Energy Efficient Lighting for Households : A Survey

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ABSTRACT

The paper presents the results of a survey conducted in 600 households to determine the consumption patterns, types of loads and lighting requirements of households for determining energy efficient and economical domestic lighting. Based on these results, a replacement policy is formulated to decide whether an individual lighting outlet in a selected household is to be replaced by a compact fluorescent lamp or not. The economics of such replacement is also presented. It is found that with the present tariff most incandescent fittings are economical to be replaced when operating for more than an hour or two per day. The study also shows that replacement of at least one incandescent lamp by a CFL in each household throughout the Sri Lanka can cause a demand reduction of about 67 MW during the system peak and hence justify a delayed commissioning of new generating capacity.

1.0 INTRODUCTION

The cost of power generation in Sri Lanka is continuously increasing as the low cost hydro power resources have been exhausted. It thus becomes increasingly important to be energy efficient in the utilisation of electricity. It is with this in mind that a pilot project was commenced. The present study has been limited to energy efficiency in lighting, and in particular to that in households.

Energy efficiency can be achieved primarily by the use of discharge lighting. For outdoor lighting, where colour differentiation is not very important, sodium vapour lamps and mercury vapour lamps are highly efficient. On the other hand, for industrial and commercial lighting, the standard linear fluorescent tubes give the best efficacy at low cost. However for some domestic applications, the linear (2 ft or 4 ft) fluorescent tubes are not aesthetically pleasing. Also the lamps should be easily replaceable by the occupants themselves without needing the services of an electrician or other specialised person. Thus the lamp must be compact and not much larger than the standard incandescent lamp it has to replace. The lamp so chosen must also have the standard incandescent socket (bayonet cap in Sri Lanka) so that it can directly replace the incandescent lamp in the same fitting without needing any changes. Thus the study has been limited to the **compact fluorescent lamp (CFL)**.

Obviously the **CFL** replacing the **incandescent lamp (IL)** must be cost effective, both from the consumers point of view and the supply authority's point of view. From the consumers point of view, what is important is the overall cost saving he can make by considering the additional cost of the **CFL**, the reduction in power consumption, the longer life time of the **CFL** and the electricity tariff block he is operating on. The nett annual savings he can make can then be calculated. From the supply point of view, the use of **CFL**s gives a peak power shaving and a reduction in the energy requirement. However the power factor of the **CFL** is also important, in that the electricity demand saving is directly related to this. A further factor that may have to be considered is the probable waveform distortion. With good quality **CFLs**, it is expected that a large reduction in the peak demand as well as the energy demand can be achieved, thus making the expected power and energy shortage towards the end of this millennium in Sri Lanka to be less felt.

The study aims at determining, through a second phase, the practical acceptance and reliability of **CFL**s with the different field conditions that may be existing in different consumer groups and different parts of the country.

2.0 METHODOLOGY

In implementation, the following methodology was adopted. Twelve sample groups, consisting approximately of 600 consumers in total, based on estimated energy consumption levels representing rural, sub-urban and urban domestic consumers were selected. The consumption patterns, types of loads and lighting requirements of these domestic consumers were determined through a survey. A replacement policy, to decide whether an individual lighting outlet in a selected household is to be replaced, was formulated. The economics of switching over and operation of energy efficient lighting in households, and savings to the consumers and supply authority were estimated.

A paper presented at the Annual Sessions of the Sri Lanka Energy Managers Association by Prof. J. R. Lucas

3.0 SURVEY

One of the main objectives being the gathering of adequate information regarding the end user lighting load pattern, a questionnaire was prepared and filled by selected enumerators during their visits to the households of a selected sample. The questionnaire included two major parts **A** and **B**.

The Part **A** of the questionnaire was filled in the first and main visit as well as in the subsequent visits made by the enumerators. The objective of the subsequent visits were to monitor the electricity consumption of the consumers prior to the replacements. At least three such visits were made in four week intervals and the date and meter reading were noted down, along with any specific comments.

Part **B** comprised of four groups of questions through which information was gathered about technical details of each and every relevant lighting point, consumers observations regarding the presence of periods of over and under voltages, occupants' views on the acceptability of energy efficient lighting technology and appliance usage. This information was gathered by the enumerators during their main visit by interviewing the occupants of the household and making necessary observations.

A training program was conducted for the selected enumerators. This included explanation of the objectives and other relevant details of the project, an introduction to the energy efficient lighting technology and a detailed discussion on the survey questionnaire followed by a trial survey.

In the trial survey, the enumerators were asked to visit one or more households with which the enumerator had no close relationships and to complete the questionnaire for that household. Some difficulties experienced by the enumerators in filling the questionnaire led to significant modifications in the questionnaire. It was noted that the enumerators had to estimate the wattage not only of most of the appliances such as refrigerators, ceiling fans but also of some lamps which were not accessible to the enumerator. The enumerators were instructed to train themselves to get a reasonable estimate in such cases.

In getting the switching on and off times of the lamps, it was noted that only a negligibly few consumers were able to give these times accurate to nearest 15 minutes, and the majority were hardly able to give it accurate to the half hour. Based on this fact it was decided to be satisfied with an error of ±15 minutes (ie. to the nearest half an hour). It was also decided not to consider the lighting points which consume less than 10 W, and those that were on for less than half hour at a time (such as toilets). No allowance was made to rectify these omissions, because the errors caused by these would be insignificant compared to other errors present.

Getting the usage durations of appliances was more difficult due to the obvious fact that the usage of most of the appliances are not linked to a time of the day. The enumerators had to get information about frequency of using a particular appliance and duration and to estimate the average usage.

The lighting load curve obtained from the trial survey results was found to be an over estimate of the real situation. The fact that the household lighting pattern depends on the day of the week (working day, Saturday or Sunday) contributes to an over estimation. To correct this, at least to some extent, the questionnaire was expanded to include the frequency of usage of each lamp (average number of days 5/10/15/20/25/30 days per month). The results of the trial survey were analyzed and the questionnaire suitably modified as described above.

Description of Selected Sample

The following areas were categorized as **Urban** in the study, as all of them come under municipal councils and have a lot of commercial activities supported by the relatively developed infrastructure. The areas are Barnes Place, Colombo 7 and Wackwella Road, Galle City which are known to be inhabited mainly by high income earners of the respective cities, whereas the Shoe Road, Galpotta Road & Sangamitta Mawatha, Colombo 13 represent an area having people of all income levels as well as people belonging to different ethnic backgrounds. The Sanjayagama area off Waidya Road, Dehiwala was identified as an area inhabited mainly by urban low income consumers. The areas were selected to give as wide a coverage as possible.

The following four sample areas were categorized as **Rural** in the study as they were selected from Pradeshiya Sabhas sufficiently far away from the respective towns. These are on Jaela-Negombo Road via Pitipana, Pamunugama; Side Roads from Homagama-Diyagama Road near Dolekade, Homagama; Pansala Road near Deniyaya Central College, Deniyaya; and Rambukkana-Mawanella Road about two miles off Rambukkana. The inhabitants in the above areas are mainly farmers, small businessmen and employees such as teachers, clerks etc. Although these areas were categorized as rural, it was identified that the life styles of these people are influenced by the fact that they are not far away from the urban and suburban areas. Their average income levels are apparently higher than the income levels of isolated rural villages and they are more exposed to urban and suburban way of life. The completely isolated rural villages would in all probability not be supplied with electricity and thus cannot be included in this survey. For reasons of practicability, regions far away from Colombo, other than from where enumerators were available were not included in the survey.

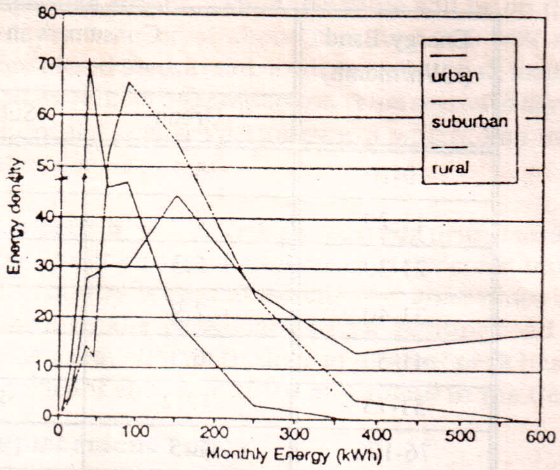
The remaining four sample areas were categorized as **Suburban** in the study. These are Meera Road, Isadeen Town, Matara; Sri Sudharmarama Road, Ratmalana; Moratuwa Road starting from Piliyandala Junction; and Pragathi Mawatha & 1st Lane in Homagama Town. These areas, which are obviously not rural, are not truly urban but are mainly inhabited by relatively high income earners. It was observed that the component of low income earners living in these areas were very small.

Fifty households were selected for the survey in each sample area described above, according to the following criteria. It was attempted to select fifty households fed from the same transformer. This was done in order to make broad based observations regarding the voltage regulation. If such a feeder supplies more than fifty households, approximately twenty-five houses at the beginning of the feeder and the rest at the end of the feeder were selected. Within the selected feeder ends no house was skipped other than in unavoidable circumstances such as unoccupied house and serious objections from the occupant to take part in the survey.

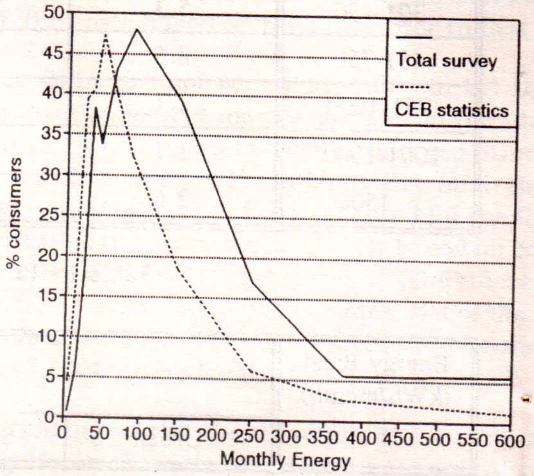
4.0 RESULTS AND ANALYSIS OF SURVEY DATA

For validation of rural, suburban and urban categorization, monthly electricity consumption patterns of the households obtained through the survey were analyzed. The monthly consumption of the households, averaged over the three month period at the beginning of the study, falling in different energy bands were counted. The corresponding percentage distributions are listed in Table 1. The distribution of energy in the different bands are shown in Table 2.

Figure 1 shows the distribution of energy density against the monthly energy. Figure 1(a) shows the difference in the distribution for the urban, suburban and the rural samples. It is seen that the concentration of consumers occurs in different energy bands. In the urban sample, the maximum energy is consumed by those consuming about 150 kW/month, whereas in the suburban group the peak occurs at about 90 kWh/month. In the rural category selected the concentration is around 35 kWh/month.



(a) Comparison for Urban, Suburban and Rural



(b) Comparison of survey results with CEB Statistics

Figure 1 - Distribution of Energy Bands

Figure 1(b) shows the composite distribution from thesurvey as compared with the CEB statistics. It is seen that the survey sample is biased away from the very rural consumers consuming less than 10 kWh/month, and peaks at about 85 kWh/month, whereas the overall CEB figure for Sri Lanka show a much lower value at 45 kWh/month. This was to be expected, as in the study, very low consumers were consciously kept low as this group could not contribute to a significant reduction in the electricity consumption by energy efficient lighting.

The main data analyzed was the duration of operation of the different wattage of incandescent lamps with a view to replacing feasible lamps with **compact fluorescent lamps (CFL)**. Other information gathered were mainly to obtain the consumer's average monthly consumption, information on low and excessive voltage levels at the consumer's premises, preference of consumer towards fluorescent lamps prior to the field replacement study, and usage of other appliances in the home.

Energy Band (kWh/month)	Consumers in energy band (%)			Total (%)	1992 CEB Statistics
	Urban	Suburban	Rural		
0-10	3.2	0	1.5	1.5	8.93
11-20	2.6	2.1	6.4	3.7	11.91
21-30	5.3	3.6	11.9	7.0	15.72
31-40	7.9	4.1	20.3	10.9	11.63
41-50	6.3	2.6	13.4	7.5	10.52
51-75	12.2	21.0	18.3	17.2	16.20
76-100	8.5	19.0	13.4	13.7	9.21
101-201	29.6	36.4	12.9	26.1	12.25
201-300	10.1	9.7	1.0	6.8	2.39
301-450	5.3	1.5	0	2.2	1.03
451-750	8.5	0	0	2.7	0.52
751-1000	2.1	0	0	0.7	0.14
1001-1500	1.1	0	0.5	0.5	0.11
> 1500	2.6	0	0.5	1.0	0.15

Table 1 - Percentage of consumers in energy bands

Energy Band (kWh/month)	Normalised Energy Density				
	Urban	Suburban	Rural	Total	CEB Statistics
0-10	1.6	0	0.75	0.75	4.46
11-20	3.9	3.2	9.6	5.6	1.79
21-30	13.3	9.0	29.8	17.5	39.3
31-40	27.7	14.4	71.1	38.2	40.7
41-50	28.4	11.7	60.3	33.8	47.3
51-75	30.5	52.5	45.8	43.0	40.5
76-100	29.8	66.5	46.9	48.0	32.2
101-201	44.4	54.6	19.4	39.2	18.4
201-300	25.3	24.3	2.5	17.0	6.0
301-450	13.3	3.8	0	5.5	2.6
451-750	17.7	0	0	5.6	1.1
751-1000	7.4	0	0	2.5	0.5
1001-1500	2.8	0	1.3	1.3	0.3
> 1500	-	0	-	-	-

Table 2 - Energy Distribution in the energy bands

Daily Lighting Load Curves of Consumer Groups

The information regarding the daily load curve was extracted for each consumer group using the survey data.

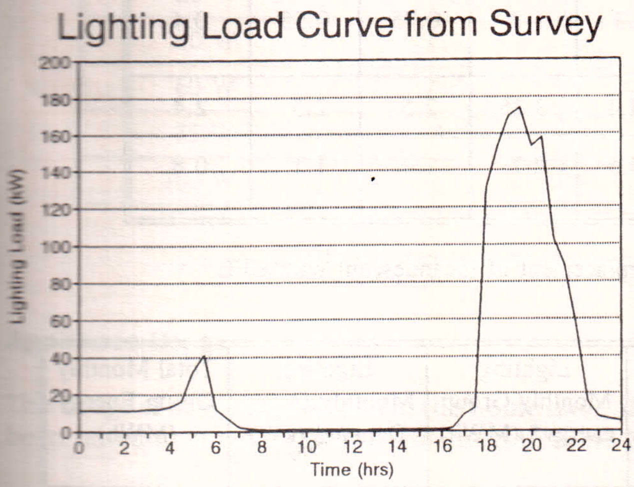


Figure 2 - Overall Lighting Load Curve

The data has been given by the consumers mainly to the complete hour, rather than to the half-hour. Thus information on the half-hour, although plotted, is not considered to be accurate. Figure 2 shows the overall lighting load curve obtained when all the groups are considered together. Figure 3 shows a typical daily load curve for Sri Lanka obtained in December 1991.

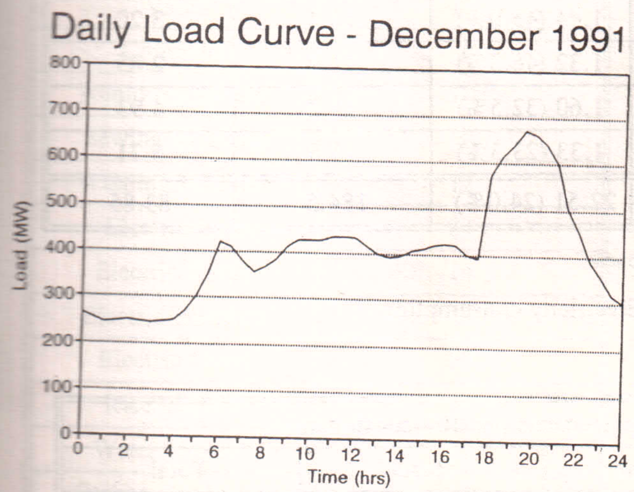


Figure 3 - Daily Load Curve for Sri Lanka

It is seen that as expected, the domestic lighting load peak occurs from 6 pm to 8 pm. This peak has a value of just under 180 kW for 600 consumers or about 30 kW per 100 consumers. This would seem to indicate a figure of about 400 MW for the island wide consumer number of 1.37 million. In fact from table 2 it can be seen that the selected sample has approximately twice the energy consumption of an average group of the same size. This is to be expected as very low consumers have not been considered in the study for reasons explained earlier. Thus the value will be on the high side by a factor of about two, and 200 MW may be considered as the contribution to the peak load by the domestic lighting component. This seems to agree with the peaks occurring in figure 3 which also includes other domestic loads.

Comparison shows that the morning peak load and the night peak load for the total electricity consumption in the Country occurs at exactly the same times as that shown by the peak loads in the lighting load curve. Thus a reduction in the lighting load at peak has a very significant effect on the total demand in the Country.

Replacement Policy

In determining the cost of energy, the domestic tariff rate D1, effective from 1 February 1994, and given in Appendix A1 was utilised, and a comparison was made with the costs based on the tariff prior to that.

Since **CFLs** are not widely available in Sri Lanka at present, the present market price is on the high side. Thus likely future prices were considered [IL cost = Rs 25 and CFL cost = Rs 600] in the analysis. The additional initial capital cost required for the **CFL** was distributed using an annuity factor based on commercial interest rates [16% per annum]. The efficacy of the **CFL** was considered to be five times that of the **IL**, and the life of the **CFL** to be eight times [1000 hours for the **IL** and 8000 hours for the **CFL**.]

Considering all the above factors, the minimum daily usage for each wattage of **IL** for economical replacement was determined. The results are given in Table 3. It is seen that with the present tariff, a 25 W **IL** becomes economical to be replaced when operated for more than about two and half hours at a tariff rate of Rs 4.40 per unit, whereas a 60 W equivalent replacement can be economically replace at three-fourths of an hour.

Table 4 gives the electricity consumption pattern of the groups. Table 5 gives the calculated economical replacements for existing **ILs** based on the new tariff (effective from February 1994), and table 6 gives the corresponding numbers to be replaced if based on the tariff existing prior to February 1994. These show that the new increased tariff makes about two **ILs** in households on the average to be economical to be replaced with **CFLs**.

Unacceptable Voltage Levels

The survey indicates that 17 % of consumers have unacceptably low voltage levels as indicated by dim lights and non starting of fluorescent lamps mainly during 1800 to 2000 hrs. Also, 17 % of consumers have reported very frequent burning of lamps, which may be related to the overvoltage in the system. The majority of those reporting this could not give a specific time when this occurred.

Tariff Based	Incandescent Lamp Rating (W)	25	40	60	75	100
Present from Feb 94	Energy (kWh/month)	1.75	1.45	1.35	1.25	1.25
	Average Duration (hrs/day)	2.3	1.2	0.75	0.55	0.4
Prior to Feb 94	Energy (kWh/month)	15.4	3.25	2.5	2.5	2.4
	Average Duration (hrs/day)	20.5	2.7	1.4	1.1	0.8

Table 3 - Energy Level for Economical replacement of Incandescent with CFL

Area/Classification	Number of Consumers	Lighting Daily Group energy (kWh)	Lighting Monthly Group energy* (MWh)	Lighting Monthly Group Demand (kW)	Total Monthly Group Energy (MWh)
Colombo 7/Urban	50	177.9	5.34 (20.8%)	33.1	25.62
Colombo 13/Urban	50	39.6	1.19 (14.8%)	9.8	8.06
Galle City/Urban	50	74.9	2.25 (25.6%)	19.5	8.80
Dehiwala/Urban	50	20.2	0.61 (24.6%)	5.4	2.48
Matara City/Suburban	50	65.8	1.97 (37.7%)	23.4	5.22
Piliyandala/suburban	50	63.4	1.90 (37.9%)	12.3	5.01
Homagama Town/Suburban	50	46.6	1.40 (25.6%)	13.5	5.47
Ratmalana/Suburban	50	72.0	2.16 (33.2%)	17.2	6.50
Pamunugama/Rural	50	48.0	1.44 (45.0%)	13.1	3.20
Rambukkana/Rural	50	44.2	1.32 (46.3%)	11.7	2.85
Deniyaya/Rural	50	53.2	1.60 (32.5%)	15.2	4.93
Homagama/Rural	50	44.4	1.33 (23.3%)	11.3	5.71
Total	600	750.2	22.51 (24.0%)	184.5	83.85

* Values within parenthesis corresponds to the percentage lighting component

Table 4 - Estimated Group Electricity consumption

Power	Number of Replacements per 100 consumers			
	Urban	Suburban	Rural	Total
25 W	3	1	1	1
40 W	86	143	88	106
60 W	212	181	166	186
75 W	35	22	37	32
100 W	60	25	24	36

Table 5 - Economical Replacements by Fluorescent lamps [New tariff]

Power	Number of Replacements per 100 consumers			
	Urban	Suburban	Rural	Total
25 W	10	17	7	11
40 W	117	209	131	152
60 W	234	228	195	219
75 W	39	25	45	37
100 W	60	28	25	38

Table 6 - Economical Replacements by Fluorescent lamps [Old Tariff]

Appliance Usage

The usage of other appliances in the home have also been noted in the survey and are given in table 7.

Appliance	Average/ 100 households
Electric Fan	133
Refrigerator	56
Air Conditioner	8
Television	87
Video	17
Computer	2
Audio Equipment	70
Sewing Machine	8
Washing Machine	12
Electric Iron	84
Electric Kettle	14
Electric Hotplate	7
Electric Oven	10
Rice Cooker	20
Water Heater*	32
Kitchen Appliances	22
Water Pump	21
Office Equipment	-
Other Appliances	6

*Includes immersion heaters

Table 7 - Appliance Usage

Acceptability of Fluorescent Lamps

About 95 % of consumers interviewed have indicated that they would like to use (conventional) fluorescent lamps if provided free. The consumers would agree to fit fluorescent lamps in the following locations in the percentages indicated in parenthesis: Living room (87.5 %), Dining room (85.8 %), Bedrooms(80.3 %), Kitchen(90.3 %), Pantry (80.8 %), Toilet (81.8 %), Store room (79.5%), Corridors (83.7 %) and Exterior (86.8 %).

Those disagreeing have given one or more of the following reasons: Aesthetically not pleasing (55%), Too bright causing a glare (4%), Unnecessary (12%), Noise generated (2%) and Health problems associated (16%).

5.0 ECONOMIC ANALYSIS

The economic analysis is carried out from the consumer's point of view and from the supply authority's point of view.

Consumer Side

The consumers will be encouraged to use energy efficient lamps only if a reasonable saving in energy costs can be achieved to compensate the extra capital expenditure associated with such lamps. The discussion is limited to the use of Compact Fluorescent lamps (**CFLs**) as an alternative to incandescent lamps (**ILs**). A sample calculation is given for this purpose.

Life of CFL	8000 hrs
Power consumption	11 W
Cost of each unit	Rs 600
Life of IL	1000 hrs
Equivalent IL Power consumption	60 W
Cost of each IL unit	Rs 25.00
Lamp usage	4 hrs/day
Annual discount rate	10%
Annuity factor for a 5 year duration	0.264
No of ILs required	3 units over two years

Average cost of ILs	Rs 37.50 per year
Energy saving from CFL use [(60-11)*1500/1000]	Rs. 73.5 kWh/year
Saving in energy costs (@ 4.40 Rs/kWh)	Rs 323.40
Total savings (Rs 37.50 + Rs 323.40)	Rs 360.90
Cost of CFL per year (Rs 600.00*0.264)	Rs 158.30
Total net saving (Rs 360.90 - Rs 158.30)	**Rs 202.60 per year**

The above calculation can be carried out for different number of hours of usage of the IL which is replaced with an equivalent CFL. In all these calculations an annual discount rate of 10% has been assumed. Also the results given are based on 60 W ILs, 13 W magnetic ballast type and 11 W electronic ballast type CFLs which are the accepted equivalent lamps for 60W ILs.

Figure 4 shows the saving which can be achieved by the consumers when integral type CFL with an electronic ballast is used if their energy price is at Rs 5.25 per kWh or at Rs 4.40 per kWh. Consumers in the category where the per unit cost is Rs. 1.70 do not save by using CFLs. It is important to note that if an IL which operates even an average of 1 hour a day is replaced with a CFL these consumers get a financial benefit.

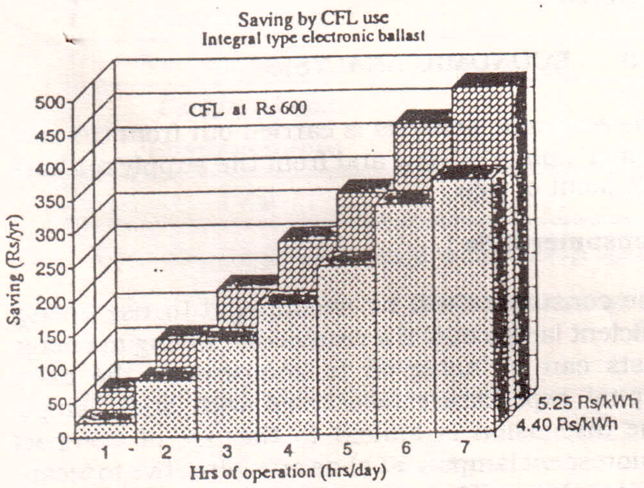


Figure 4 - Saving to consumer if one 60W IL is replaced by an 11W CFL

Supply side

There are two major advantages to the supply authority associated with the use of energy efficient lighting technology.

* The peak load in the system is reduced and hence the generation, transmission and distribution capacity costs.
* The total energy demand is reduced and hence the operating costs in the system.

The avoidable cost of producing a unit of energy for lighting can be assumed as the fuel costs associated with gas turbines since lighting load comes onto the system mostly at the system peak-load time. In other words, the incremental saving of energy is those from Gas Turbines. When the system transmission and distribution energy loss which is approximately 20% is considered, a saving of 1.0 unit of energy at the demand level results in a saving of 1.25 units of energy at generation level. Therefore when the lighting demand is reduced by 1.0 unit the supply authority experiences a reduction of approximately Rs 4.68 per kWh on fuel costs assuming that the incremental cost of gas turbine energy is Rs 3.75 per kWh.

A considerable cost saving to the supply authority can be obtained if the domestic consumers in the lowest block (Rs 1.70 per kWh) replace one 60W IL with a CFL, as these blocks is supplied below cost. Thus if the supply authority wishes to encourage the use of integral type CFLs with electronic ballasts among these consumers, they need to be supplied with CFLs at a subsidised price as they themselves do not get any financial benefit by replacement.

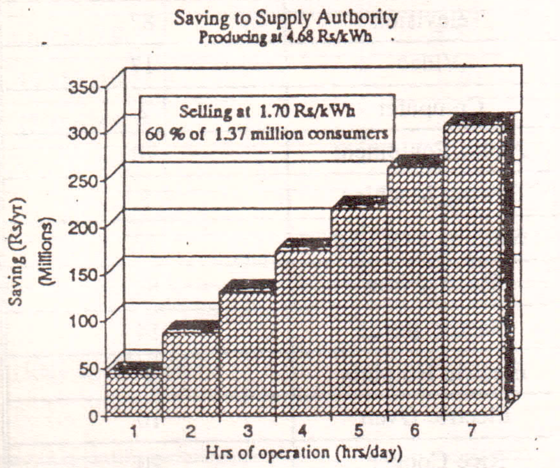


Figure 5 - Saving to Supply authority if all the consumers in the lowest block of consumption replace one 60W IL by an 11W CFL

The saving to the supply authority can be extrapolated to cover the whole country. There are about 1.37 million domestic consumers in the country and about 60% of them are in the lowest block of consumption. If these consumers in the lowest block replace one 60W IL with a CFL, the total saving to the supply authority is given in Figure 5.

In such a situation, the country's electric energy saving in one year is given in Figure 6.

electric irons (84 per 100), refrigerators (56 per 100) and electric water heaters/cookers (83 per 100).

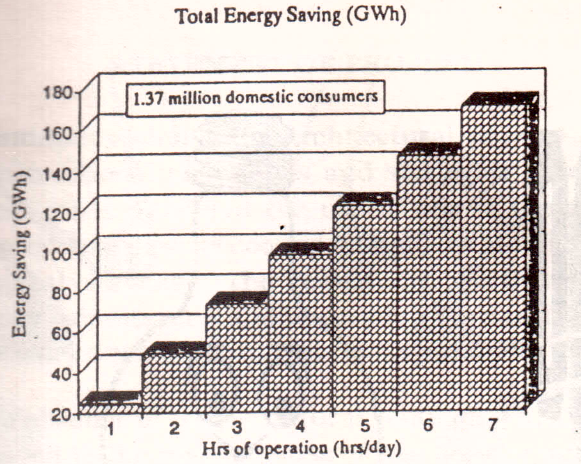


Figure 6 - Total energy saving to the Country if all domestic consumers replaced one 60W IL with an 11W CFL

Figure 7 shows a pie chart of the power saving that could be achieved with this same replacement.

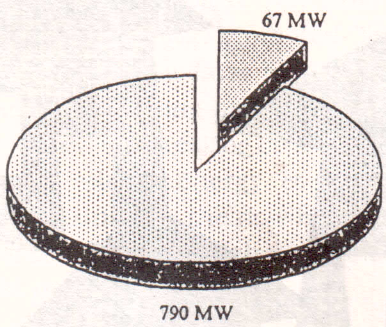


Figure 7 - Reduction in Peak demand if each of the domestic consumers replace one 60 W IL with an 11W CFL

All these calculations are based on 11W integral type CFLs, and 60W ILs.

6.0 SUMMARY OF OBSERVATIONS

The consumption pattern of the sample selected did not match perfectly to the island wide consumption pattern given by the CEB statistics. It was noted that the sample was biased towards the higher consumption groups. This is to be expected because in the sample selected, less emphasis was given to the consumers falling into the low energy bands because very little energy savings could be expected from this group.

The average lighting component in the sample of the domestic consumers was found to be 24%. The balance energy was mainly utilised for electric fans (133 per 100 households), televisions (87 per 100), electric irons (84 per 100), refrigerators (56 per 100) and electric water heaters/cookers (83 per 100).

The majority of the consumers (95%) have indicated their willingness to use fluorescent lamps if they are provided free. Only very few people placed restrictions on the location of usage. Those who are unwilling to replace with fluorescent lamps gave aesthetically not pleasing as their main reason, and some also indicated assumed associated health problems, not worth the trouble, glare and noise as some of the other reasons for their displeasure. About 17 % of the consumers complained of low voltages, especially during the peak hours.

It was found that an average household in the sample considered consumed approximately 300 W during the evening peak which occurs at about 2000 hrs, and about 60 W during the morning peak at about 0530 hrs.

It was observed that the domestic peak can be economically reduced, under the present tariff, by replacing on the average of 4 incandescent lamps with the equivalent compact fluorescent lamps. However, in the phase 2 of the project, we do not intend to replace more than two bulbs per household mainly due to financial reasons. The study has shown that about half the replacements will be for 60 W incandescent lamps.

For a consumer with a monthly consumption of over 60 units, the study has shown that a net saving of Rs 202.60 per year can be achieved by replacing each 60 W incandescent lamp burning more than 4 hours a day, with a compact fluorescent lamp of 11 W.

It is estimated that an energy saving of 100 GWh can be obtained per year if each of the approximately 1.37 million domestic consumers replace one 60W incandescent lamp burning over 4 hours a day with an equivalent compact fluorescent lamp. This corresponds to a reduction of about 67 MW during the system peak load.

Acknowledgements

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