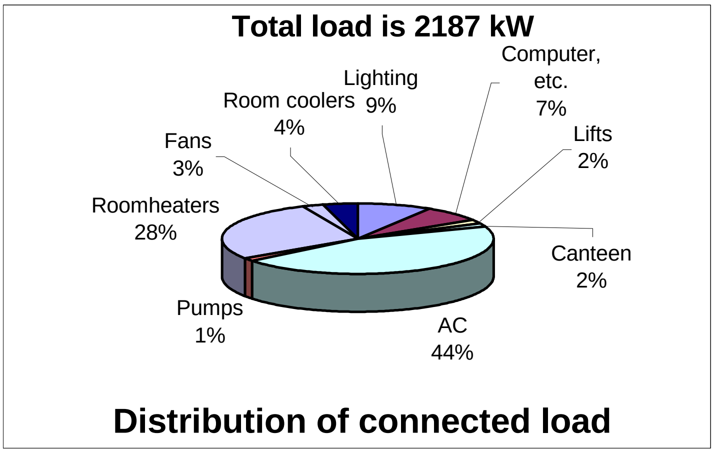
2.0 INTRODUCTION

Rail Bhavan is the office building of Ministry of Railways where planning, decisions regarding operation and control of entire Railway network in the country are carried out. The built-up area of the building is 2,910 square metres and there are about 4,850 employees. The regular office timing is 9.00 hours to 17.00 hours and five a week operation.

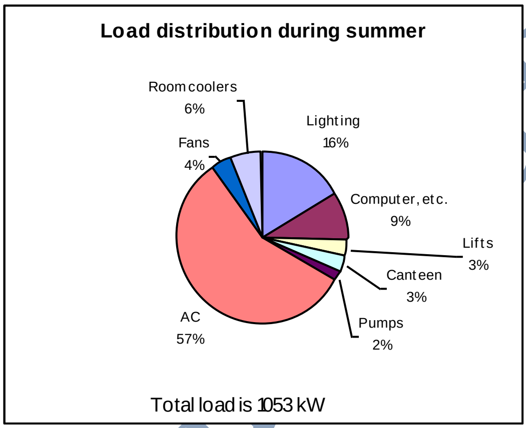
It is highly appreciable that the officials of Rail Bhavan have introduced 515 nos. of 11 W CFLs for corridor lighting and also modified the passenger lift system with microprocessor-based system as an energy conservation measures.

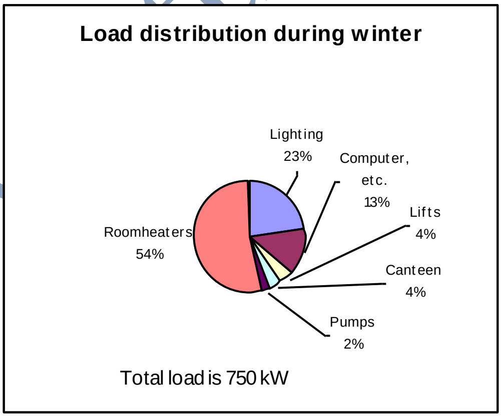
3.0 ENERGY SOURCE AND DISTRIBUTION

The Energy demand for the facility is met from Electricity, LPG and diesel. Major source of energy is electricity and LPG is used for cooking in canteen. Diesel is used to run the emergency Generator set. The total connected load in the facility is 2,187 kW and the load distribution is shown below. The sanctioned load is 1,210 kW.

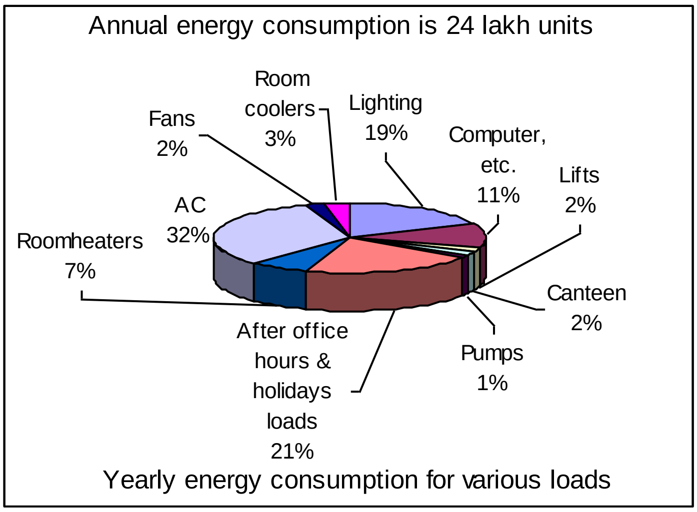


The load distribution during summer and winter seasons were analysed and given below.





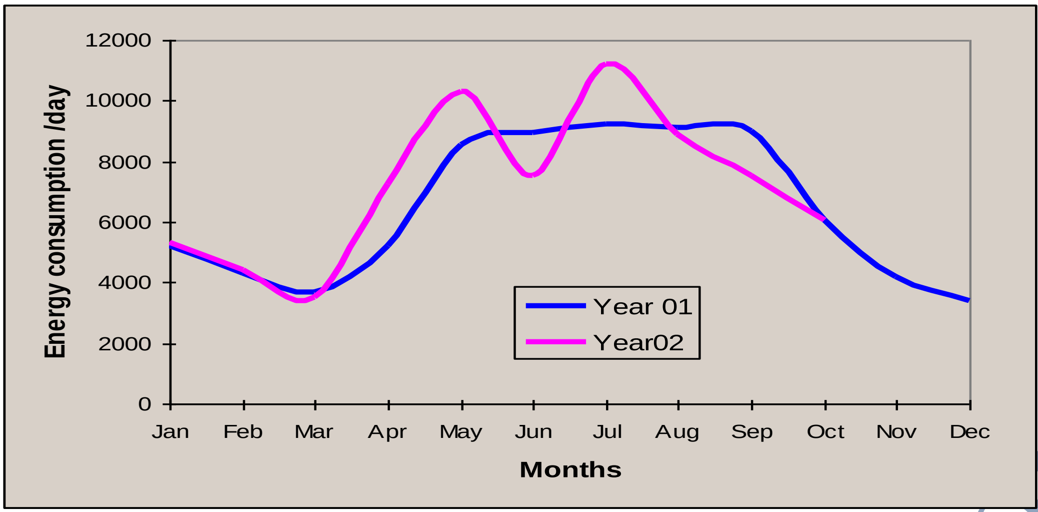
Based on the operating power & duration of running of various loads, the annual energy consumption for various loads were established and depicted below. It is seen that AC accounts for 32 %.



The Facility is getting electrical power supply from New Delhi Municipal Council (NDMC) at 11 kV and also having two Diesel generator set of 500KVA & 166KVA capacity as a back up supply. The power is distributed through three step down (11,000/415 V) transformers of 750 kVA each. Presently two transformer are working and one is standby. There are five interconnected LT bus for distribution of power, out of which three are for power and two for emergency loads like lighting and lifts. Normally all five LT bus are energized from NDMC power supply and in case of failure of power supply, the DG sets are started and only the two emergency panel are energized. (Annexure #1 - Single line diagram)

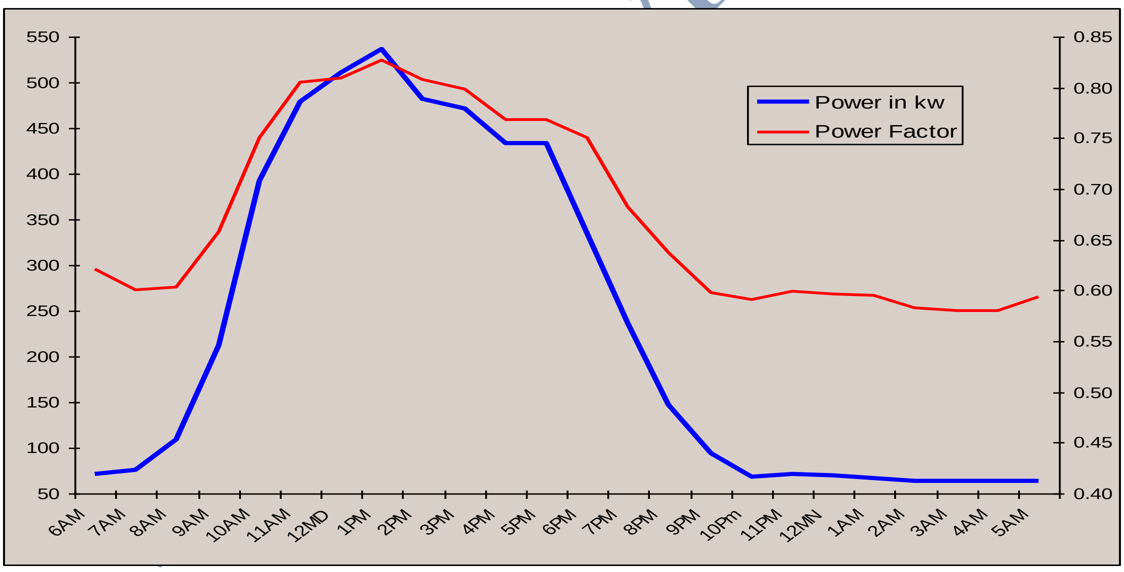
The monthly energy consumption details for the last two years are provided in Annexure II.

The daily energy consumption pattern for last the two years is shown below (Graph # 1). It is evident from the above graph that energy consumption is almost double during the summer period May–September because of cooling need (Air conditioners, fans and air coolers). The usage pattern is almost similar with slight upward variation of 3% for the last two years except for the dip in the month of June 02 which is due to increased usage of emergency power from Diesel generating sets due to power cuts.



Study has been conducted during winter season hence there was no AC load. During the study period, the electrical power was measured over a period of 24 hours and it was found that the peak demand of the facility in winter is around 550 KW and the minimum demand is 63 KW (during night time).

Power consumption and power factor variation plot for 24 hours (graph # 2)



It is very evident from the graph#2 that average load during working time (10AM to 6PM) is around 430 kW and peak demand of 550 kW occurs during lunch time (12.30PM–1.30PM) this is because of heavy usage of lift by the staff and heating food articles in the canteen.

Graph #2 also shows the variation in power factor from low loads to peak loads and it is very low at light loads. The average power factor during the night time from 7PM to 7AM is 0.6 and during the working time (i.e. 10AM to 6PM) it is 0.79.

4.0 STUDY RESULTS

The study results are presented in the following sections.

4.1 DG set

The plant has two DG sets (166 kVA x 1 no. & 500 kVA x 1 no.) which are run only during NDMC power failure. . During the course of the study, it was observed that the loading of the two DG sets were less than 50% and the 500 kVA DG set is sufficient to cater to the load requirement during winter season (loading pattern during summer has to be observed). Trials were taken and the plant authority has taken the decision to run only one DG set hence optimized the DG loading.

The NDMC power supply is quite reliable and the DG sets are operated occasionally for smaller duration hence further study on DG was not required.

4.2 Lighting system

Adequate and proper lighting contributes both directly and indirectly towards productivity and safety, and towards providing an improved work atmosphere. In fact, all these are inter-related and complimentary to each other. There are several factors which contribute towards proper lighting and it would be very difficult to deal with all of them when providing general illumination to a large area. However, all efforts were made to study and include these factors.

To study, analyze and identify energy conservation options in lighting, a study of the plant lighting load was conducted. The purpose of the study was to determine the lighting load and its distribution in various sections of the Building, determine the quality of illumination provided, and recommend measures to improve illumination and reduce electricity consumption.

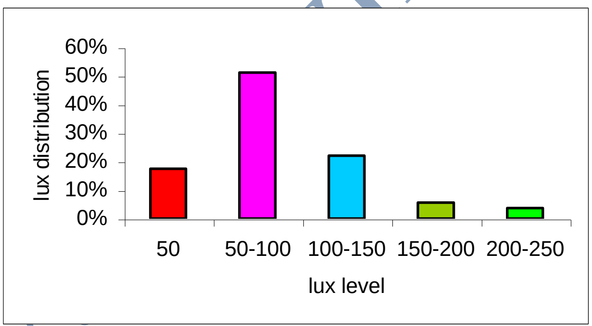
A high quality and accurate digital lux meter was used to measure the illumination level at various sections of the building during working hours. Other performance indicators such as type of lamps used, type of luminaries, mounting height, physical condition of lamps and luminaries, use of day lighting, etc. were also noted down.

4.2.1 Lighting inventory and lux level

To determine the total lighting load, a physical count of the number of light fixtures provided in different floor of the Building was carried out. It was found during the survey that mainly twin 40-W fluorescent tube light have been used in the building.

The illumination level was also measured primarily at working planes at various rooms of the building. Care was taken to reduce the effect of day lighting while taking the measurements. The recorded inventory and measured illumination levels in the facility are provided in Annexure III along with the list of numbers of light fittings installed.

Based on the measured lux levels, it was found that about 65% of the measurement points shown Lux level of less then 100 and the lighting level distribution is depicted below.



It is clear from the above Figure that about 50% of the measured illumination level falls in the range between 50 to 100 lux. It is evident that more than 65% of lighting points have lux level less than 100 and 35% more than 100 lux level. Therefore improvement in lux levels would be one of the major thrust areas of improvement in the illumination system.

It could be seen from Table A of Annexure III that the second floor accounts for the highest numbers of installed fitting as well as highest lighting lux level in the building.
Major reasons for poor illumination levels are as follows

- Poor reflectors / no reflector installed for the tube lights
- Large height of installed fittings from the working plane

- Reduction in lumen due to ageing
- Improper design of furniture and seating arrangement

4.2.2 Setting baseline in lighting system

Metering and monitoring are the major activities of any energy audit and the results of energy audit are based on the quality of data collected and measurements carried out. For realizable energy savings care should be taken during audit period so that after implementation of energy saving measures saving should be measurable.

In Rail Bhavan, the electrical distribution (Annexure –I) of Lighting load is in emergency bus along with the lift loads. From emergency bus bar, it goes to each floor and each wing then further distributed from Distribution board. Total lighting load measurement at single point and floor wise was envisaged but due to lifts load and some wings of ground floor and second floors are getting supply from 1st floor lighting circuit, the circuit could not be segregated from lift loads. It was also informed by the Rail Bhavan authority that possibility of small mixed loads like computer, AC may also be there in the circuit .

The power distribution in each floor was measured and given in Annexure IV. To arrive at per tube light power consumption, measurements at following different points were carried out .

1. Floor wise (ground,1st and second floor metering at different wings at different DB's)
2. Incoming feeder of emergency bus
3. lighting DB of conference hall
4. Single tube light

Particulars	Power in KW	No. of tube light	Per tube consumption in watts	Remarks
Ground &1st floor	55	1126	48.8	Mostly lighting loads
Emergency panel	209 -280*	3438	61 - 81	Lift loads included
Conference hall	4.45	96	46.4	Only lighting load
Single tube light	0.080	2	40	Only lighting load

*Variation is due to lift loads.

It is clear from the above table that variation in the consumption is from 40 watts to 49 Watts (excluding the jerk from lifts) from the emergency panel. It was informed by Rail Bhavan authority that apart from lift load, small load of AC, computer and fax machine are also connected. Hence, ***if these loads can be segregated from the emergency lighting panel, the total building load can be measured at the incoming feeder of emergency panel.*** Variation in per tube consumption from 40 watt to 46.4 Watt in pure lighting circuit is because of poor power factor of 0.6 and number of tube-lights.

Based on measurements in pure lighting load circuit, power consumption per tube light of 46.4 watt can be considered as base line and savings can be measurable by slightly changing the present circuit for metering. Based on 46.4 watt, the total lighting load (40 W FTL) for 3,550 tube lights is around 164.7 kW.

4.2.3 Options for improvements in lighting system

The conventional fluorescent tube lights (FTLs) form a major portion of office lighting. There are almost 3,606 FTLs and 515 CFLs. Lighting system accounts for 36,000 kWh per month of energy consumption. Based on the measurements and observations made during energy audit, the following options have been evolved for reducing energy consumption as well as improvement in lux levels in lighting system.

a. The tube lights energized at the outer windows in each room may be put off when sufficient day light is available. The savings are difficult to quantify.
b. In a few of the rooms (Room no. MSR 245, 243, 247, 249, 251 A & 252), tube light is energized (total 19 nos.) on the top of twin tube fittings to illuminate the ceiling. It is suggested to remove such fittings. It is also suggested to replace each 40 W tube light (standard FTL) with high lumen tube light (36 W) with electronic ballast. This will improvement the lux level substantially, which in turn may improve the working efficiency of the employees because of better working condition. In order to improve the lux level further and to avoid stroboscopic effect (as tube is above the fan), it is suggested that fittings which are ceiling mounted should be transformed to suspended one. This care should be taken during the implementation of the above.

The capital cost required for the modification is Rs. 24.85 Lakhs and energy saving envisaged is 1,50,484 kWh/year and the pay back period is 2.59 years.

4.3 Water pumping system

At Rail bhavan, major portion of water is received from NDMC at pump house where three pumps (1 x 10 HP submersible: 3-4 years old & 2 x 7.5 HP centrifugal which are more than 30 years old) are installed to pump water to overhead tanks from where it is distributed to various end use points. In addition to the above, two tube well pumps (one at exit gate & other at Nursery) are installed to supplement the water supply.

Initially, there was another 7. 5 HP centrifugal pump (in pump house) which was later replaced by this submersible pump with casing being there and other piping circuit remaining same. We brought to the notice of the Rail Bhavan officials that the casing is stagnating the flow & affect the performance of the pump considerably.

The electrical power consumption of various motor-pump units are measured and given in Annexure V. The performance of the submersible pump at pump house is evaluated and presented below.

Sl.No.	Particular	Value	Unit	Remark
1	Rating of Pump	7.5	kW	
2	Electrical consumption	8.85	kW	Measured
3	Flow rate	490.4	LPM	Measured
4	Delivery head	28	m	After Pr. Gauge
5	Delivery head	1.5	m	Before Pr. Gauge
6	Total head	29.5	m	Calculated
7	Motor-pump efficiency	26.7	%	Calculated

It is seen from the Table that the overall efficiency is low. Hence, it is suggested to replace the pump with a new mono-block pump set which will have an overall efficiency of 60 %. The annual saving expected is 5,093 kWh. The investment is Rs. 30,000- and the pay back period is 0.92 years.

Since the other pumps are run for 1-4 hours/day, further energy saving potential is negligible.

4.4 Canteen

At Rail Bhavan, canteen facility (located at third floor) is provided for employees. On an average 8,000 visitors (no. of visits of each employee) avail the facility, out of which 1,000 visitors take lunch daily. Majority of the items in canteen are being cooked using LPG. Electrical heaters are also being used for heating water which in turn is used for various applications like tea/coffee warmer, for making tea/coffee, plate washing, etc.. The details of loads at canteen in given below.

Sl.No.	Location	Application	Power Consumption (kW)	Operating Hrs per day	Working days per week
1	Third Floor Canteen	Tea warmer	2	7	5
2	Third Floor Canteen	Coffee maker (3 no.)	2 each	7	5
3	Third Floor Canteen	Geyser for plate washing (2 no.)	2 each	12	5
4	Second Floor - Pantry	Coffee maker	2	12	5
5	Second Floor - Pantry	Boiler - milk heating	2	8 to 10	5
6	Second Floor - Pantry	Boiler - Water heating	2	8	5
7	Second Floor - Pantry	Boiler - Water heating	2x2 No.	8	5
8	Second Floor - VIP canteen	Water Heater	2x2 No.	12	5

Since the requirement for heating is quite high, it is suggested to introduce **solar hot water system** on the terrace of the building. **It is established that each 100 litres capacity solar hot water system can save either 1500 kWh of electricity per year or 195 kg of LPG per year** (Source: MNES, 1998). The capital cost for 4,500 litres capacity system is Rs. 8.0 lakhs, and the saving envisaged is 5,040 kg of LPG and 27,216 kWh of electricity per year. The pay back period is 2.70 years.

Use of electricity for heating application is not an efficient route. Hence, hot water from solar system may be used to the maximum extent in place of electrical heating. Even for heating of Milk, etc. LPG, is a better option than electricity.

4.5 HVAC system

AC and room heaters are the heating, ventilation and air conditioning (HVAC) provided in the facility.

4.5.1 Air conditioning system

The plant has installed 410 no. of 1.5 TR window air conditioners (AC) of various make/model at different locations. There are also 1.5 TR x 9 no.; 4.3 TR x 10 no. and

7.5 TR x 4 no. of split package units to cater to the cooling need. On an average, these AC units are used 6 months in an year.

Sample measurement was taken on a few of the ACs and the results are given in Annexure VI. Since there are lot of AC units in 1st to 5th floor of the building and air cooled AC systems consume more specific power, it is suggested to go for **centralized AC system** with chilled water as secondary refrigerant. The plant can be either installed on the terrace of the building or on the terrace of the 'F' wing. The chilled water line can pass through the existing ducting in the verandah of each floor. Fan coil units (FCUs) with modulating motorized valves can be installed to replace the existing units. In Ministers rooms, the existing AC units may be retained so that the units may be run when the central plant is not working, if required. 2x 200 TR screw chiller, which has better energy efficiency both at full load & part load (0.46-0.66 kW/TR) is recommended. The feasibility of the proposed system is to be considered in civil angle also.

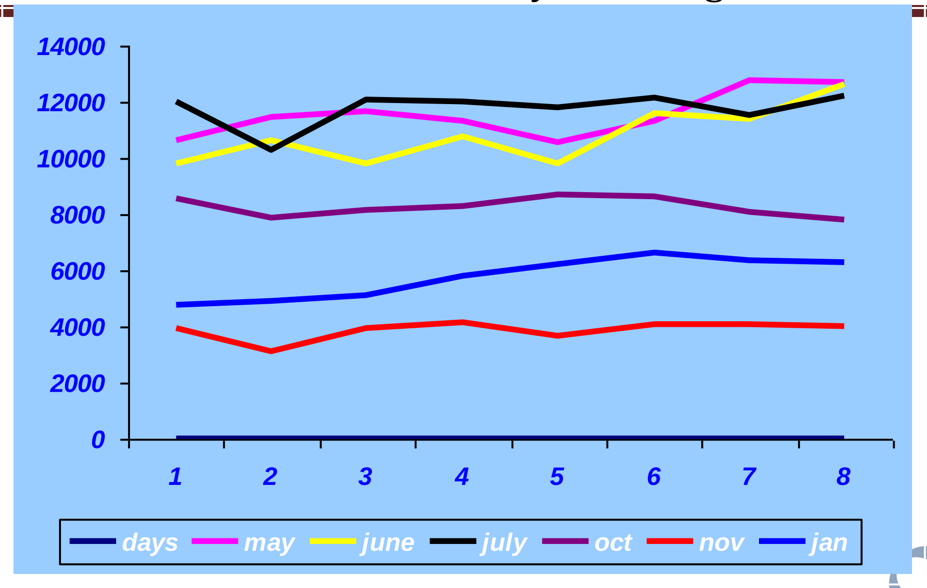
4.5.2 Room heaters

Rail Bhavan has 435 nos. of room heaters of combination of 2 & 0.7 kW capacity to use during winter season. On an average, these heaters are used for 2 months in an year.

Use of electricity for heating application is not an efficient route. Hence, it is suggested to install a light diesel oil (LDO) fired **hot water generator** on the terrace of the building. The hot water can be circulated through the same water circuit (of centralized AC system) sothat individual rooms are kept warm. The capital cost of the system is Rs. 5.0 lakhs and the annual net cost saving is Rs. 5.0 lakhs.

4.6 Energy usage pattern

The energy consumption for different days in various months were collected; plotted and depicted below. It is seen that there is 10-12 % variation in daily energy consumption. This variation can be minimized/controlled by optimizing the running of loads like lifts (operating minimum no. of lifts by increasing the load factor), exhaust fan in toilets (through timer), etc..



Usage patten:10-12% variation in consumption

The saving calculation for various systems are presented in Annexure VII. The proposed measurement & verification (M&V) protocol are provided in Annexure VIII.

5.0 CONCLUSIONS

Presently, the average annual energy consumption is 24 lakh units. The possible saving by implementing the proposed measures are 5.98 lakh units of electricity & 5,040 kg of LPG used in canteen which comes to about 25 % reduction of annual energy bill, at a capital investment of Rs. 163.15 Lakhs.

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