STUDY REPORT ON ELECTRICITY DEMAND CURVE AND SYSTEM PEAK REDUCTION

PUBLIC UTILITIES COMMISSION OF SRI LANKA

DECEMBER, 2012

This report contains detailed analysis of the system load profile, including the contributing factors for the high evening peak demand and practical demand side management options to arrest further worsening of the system load factor. Also the information about the consumer response to tariff change in 2011 is included in this report. Respective Conclusions and Recommendations also have been presented.

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EXECUTIVE SUMMARY

The Electricity system load profile of Sri Lanka has a high evening peak and as a result has a low load factor. On the other hand limitations in the Electricity supply side to accommodate the demand have caused power cuts in recent past. Some steps have already been taken to mitigate the issue with system peak, including the new tariff structure which came into effect from January 2011 onwards. Therefore, studying about the system load profile and finding further options to flatten the system load curve is a timely requirement.

The Public Utilities Commission of Sri Lanka, being the economic, technical and safety regulator of the electricity industry in Sri Lanka, has decided to conduct a study to improve this situation. Therefore, collecting and compiling of relevant data and making conclusions on the same matter were carried out through this study.

The general objective of this study is to conduct detailed analysis of the system load profile, analyze the contributing factors for the high evening peak demand and practical demand side management options to arrest further worsening of the system load factor. Also the scope of the study contained a study about historical characteristics of the system load profile and a study about the consumer response (TOU Consumers) to tariff change in 2011.

The Overall Study consisted of following parts.

1. A Literature Survey
2. A study based on Electricity load profile data and electricity consumption data, published by Sustainable Energy Authority (SEA) and Submitted by Ceylon Electricity Board (CEB)
3. A study based on Data Received from Distribution Licensees (DLs)

Key Findings

1. With the Literature survey, following aspects have been found that can be used to reduce the peak Electricity demand and flatten the Electricity load profile.
   a. Introducing a power factor penalty.
   b. Introduce a charge for reactive energy usage by consumers. (a kVArh charge)
   c. Postpone demands of industrial consumers during peak hours.
   d. Implementing building codes, Using Equipment and building standards at the design stage and as well as at the operation stage, Conducting Regular Audits to find out key issues etc.

2. Followings are found out using the data on Electricity load profile and Electricity consumption.
   a. During the two year period from 2009 to 2011 there is a rapid increase in Electricity sales when comparing with electricity sales growth data before 2009. 15 year average demand increase is 6.8%
   b. Electricity system Maximum demand has not shown a clear increasing trend from 2006 to 2010. However, from 2010 to 2011 maximum demand shows a rapid increase. Maximum demand growth rate is lower than sales demand growth; the 15 year average maximum demand growth rate is 6.5%.

c. Annual System Load Factor, which had been showing an increasing trend from 2008 to 2010, has decreased in 2011 to 60.8%.
d. The typical system peak at present occurs- 19.00 to 20.00; with a steep increase from 18:00 to 19:00, and depreciates with a slow rate of decreasing which takes about 3 hours. (From 19:00 to 22:00)
e. During a typical day, base active power demand of Sri Lanka is about 40% of the corresponding maximum demand. Also demand goes above 80% of the maximum demand during a period of 4 hours per day.

Conclusions

a. Time interval of Peak time coincides with the system peak hours and no further revision is required in Peak time interval.
b. Average power demand on Sundays during "Day" and "Peak" intervals is higher than the average "Off-Peak" demand of a typical weekday. Therefore, altering TOU time intervals for Sundays and Public Holidays as off-peak is inappropriate to Sri Lanka.
c. Despite natural improvements in system load factor over the past fifteen years, aggressive action is still required to curb further growth in peak demand, since an adverse trend is observed during recent past.
d. Mandating the TOU tariff for Bulk consumers has not become effective as anticipated and there is much potential for consumers to reduce their peak demand by shifting loads and improving their power factors. Peak time tariff can be increased further as an incentive to reduce system peak demand.

Recommendations

a. Distribution Licensees have already installed programmable meters with memory capacity, for all the bulk consumers of General Purpose category. Data from these meters shall be used to conduct a further study to analyze the implications of introducing mandatory TOU tariff scheme for bulk General Purpose consumers. Study should cover both demand shifting potential of the consumers and the revenue implications of the utilities.
b. A detailed study should be conducted on the load profiles of Domestic consumers, whom contribute heavily to the system peak demand, the possibility to adopt mandatory/ optional TOU tariff for larger domestic consumers shall be examined through this study. Since, existing metering equipment of domestic consumers is not geared for such data collection, sample data will have to be collected using data loggers.
c. Implementation of power factor charges and/or reactive energy (kVArh) charges shall be further studied to curb increasing MVAr demand, especially on the charge value and related incentive mechanism.
d. The relative rates for Time-Of-Use intervals shall be reexamined and adjusted (increase peak charges) to ensure that price signals are adequate to motivate consumers to shift demand from peak to off-peak time.

INTRODUCTION

The Public Utilities Commission of Sri Lanka (the Commission) is the economic, technical and safety regulator of the electricity industry in Sri Lanka. The Commission is entrusted with the function to collect and record information relating to the Electricity industry of the Country. The intention of this report is to analyze the system load profile of Sri Lanka and to seek ways and means to shift the system peak that result in a more flat load profile.

Background

Currently, for a typical week day the total Electricity generation in Sri Lanka is around 32 GWh. Also, the System load profile of Sri Lanka on a typical day is given in Figure 1. In this particular profile following characteristics can be identified.

Maximum demand = 1954.7MW, has occurred at 19:00

Minimum demand = 871.6 MW, has occurred at 02:00

Average Demand = 1325.6 MW, is shown by a red line.

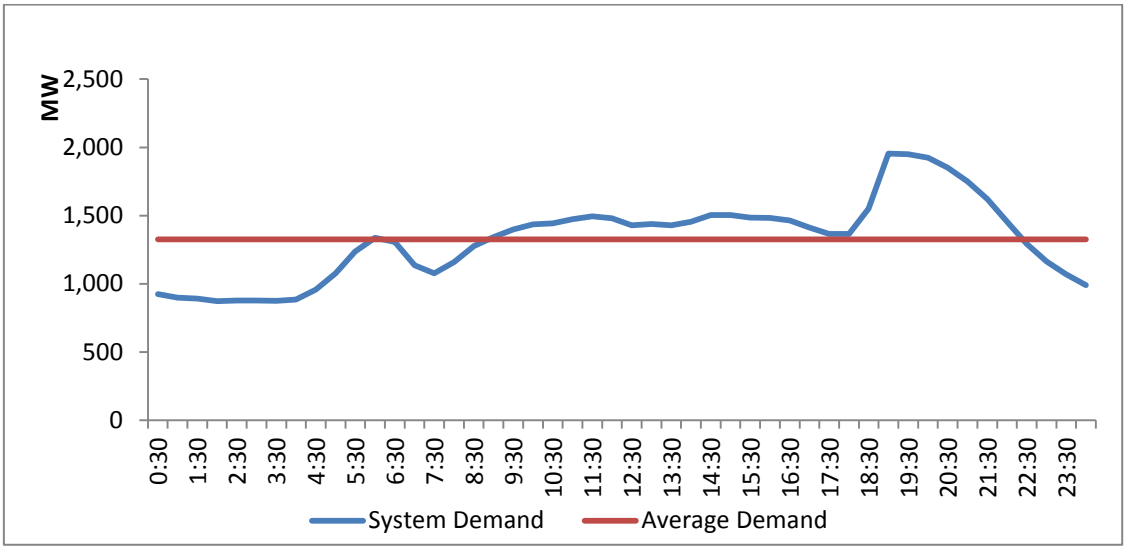

Figure 1: Typical System Load Profile of Sri Lanka

The load curve has a close relationship with the human behavior and other economic activities of the country, having a morning peak, Day peak and a night peak, which is the maximum of all. Even though it is desirable to have a flat load curve, due to this behavioral impact, the curve is having rather large variations. The extent of variation is so substantial that the maximum demand is having a greater value, which is about 2.24 times of the minimum demand.

The most undesirable aspect as far as the load curve is considered is the night peak, which includes predominantly the household electricity consumption. The present flat tariff structure does not force the domestic consumers to reduce energy consumption during the night peak. However, the night peak can be reduced by improving attitudes of consumers, which has already been practiced by Ministry of Power and Energy, Licensees (CEB and LECO) and Sustainable Energy Authority (SEA) through awareness programs during recent past.

Also the tariff change which was introduced in 1st January 2011 made three part Time Of Use (TOU) tariff mandatory for Industrial and Hotel consumers, which was optional earlier. The major objective of introducing mandatory three part tariff was to reduce the system demand during the peak hours. After such change, consumers usually tend to change their energy consumption pattern to have more economical benefits under new tariff structure. The most common and simplest step taken by the consumers to reduce their electricity cost under TOU structure is to change their load patterns by shifting loads from higher priced blocks like Peak Time and Day Time to Off-Peak Time.

Scope and Objectives:

The scope of this Study is limited to following areas:

a. General insight of the methods available on Demand Side Management (DSM) and their practicability.
b. Alterations in System Load Profile of Sri Lanka during recent past.
c. Load profiles of selected sample of TOU consumers, before and after the tariff change in 2011.
d. Recommend feasible ways and means to control and shift the System peak.

The Objectives of the study is given below:

a. Conduct detailed analysis of the Electricity system load profile to find out present characteristics and future trends.
b. Analyze the contributing factors for the high evening peak demand.
c. Practical demand side management options to arrest further worsening of the system load factor.
d. Explore the feasibility of new tariff structure and new definitions for TOU time intervals.
e. Find out Consumer response towards TOU Tariff structure.

Data Collection

Following are the data channels that used for this report.

1. A Literature Survey
   A literature survey is conducted to gain knowledge about available methods on Demand Side Management and Load Shifting. A list of References is given in ANNEX 1.

2. System Load Profile data
   SEA has published the Electricity consumption data in Sri Lanka, from 1997 to 2010 in their energy balance. Also the System Load Profile data related to year 2011 and 2012 were obtained from Transmission Licensee (CEB).

3. Electricity consumption Data of TOU Consumers.
   Consumption patterns of consumers who are billed under TOU tariff was collected from all the DLs (before and after the implementation of Mandatory TOU tariff scheme in January 2011).

LITERATURE SURVEY

A literature survey was done in parallel to the study. The intention of the literature survey was to find out key aspects associated with controlling the peak demand. Some key findings of the literature survey are outlined below with some particulars of applicability to Sri Lanka.

1. Charge on maximum demand and Demand reduction

Presently a charge is imposed on consumers on maximum demand. Therefore Consumers try to reduce their demand by improving power factor (PF), which leads to reduce the peak demand of the system. Some alternative methods of imposing the bulk consumers to reduce their loads during peak are given below.

Power factor charges, where users are penalized for having power factors below a fixed threshold, usually 0.90 or 0.95 **([2] Sustainable energy regulation and policymaking for Africa, Demand-side management Module 14)**

This charge can be introduced to Sri Lankan Tariff structure in following methods.

a. Remove the Demand charge from the tariff structure and introduce only the power factor penalty.
b. Introduce power factor penalty as an additional charge without removing the demand charge.
c. Apply the power factor penalty only during 1800 to 2200, where the system peak usually occurs, while keeping the demand charge, unchanged.
d. Introduce a charge for Reactive energy (kVArh) usage by the consumers.

2. Postpone Demand (**[1] Ananth V. Iyer et al)**

In this method there are not any measures to reduce demand or Electricity consumption and it is entirely based on shifting the loads of a certain Consumer from peak time to off peak time.

The basic idea behind this method is postponing a part of the demand by a consumer under the request of the supplier.

At a time where the supplier cannot meet the demand, the supplier can request from his industrial consumers to reduce their load by postponing some of his activities. After that the supplier can pay the consumer for the demand that was postponed at a pre-specified rate.

Here the supplier announces a certain fraction (1 - β) of demand that will be postponed to a non-regular time period. β is the amount of demand covered up by the supplier during a regular production period.

The supplier supplies the customers the earlier announced fraction (β) of the demand in the regular production period and the remaining (1 - β) fraction of the demand in the later postponement period.

Also when goes deep in to this method, there can be two options.

a. Postpone a fraction of demand for each customer.
b. Postpone all demand for a fraction of customers.

3. Designer/Installer behavior (**[4] Jonathan Koomey et al)**

   The way technology is designed and installed can have important implications. Over-sizing equipment which is common in heating, cooling systems and pumps is a major issue as far as Electricity demand is concerned. Poor design and poor installation practice can make a system inefficient, independent of the equipment efficiency. Following methods can impose an effect to reduce the Electricity demand of industries and other consumers.

   a. Implementing building codes.
   b. Using Equipment and building standards at the design stage and as well as at the operation stage.
   c. Regular Audits to find out key issues.

DATA ANALYSIS AND FINDINGS

Analysis based on System Load Profile data.

A summary of the system load profile data gathered through the study is given in Table 1.

Year	Electricity Sales (GWh)	Maximum Demand (MW)	Average Demand (MW)	Morning Peak (MW)	Day Peak (MW)
1997	3,971	896	531	542	575
1998	4,460	1,137	697	736	748
1999	4,754	1,291	769	821	791
2000	5,188	1,394	852	931	885
2001	5,178	1,445	832	906	827
2002	5,454	1,422	883	931	951
2003	6,160	1,516	943	911	1,011
2004	6,599	1,563	933	988	1,019
2005	7,201	1,748	1,050	980	1,132
2006	7,766	1,893	1,142	1,065	1,242
2007	8,169	1,842	1,188	1,195	1,333
2008	8,350	1,922	1,202	1,085	1,348
2009	8,372	1,868	1,223	1,127	1,413
2010	9,191	1,955	1,326	1,337	1,505
2011	9,973	2,163	1,423	1,345	1,581

Table 1: System Electricity data derived from submissions

Electricity Sales: Can be directly taken from the published statistics. This represents the total Electricity sales during the year under consideration.

Maximum Demand: Can be directly taken from the available data. This refers to the maximum system peak during the respective year. Usually the Maximum demand occurs at night between 18:30 and 20:00.

Average Demand, Morning Peak and Day Peak: The system load curve of the day on which the maximum demand occurred for each year was available. The average demand of that curve is given under “Average Demand”. The maximum value of that curve in the time interval 04:00 to 07:30 is given under the title “Morning Peak”. Also the maximum value of the curve in the time interval 08:30 to 16:30 is given under the title “Day Peak”.

Electricity Sales Growth

Graphical representation of Electricity sales from 1997 to 2011 is given in Figure 2.

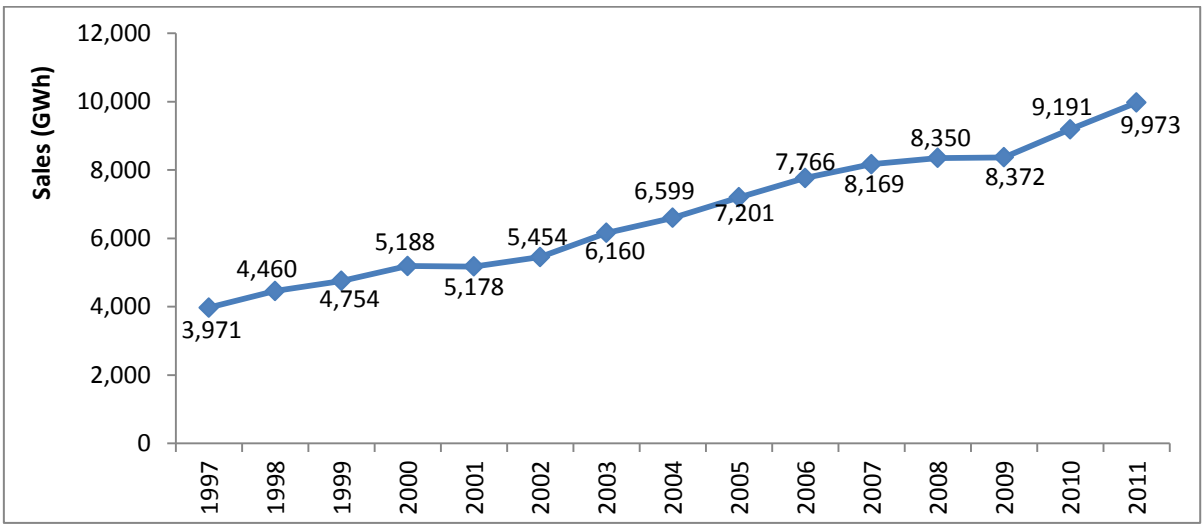

Figure 2: Electricity Sales Growth 1997-2011 (GWh)

Electricity sales have been keeping increasing throughout the past 15 years, at an average rate 6.8%. However there is a slight decrease in 2001. Electricity sales in 1997, 3971 GWh has almost tripled by 2011, 9973 GWh. During the two year period from 2009 to 2011 the sales show a clear rapid increase, with an increment of 1601 GWh. With the end of the prevailed war in 2009, post–war development projects and rehabilitation in the liberalized areas of the country might have influenced such growth.

Maximum Demand Growth

Figure 3 shows the growth of Maximum Demand from 1997 to 2011.

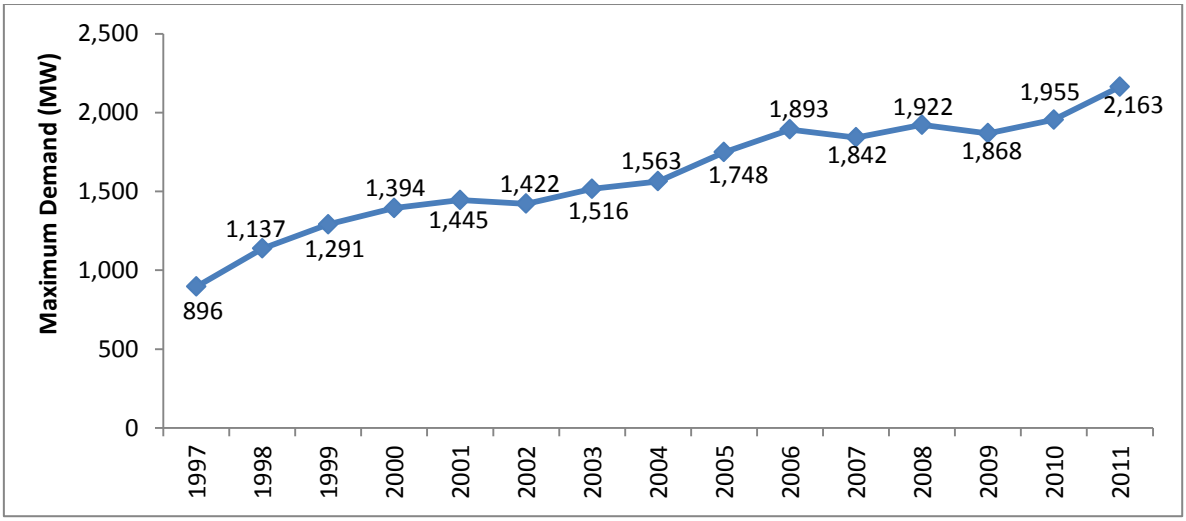

Figure 3: Maximum Demand Growth 1997-2011 (MW)

Maximum Demand has been increasing throughout the past years, at an average rate of 6.5% with a several decreases in 2002, 2007 and 2009 with respect to the related previous year. Although the energy sales has increased in 2007 and 2009, the respective maximum demands has decreased,

which is a positive trend in flattening the System load curve. However, from 2010 to 2011 maximum demand shows a rapid increase (108 MW) which should be controlled in coming years with appropriate demand side management measures.

Peak Factors

In addition to examining about system peak directly, variation of peak factors throughout past 15 years was taken in to consideration. Three peak factors related to Morning, Day and Night were considered separately. All the values used in this analysis were extracted from the System load curve of the day on which the maximum system demand of the respective year was recorded.

a. System Peak Factor = $\frac{System\ Peak\ Demand}{Average\ Demand}$

b. Morning Peak Factor = $\frac{Morning\ Peak\ Demand}{Average\ Demand}$

c. Day Peak Factor = $\frac{Day\ Peak\ Demand}{Average\ Demand}$

Table 2 shows the respective values of System Peak Factor, Morning Peak Factor and Day Peak Factor throughout past 15 years.

	System Peak Factor	Morning Peak Factor	Day Peak Factor
1997	1.687647	1.020876	1.083032
1998	1.632170	1.056245	1.073327
1999	1.679759	1.068748	1.029584
2000	1.636616	1.093504	1.039721
2001	1.735381	1.088367	0.993580
2002	1.611041	1.054689	1.077691
2003	1.606887	0.966200	1.071682
2004	1.676276	1.059226	1.092464
2005	1.665666	0.933734	1.078939
2006	1.656923	0.932342	1.087310
2007	1.550758	1.006225	1.122237
2008	1.598783	0.902362	1.121527
2009	1.526877	0.921374	1.155254
2010	1.474591	1.008534	1.135044
2011	1.519985	0.945537	1.111020

Table 2: Main System Peak Factors

System Peak Factor

Variation of System Peak Factor from 1997 to 2011 is plotted in Figure 4.

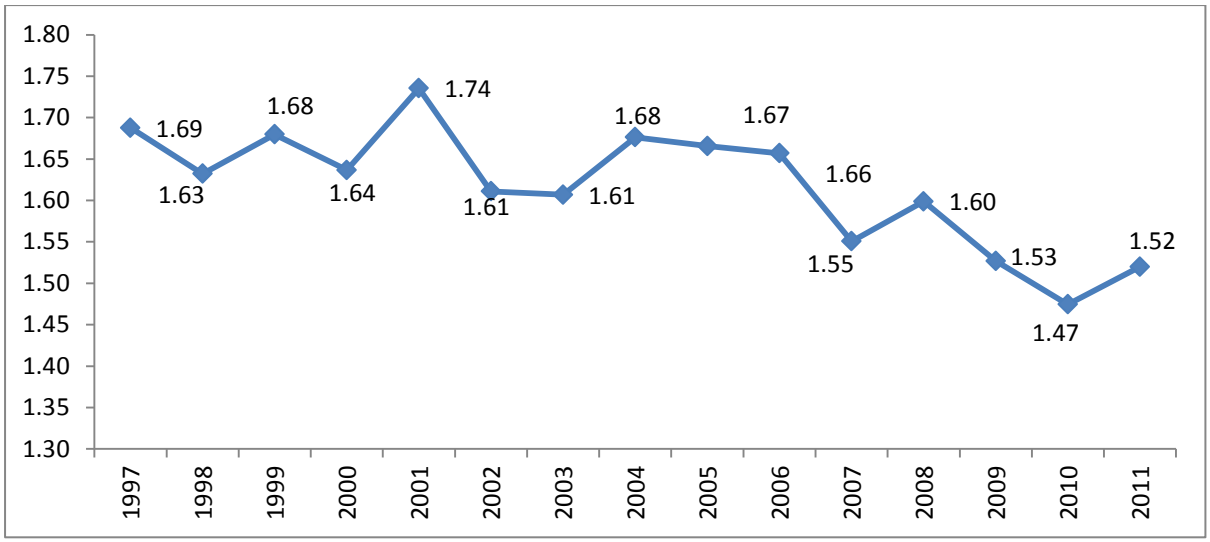

Figure 4: System Peak Factor

The System peak factor has been decreasing from 2008 to 2010, with an average decreasing rate of 4% However, a sudden increase is obtained for 2011. The minimum value of 1.47 has been recorded in 2010. Even with a slight increase, the peak factor of 2011 remains at 1.52 which is less than that of 2009(1.53), being the second best of all. Therefore, as a whole it can be concluded that the Peak factor has been improving during last 15 years.

Morning Peak Factor

Variation of Morning peak factor during the period 1997 to 2011 is shown in figure 5.

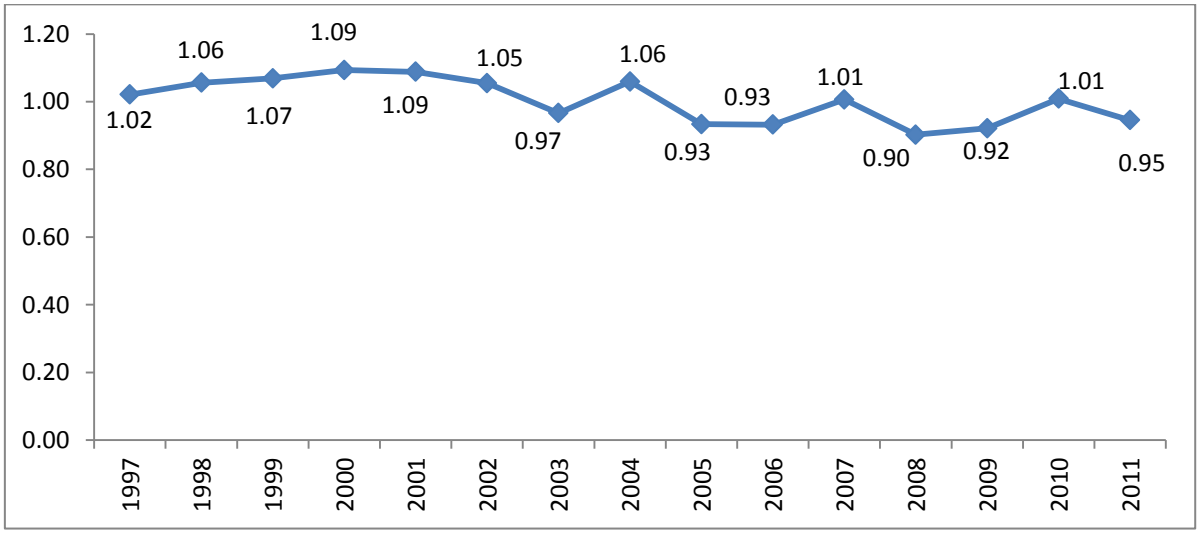

Figure 5: Morning Peak Factor

Morning Peak Factor has been changing with minor fluctuations but being closer to 1, with a maximum of 1.09 and a minimum of 0.9. Also a trend of increasing or decreasing cannot be observed.

Day Peak Factor

Figure 6 depicts the variation of Day peak factor from 1997 to 2011.

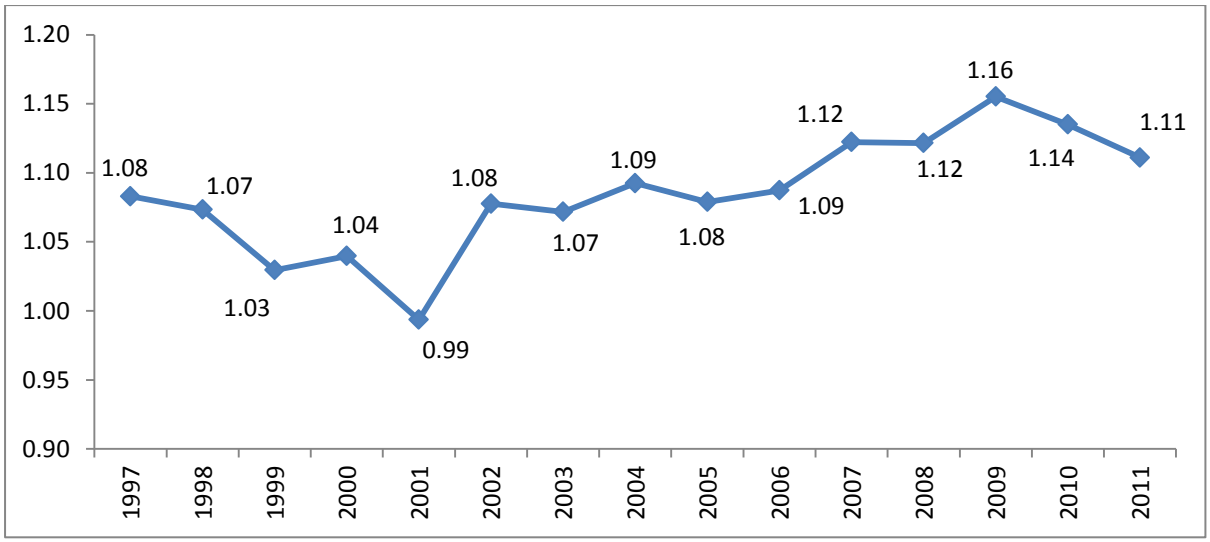

Figure 6: Day peak Factor

Day Peak Factor, which shows an increasing behavior from 2001 to 2009, with an average rate of 2%, has been decreased from 2009 to 2011 with an average rate of 2%. Except in 2001, Day Peak has a value greater than 1. The decreasing trend during recent years is very decent.

Time of occurrence of Maximum demand

Time of occurrence of maximum demand from 1997 to 2011 is given in Table 3. However, the Sri Lanka time reverted on 15 April 2006 to match Indian Standard time. The third column of Table 3 shows the compensated time of occurrence against the time change.

Year	Time of occurrence	Time of occurrence (Compensated)
1997	19:30	19:00
1998	18:30	18:00
1999	19:30	19:00
2000	19:30	19:00
2001	19:30	19:00
2002	19:30	19:00
2003	19:30	19:00
2004	19:30	19:00
2005	20:30	20:00
2006	19:30	19:30
2007	19:00	19:00
2008	19:30	19:30
2009	19:30	19:30
2010	19:00	19:00
2011	19:30	19:30

Table 3: Time of occurrence of Maximum demand with compensated time

Mode of the times of occurrence is 19:00, the compensated time. Also there are a few instances where the time of occurrence was 19:30. A considerable deviations from the mode have been recorded in 1998 (18:00) and in 2005 (20:00).

Annual System Load Factor

Annual System Load Factors from 1997 to 2011 was calculated using the available Generation data and Peak demand data. The respective equation used, is given below and the calculated values are given in Table 4.

$$Annual\ System\ Load\ Factor = \frac{Gross\ Generation\ (MWh)}{System\ Peak\ Demand\ (MW) \times 365\ \times 24}$$

Year	Annual System Load Factor
1997	62.5%
1998	55.8%
1999	54.6%
2000	55.7%
2001	52.9%
2002	55.9%
2003	61.2%
2004	63.0%
2005	57.8%
2006	57.3%
2007	61.4%
2008	59.4%
2009	61.0%
2010	63.1%
2011	60.8%

Table 4: Average System Load Factor from 1997 to 2011

The Figure 7 graphically represents the values in Table 4 along with the respective year.

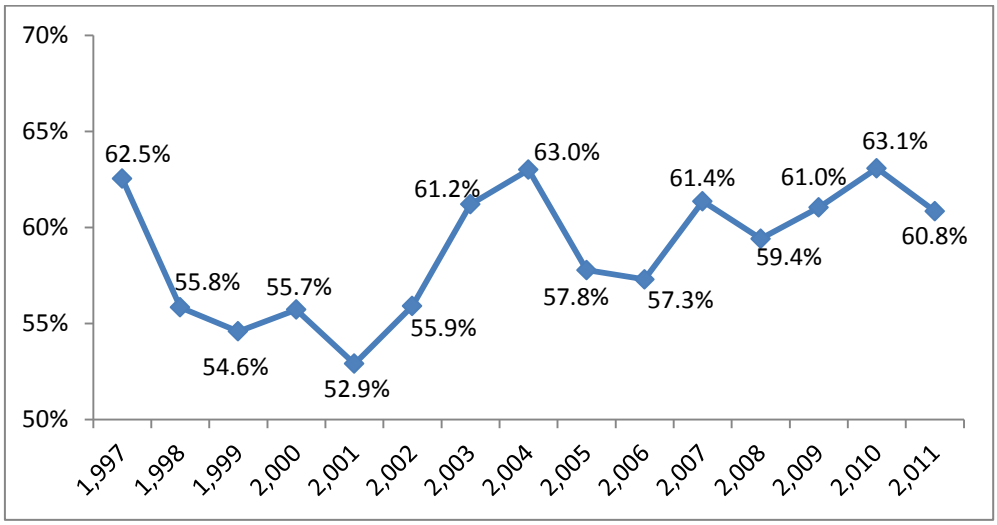

Figure 7: Average System Load Factor from 1997 to 2011

Throughout the considered 15 years period, Annual System Load Factor does not show a clear increasing or decreasing trend. However, from 2008 to 2010 the Annual System Load Factor shows

an increasing trend with an average growth rate of 3.1%. Maximum value of Annual System Load Factor was recorded in 2010 (63.1%) and it has dropped to 60.8% in 2011.

Study on Typical System Load profile at Present (2012)

CEB submitted System Load profile data for 14 consecutive days in 2012 under the request made by PUCSL. The data they submitted covers the time period from 17th of September to 30th of September. Also the aforesaid time period does not include any scheduled load shedding. Based on these data following analysis was done.

System Active power demand curves were plotted for three scenarios (Using the Average values). The scenarios are "Only Sundays", "Only Week days" and "All 14 days". Figure 8 shows the curves.

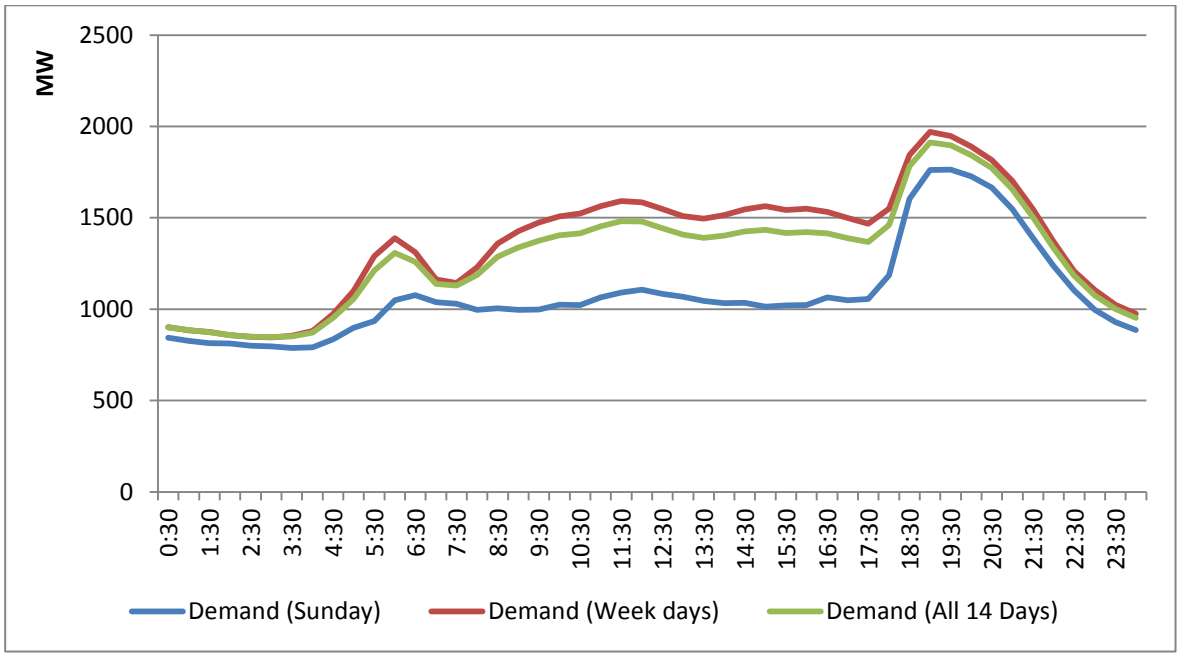

Figure 8: Averaged Active Power Demand Curves

a. The system peak occurs with a steep increase from 18:00 to 19:00 and depreciates with a slow rate of decreasing which takes about 3 hours. (From 19:00 to 22:00) This feature is common for all three curves. General opinion on the night peak is that it is predominately governed by domestic activities and lighting.
b. Morning peak of weekdays (recorded at 06:00) is rather symmetrical, which consists with rapid increase and a rapid decrease. However, when considering only Sundays, the curve does not show a significant peak demand, but just a slight increase, which is recorded at 06:30.
c. Day peak is recorded at 11:30 for a week day where that of Sundays is recorded at 12:00. However, during Day, the power demand is fluctuating without any sharp increases or decreases.

Some important values derived by submitted data from CEB for "Only Sundays", "Only Week days" and "All 14 days" are given in Table 5.

Index	Only Week Days	Only Sunday	All 14 Days
Maximum Power Demand (MW)	1971	1764	1913
Average Power Demand (MW)	1360	1082	1298
Load Factor	69 %	61 %	68 %
Power factor at Maximum Power Demand	0.931	0.946	0.934
Time of Occurrence of Maximum Power Demand	19:00	19:30	19:00
Maximum MVAr Demand (MVAr)	816	610	733
Time of Occurrence of Maximum MVAr Demand	11:30	19:00	19:00
Power factor at Maximum MVAr Demand	0.890	0.945	0.934
Minimum Power Factor	0.889	0.936	0.900
Time of Occurrence of Minimum Power Factor	11:00	11:30	11:30

Table 5: Derived important values from submitted data

a. The Load factor (69 %) of week days is the best among all three scenarios. Even though, the Peak demand of Sundays is less than that of a week day, the Active power demand curve is flatter in week days.
b. The occurrence time of system peak is slightly different on Sundays (19:30), when compared with that of on a week day (19:00). Average Power factor at Maximum Power Demand of Sundays is 0.946, which is better than that of a typical week day (0.931).
c. Usually minimum power factor occurs during day time, between 10:30 to 11:30. On Sundays it is 0.936 and in week days it is 0.889. However, an average Maximum VAr demand of 816 MVAr was recorded at 11:30 on week days, where that of a Sunday (610 MVAr) usually occurs at 19:00. In a typical week day, the power factor at maximum VAr demand is 0.890.
d. Maximum VAr demand and minimum power factor on a typical week day occurs during day time, around 10:30 to 11:30. Also the calculated values suggest that there is some opportunity for further improvements of the system load profile.

Sunday's Active power demand curve

Active power demand curve of Sunday was studied in detail, since it is different from typical load curve of a week day.

The intention of this particular study was to find the time intervals where the active power demand goes below the average off-peak power demand of a typical week day. In some other countries in the world, tariff rates on Sundays and public holidays are different from normal week days due to the low power demand. With this study, the relevance of this fact to Sri Lanka was examined.

The Sunday's Active load profile was plotted with average off-peak active power demand of a week day in the same coordinates and is given in Figure 9.

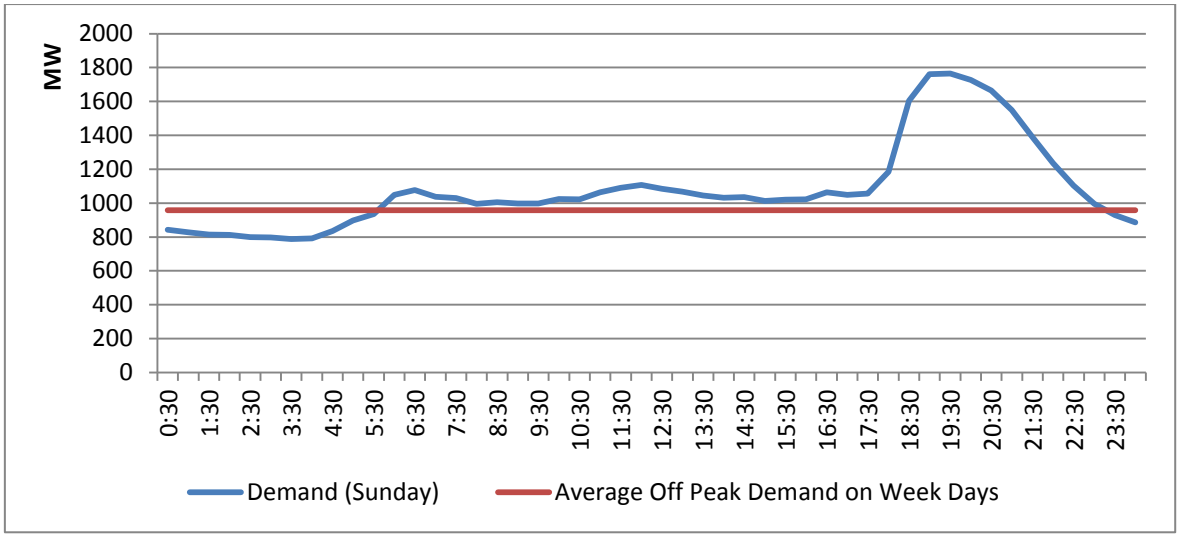

Figure 9: Active Power Demand Curve for Sunday and Average Off Peak Demand on week days

The Off peak power demand of a typical Sunday is less than that of a typical weekday during the time periods 00:00 to 06:00 and from 23:00 to 00:00. Therefore, average power demand on Sundays during "Day" and "Peak" intervals is higher than the average "Off-Peak" demand of a typical weekday. Therefore, going for new definition of time intervals for Sundays and Public Holidays is irrelevant to Sri Lanka.

Electricity Demand Duration Curve

Electricity Demand Duration curve was plotted using the received data from CEB for 14 days period. However, since the Demand curve for Sunday is differ from that of a week day, separate curves for week days and Sundays were considered. The respective Demand Duration Curves are given in Figure 10.

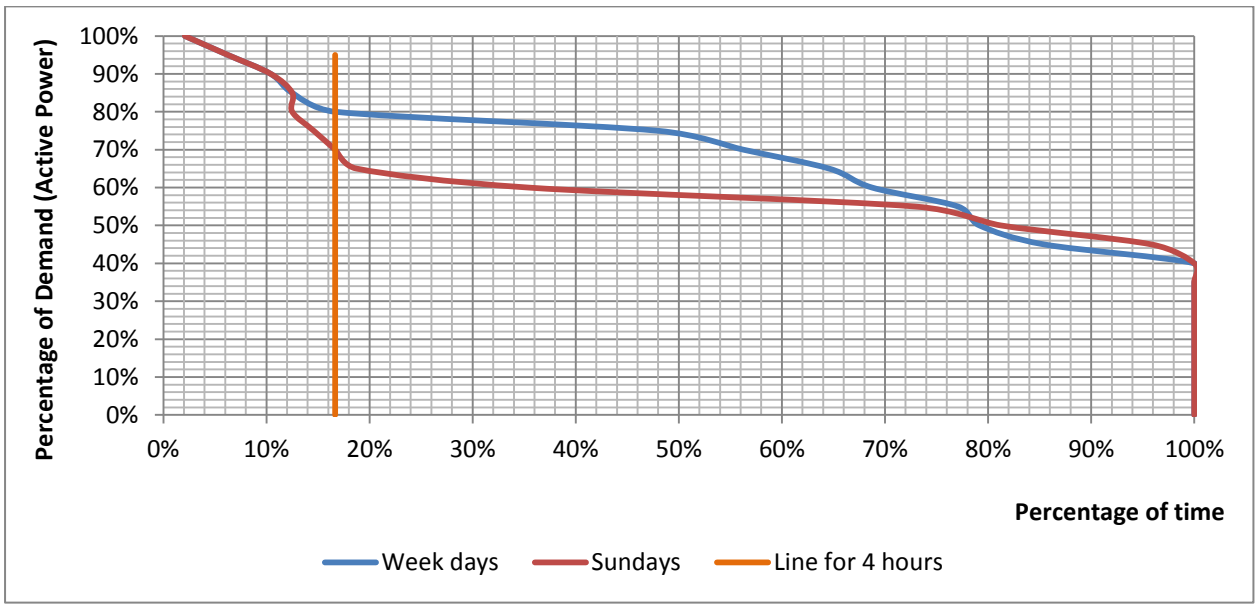

Figure 10: Electricity Demand Duration Curve (Week days)

Week Day Curve

Minimum Demand of 40% of the maximum can be considered as related to the base active power demand of the country. Also demand goes above 80% of the maximum during a period of 4 hours. By examining the usual Active power demand curve, it can be decided that this 4 hour period covers most of the demand during the “Peak” period (18:30 to 22:30). Demand varies from 40% of the Maximum to 80% of the Maximum for 84% of the time (About 20 hours).

Sunday Curve

In Sundays the base Active power demand is 40%, which is same as that of Week days. However, during 4 hours period, the power demand sustain above 70% of the maximum. Again, as same as in week days, this 4 hour period covers the “Peak” interval.

Analysis based on Electricity Consumption Data of TOU Consumers

In this phase of the study, the intention was to examine how sensitive the TOU consumers to new tariff structure (Introduced in January 2011) and to analyze their response towards the reduction of system peak. TOU tariff was mandated for bulk consumers in Industrial Category and Hotel category.

- **Industrial Consumers**
  There are three subcategories in Industrial Tariff, namely Industrial-1, Industrial-2 and Industrial-3. After the tariff change, all the bulk consumers were put into either Industrial-2 category or Industrial 3 category. Both Industrial-2 and Industrial-3 consumers use Time of Use tariffs.
  At the end of 2011, there were 4,479 consumer accounts for Industrial -2 category and 183 consumer accounts for Industrial -3 category. During the year 2011, Industrial – 2 consumers have been sold 1,785 GWh of electricity and Industrial – 3 consumers have been sold 1,331 GWh of electricity.

- **Hotel Consumers**
  Hotel Category is also subdivided into three categories Hotel-1, Hotel-2 and Hotel-3, where Hotel-2 and Hotel-3 consumers use TOU tariff. At the end of 2011 there were 217 Hotel-2 consumers and 8 Hotel-3 consumers, maintained by the Distribution Licensees. Also the total consumption during 2011 for Hotel-2 consumers was 130 GWh and that for Hotel-3 consumers is 67 GWh.

Since these consumers (Industrial-1, Industrial-2, Hotel-1, and Hotel-2) consume a large share of total consumption of the country, a sample of them was studied in this particular phase of the study.

Submitted Data from DLs

DLs were requested to submit energy consumption data of TOU consumers. The format is given in ANNEX 2. Historical consumption data under the old tariff structure and consumption data under new tariff structure was requested from them. Also, load profiles for a period of one week of those consumers were requested.

Data Analysis is entirely based on the data submitted by the Licensees. Some licensees could not meet the sample sizes specified in the given format, due to lack of consumers under related tariff category. The sizes of the samples for each tariff category, taken for the analysis are given below in Table 6, Table 7 and Table 8.

Licensee	Present tariff Category		
	Hotel 2	Industrial 2	Industrial 3
DL-1	3	23	2
DL-2	8	12	10
DL-3	1	29	0
DL-4	1	28	1
DL-5	0	18	0
Total	13	110	13

Table 6: Consumers who had been having "Flat" tariff before the tariff change in 2011

Before the tariff revision there had been a substantial number of "Flat" tariff consumers under Hotel and Industrial categories.

An important aspect is that even the bulk consumers (I3) had been using Flat tariff rates before the Tariff change in 2011, though the common practice of bulk consumers is to reduce their electricity cost by selecting TOU tariffs and following suitable load shifting methods. Using "Flat" tariffs by a Bulk consumer, disregarding the TOU option, leads to a financial loss for both Licensee and the consumer himself.

Licensee	Present tariff Category		
	Hotel 2	Industrial 2	Industrial 3
DL-1	1	3	0
DL-2	0	8	2
DL-3	0	10	0
DL-4	0	10	0
DL-5	0	8	0
Total	1	39	2

Table 7: Consumers who had been having "Two Part" tariff before the tariff change in 2011

Licensee	Present tariff Category	
	Industrial 2	Industrial 3
DL-1	0	1
DL-2	4	1
DL-3	2	2
DL-4	10	0
DL-5	0	0
Total	16	4

Table 8: Consumers who had been having "Three Part" tariff before the tariff change in 2011

The submitted data by the Licensees were analyzed to seek patterns of energy consumption.

Time Intervals of Present and Previous Tariff structures

Definitions of time intervals for two part and three part tariff structures are given below.

Two Part Tariff:

Two part tariff is not there anymore with the new Tariff scheme. However, it was there with the previous tariff structure (Before 2011) and used for calculation in this report.

Name	Time interval	No. of Hours
Peak	18:30 to 21:30	3
Off-Peak	21:30 to 18:30	21

Table 9: Time intervals for 2 part Tariff – Before 2011

Three Part Tariff:

According to new tariff structure, definitions of the time intervals are given in Table 10.

Name	Time interval	No. of Hours
Day	05:30 to 18:30	13
Peak	18:30 to 22:30	4
Off-Peak	22:30 to 05:30	7

Table 10: Time intervals for 3 part Tariff – Before 2011

Definition of the time intervals of three part tariff of the previous structure is slightly different from that of the present structure. Definition of the previous three part tariff scheme is given in Table 11.

Name	Time interval	No. of Hours
Day	04:30-18:30	14
Peak	18:30-22:30	4
Off Peak	22:30-04:30	6

Table 11: Time intervals for 3 part Tariff – 2011 onwards

Data Analysis

To express the information and for comparisons, two types of graphical representations were used. They are named as “Interval-wise Energy Consumption” and “Normalized Factor”. The explanation of respective calculations is given below.

Interval-wise Energy Consumption

Time interval wise energy consumption for each consumer category, before and after the tariff change was calculated. The calculated values are represented in bar charts. At a glance, these graphs depict the share of energy consumption with respect to time intervals for each tariff category.

Normalized Factor (NF)

- ***Average Active Power Demand (AAPD)***

To analyze the consumer response for the new tariff structure, daily load profiles before and after the tariff change should be compared. Licensees could not submit daily load profiles related to previous tariff structure, due to unavailability of records. However, licensees have submitted energy consumption during each time interval (Day, Peak and Off-Peak) separately. Therefore Average Active Power Demand (AAPD) has been calculated.

The equations used for the calculation of AAPD are given below.

$$\text{Average Active Power Demand } (\text{Day}) = \frac{\text{Average Consumption during "Day"}}{\text{No. of Day Hours}}$$

$$\text{Average Active Power Demand } (\text{Peak}) = \frac{\text{Average Consumption during "Peak"}}{\text{No. of Peak Hours}}$$

$$\text{Average Active Power Demand } (\text{Off} - \text{Peak}) = \frac{\text{Average Consumption during "Off} - \text{Peak"}}{\text{No. of Off} - \text{Peak Hours}}$$

Also, Average Daily Active Power Demand (ADAPD) was calculated using the following equation.

$$ADAPD = \frac{Average\ Daily\ Energy\ Consumption}{24}$$

AAPD gives an idea about the load management/controlling of the consumer. However, still this value cannot be used to compare the demand values of a consumer, before and after the tariff change, since, the capacity of a certain consumer might have changed (most probably, increased) and then the past value is not comparable with the present value.

- ***Normalized Factor (NF)***

For comparisons of present values with past values, AAPD was normalized against the ADAPD and expressed as a percentage. The equation used is given below.

$$Normalized\ Factor\ (NF)\ for\ a\ certain\ time\ interval = \frac{AAPD\ of\ the\ time\ interval\ \times 100\%}{ADAPD}$$

Normalized Factor (NF) gives an idea about the extent of loading in a certain time interval with respect to the Average loading. Therefore NF can be used to compare the load scheduling of consumers, before and after the tariff change regardless the capacity changes of the respective premises.

Historical Data – Consumers who had been having flat tariff rate before the tariff change of 2011.

For the consumers, who had been having flat tariff before the tariff change in 2011, there are no data available describing time related power consumption during previous tariff structure. Therefore the analysis was carried out only for the data related to new tariff structure.

Interval-wise Energy Consumption, After the Tariff Change

Calculated values for Interval-wise Energy Consumption are given in Table 12.

	Average Individual Consumption (kWh)			*Percentage*		
	Day	***Peak***	***Off Peak***	***Day %***	***Peak %***	***Off Peak %***
Industrial 2	18036	4004	5797	65%	14%	21%
Industrial 3	480778	173865	303427	50%	18%	32%
Hotel 2	34561	11774	15003	56%	19%	24%

Table 12: Interval-wise Energy Consumption – After the tariff change

The Graphical representation is given in Figure 11.

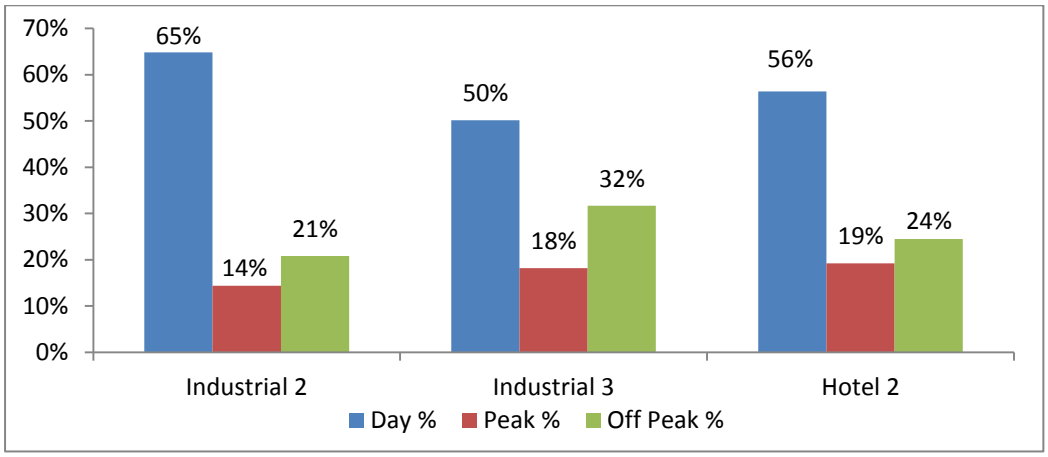

Figure 11: Interval-wise Energy Consumption of Consumers - Previously, Flat rate

I2 Consumers:

65% of the consumption is from "Day" interval, where 14% and 21% of the consumption is from "Peak" and "Off-Peak" intervals respectively.

I3 Consumers:

Maximum share of 50% is from "Day" interval which is less than that of I2 Consumers. Also a share of 18% and 32% is related to "Peak' and "Off-Peak" intervals respectively.

H2 Consumers:

When comparing with others categories, Maximum share of 19% from "Peak" interval is there with H2 consumers. "Day" share is 56% and "Off-Peak" share is 24%.

The consumers who had been having Flat rate before mandating the three part tariff were new to TOU tariff. Consumers in all the tariff categories have their maximum share in "Day" interval, since it covers the maximum duration (13 hours).

Normalized Factor (NF), After the Tariff Change

Data related to NF are tabulated in Table 13.

	Individual Consumption (kWh)				*AAPD (kW)*			*ADAPD (kW)*	*Normalized Factor*		
	Day	*Peak*	*Off Peak*	*Total*	*Day*	*Peak*	*Off Peak*		*Day %*	*Peak %*	*Off Peak %*
Ind 2	18,036	4,004	5,797	27,837	1,387	1,001	828	1,160	120%	86%	71%
Ind 3	480,778	173,865	303,427	958,070	36,983	43,466	43,347	39,920	93%	109%	109%
Hotel 2	34,561	11,774	15,003	61,338	2,659	2,943	2,143	2,556	104%	115%	84%

Table 13: Normalized factor – After the tariff change

Data in Table 13 are represented in the bar chart given in Figure 12.

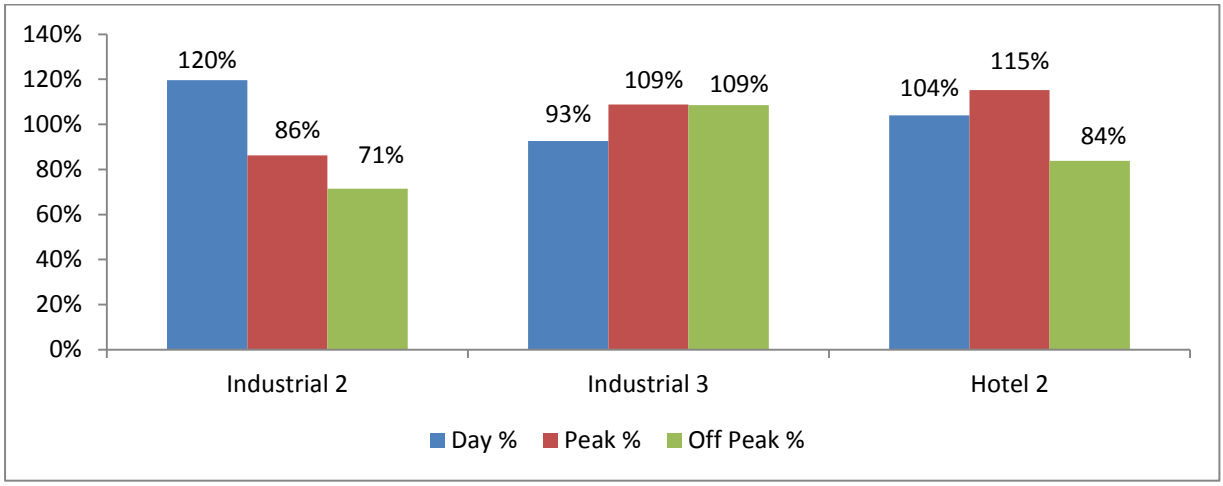

Figure 12: Normalized Factor - After the tariff change

I2 Consumers:

I2 consumers have greatest NF of 120% during "Day", and the least NF of 71% during Off-Peak. They have the heaviest load during Day and it is economical for them. NF during Peak is 86% which is greater than that of Off-Peak. Therefore still they can reduce their cost by transferring some loads to "Off-Peak" from "Peak".

I3 Consumers:

I3 consumer's response for TOU tariff structure is not satisfactory. NF during Day, 93%, is the least, while NF during Peak, 109%, is the greatest. NF during Off-Peak is also 109%. They have Loaded the Peak hours unnecessarily, while Day hours are lightly loaded. Although, I3 consumers usually have comparatively high electricity costs, they have not been motivated by the TOU tariff to reduce loading in peak hours.

H2 Consumers:

H2 Consumers also have not responded to the TOU structure as expected. Maximum NF of 115% is during Peak hours, and minimum NF of 84% is during Off-Peak hours. H2 consumers have a greater potential of transferring loads from "Peak" to "Off-Peak".

Historical Data – Consumers who were having two part tariff rate before the tariff change of 2011.

Interval-wise Energy Consumption, Before the Tariff Change

According to the data submitted by the licensees, Interval-wise Energy Consumption before the Tariff change is calculated and expressed in Table 14.

	Average Individual Consumption (kWh)		*Percentage*	
	Day	*Peak*	*Day %*	*Peak %*
I2	3,015	38,095	7%	93%
I3	34,674	267,421	11%	89%

Table 14: Interval-wise Energy Consumption – Before Tariff change

The corresponding Graph is given in Figure 13.

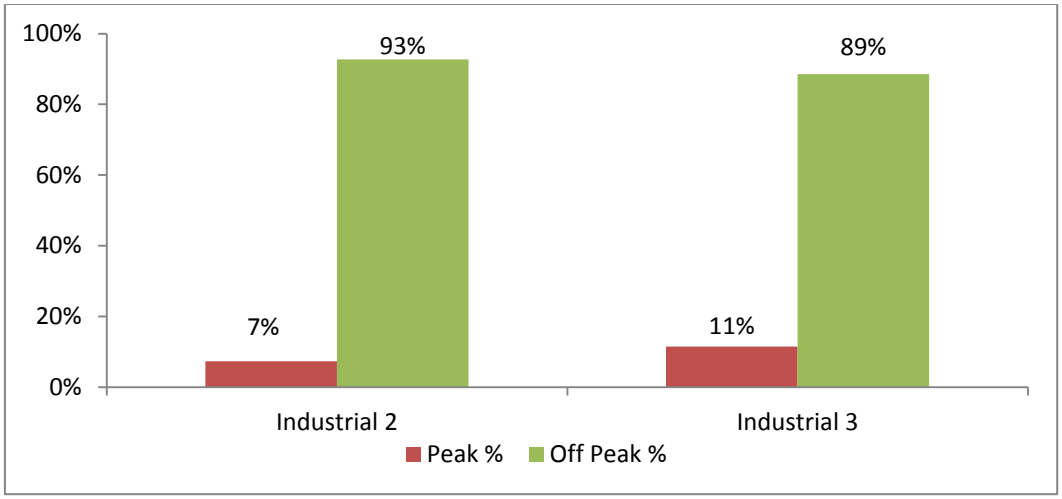

Figure 13: Interval-wise Energy Consumption of Consumers, Before the Tariff Change

I2 Consumers:

93% of the total consumption is from "Off-Peak" interval and the rest is from "Peak" interval.

I3 Consumers:

Maximum share of 89% is from "Off-Peak" interval which is slightly less than that of I2 Consumers. Also a share of 11% goes to "Peak' interval.

H2 Consumers:

Since the sample size for H2 is 1, analysis of H2 consumers is omitted.

Interval-wise Energy Consumption, After the Tariff Change

Table 15 below shows the calculated values. However, there is a difference of the sample sizes due to the shortage of energy data before the tariff revision, received from LECO.

	Average Individual Consumption (kWh)			*Percentage*		
	Day	*Peak*	*Off Peak*	*Day %*	*Peak %*	*Off Peak %*
I2	42,257	6,216	11,089	71%	10%	19%
I3	160,059	36,571	66,912	61%	14%	25%

Table 15: Interval-wise Energy Consumption – After Tariff change

The graphical representation is given in Figure 14.

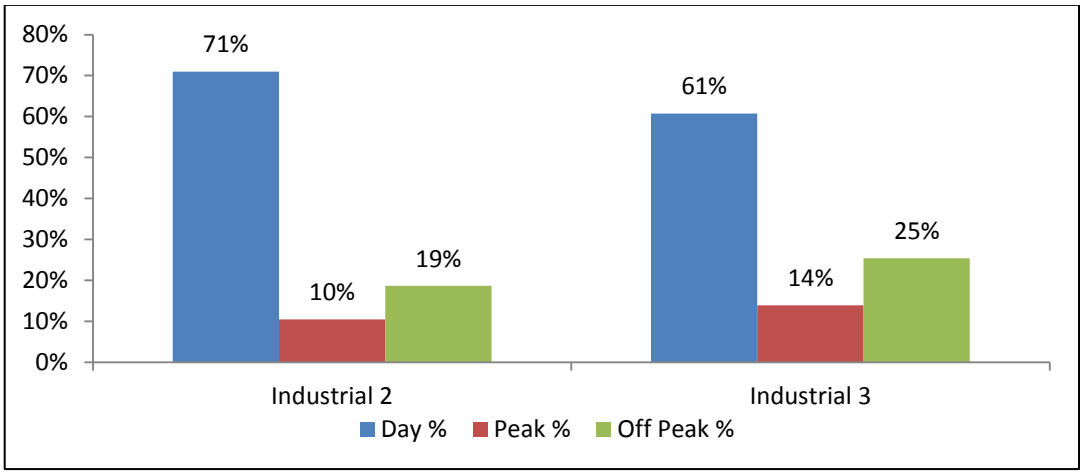

Figure 14Interval-wise Energy Consumption of Consumers, After the Tariff Change

I2 Consumers:

71% of the consumption is from "Day" interval which is higher than that of consumers who had been having Flat rate previously, Also 10% and 19% of the consumption is from "Peak" and "Off-Peak" intervals respectively.

I3 Consumers:

Maximum share of 61% is from "Day" interval which is less than that of I2 Consumers. Also a share of 14% and 25% is related to "Peak' and "Off-Peak" intervals respectively.

Normalized Factor, Before and After the Tariff Change

Before mandating the TOU three part tariff, these consumers had been having TOU two part tariff. Therefore, TOU tariff was not a new experience for them, and they were expected to adjust themselves finely to three part tariff.

Table 16 shows the calculated values in this regard, considering the data before the tariff change.

	Individual Consumption (kWh)			*AAPD (kW)*		*ADAPD (kW)*	*Normalized Factor*	
	Peak	*Off Peak*	*Total*	*Peak*	*Off Peak*		*Peak %*	*Off Peak %*
I2	3015	38,095	41,110	1,005	1,814	1,713	59%	106%
I3	34,674	267,421	302,094	11,558	12,734	12,587	92%	101%

Table 16: Normalized Factor – Before the tariff change

Table 17, given below shows the calculated values in this regard, considering the data after the tariff change.

	Average Individual Consumption (kWh)				*Average Active Power (kW)*			*ADAPD (kW)*	*Normalized Factor*		
	Day	*Peak*	*Off Peak*	*Total*	*Day*	*Peak*	*Off Peak*		*Day %*	*Peak %*	*Off Peak %*
I2	42,257	6,216	11,089	59,562	3,251	1,554	1,584	2,482	131%	63%	64%
I3	160,059	36,571	66,912	263,542	12,312	9,143	9,559	10,981	112%	83%	87%

Table 17: Normalized Factor – After the tariff change

Graphs given in Figure 15 and in Figure 16 depict the values of NF before and after the tariff change.

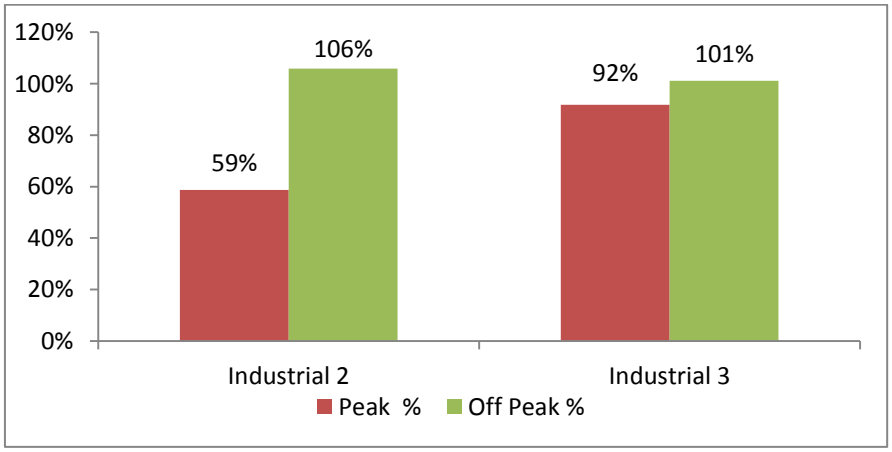

Figure 15: Normalized Factor, Before Tariff Change

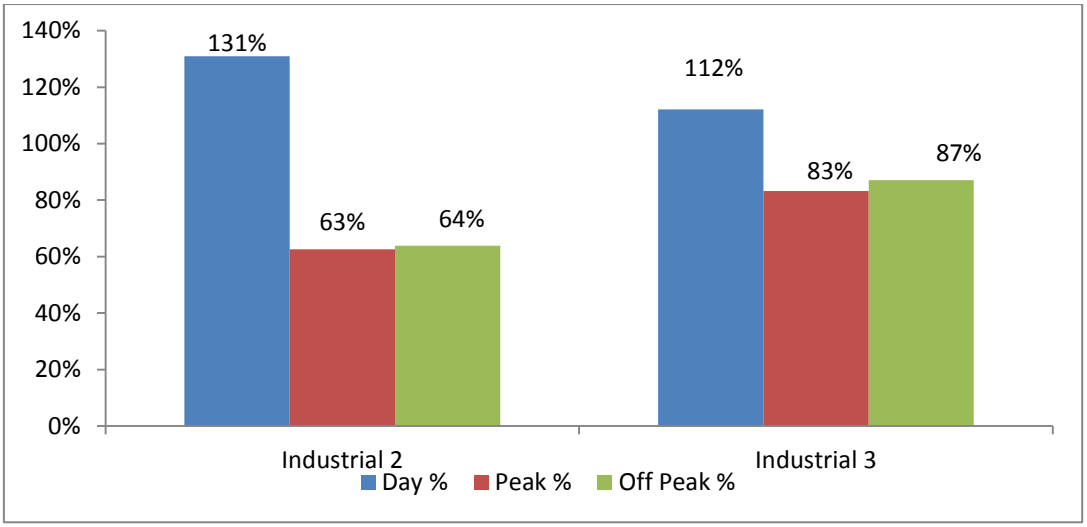

Figure 16: Normalized Factor, After Tariff Change

I2 Consumers

NF during Peak has been increased for I2 consumers from 59% to 63% which is not a change in a considerable margin. However, still these consumers can reduce their cost by transferring some loads to Off-Peak, since NF for Off Peak, 64%, is almost the same as that of Peak.

I3 Consumers

Response of I3 consumers for the tariff change is effective. Since their NF for Peak has been reduced to 83%, which was 92% before the Tariff change. However, I3 consumers still have a potential on reducing peak loads since their Off peak NF is 87%, a lower value than that of Day interval, 112%.

Historical Data – Consumers who were having three part tariff rate before the tariff change of 2011.

These consumers consume relatively larger amounts of electricity. They can be thought of as knowledgeable consumers about three part tariff, load shifting and other electricity cost reducing options.

Interval-wise Energy Consumption, Before the Tariff Change

Interval-wise Energy Consumption, before the Tariff change is expressed in Table 18.

	Average Individual Consumption (kWh)			*Percentage*		
	Day	*Peak*	*Off Peak*	*Day %*	*Peak %*	*Off Peak %*
I2	60,621	7,227	12,656	75%	9%	16%
I3	1,950,648	480,003	831,704	60%	15%	25%

Table 18: Interval-wise Energy Consumption, Before the Tariff change

The graphical representation of the Table 18 is given in Figure 17.

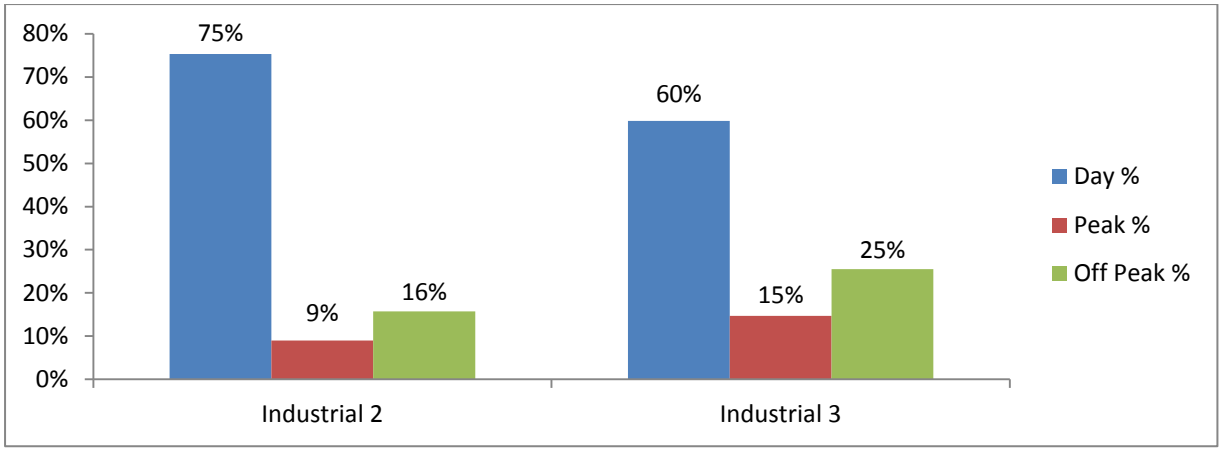

Figure 17: Interval-wise Energy Consumption, Before the Tariff Change

I2 Consumers:

I2 consumers have a maximum energy usage of 75% during Day and minimum energy usage of 9% during Peak. Also, 16% of energy usage is during Off Peak.

I3 Consumers:

Maximum share of 60% is related to Day and the minimum share of 15% is related to Peak. Off Peak share is 25%.

Interval-wise Energy Consumption, After the Tariff Change

Table 19 shows the Interval-wise Energy Consumption, after the tariff change.

	Average Individual Consumption (kWh)			*Percentage*		
	Day	*Peak*	*Off Peak*	*Day %*	*Peak %*	*Off Peak %*
I2	58,557	10,523	14,027	70%	13%	17%
I3	1,626,934	522,646	919,375	53%	17%	30%

Table 19: Interval-wise Energy Consumption, after the tariff change

The Graphical representation of the above data is given in Figure 18.

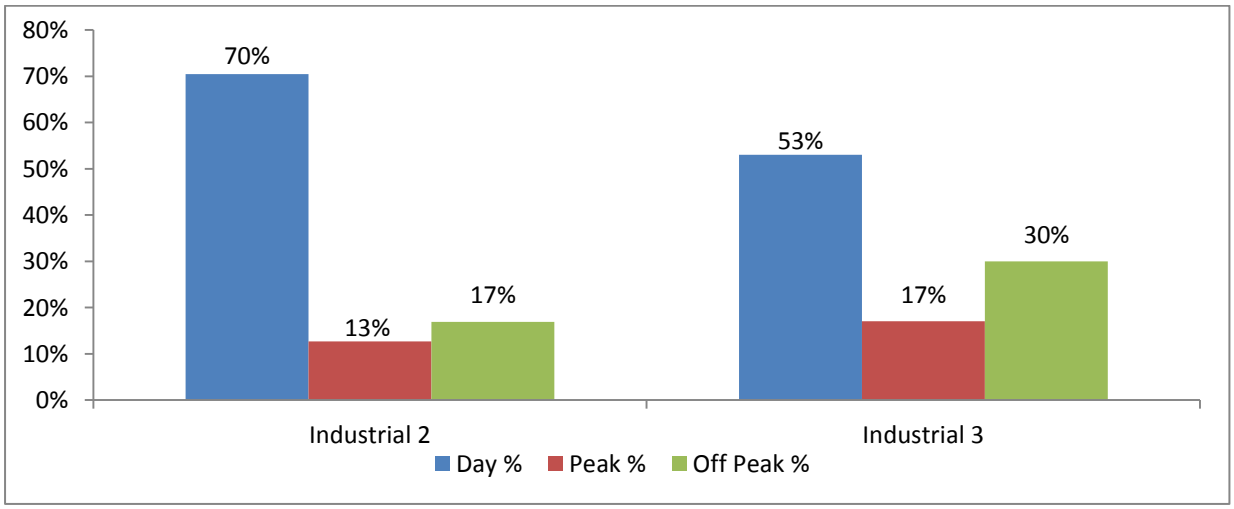

Figure 18: Interval-wise Energy Consumption of Consumers, after the Tariff Change

I2 Consumers:

I2 consumers have 70% of their energy consumption during "Day" interval and 13% of during "Peak" hours. Also 17% of the total Consumption is from "Off-Peak" interval.

I3 Consumers:

Percentage of Consumption during "Day" interval is 53%, which is much less than that of I2 consumers. However "Off-Peak" consumption is considerable which is at 30%. Also consumption during "Peak" interval is 17%.

Normalized Factor, Before and After the Tariff Change

Mandating of Three part tariff was not a new experience for these consumers, who had already been having it. However, time intervals of new tariff structure are slightly different from the earlier tariff structure.

Interval Name	Time interval (New)	Time interval (Old)
Day	05:30 to 18:30	04:30 to 18:30
Peak	18:30 to 22:30	18:30 to 22:30
Off-Peak	22:30 to 05:30	22:30 to 04:30

Table 20: Three part Time Intervals, New vs. Old

Even though, there is a slight change in time intervals, it is worth noting that the time interval for Peak, which is a major aspect in cost reduction, has not been changed.

Table 21 shows the calculated values including NF, in this regard considering the data before the tariff change.

	Average Individual Consumption (kWh)				*Average Active Power (kW)*			*ADAPD (kW)*	*Normalized Factor*		
	Day	*Peak*	*Off Peak*	*Total*	*Day*	*Peak*	*Off Peak*		*Day*	*Peak*	*Off Peak*
I2	60,621	7,227	12,656	80,503	4,330	1,807	2,109	3,354	129%	54%	63%
I3	1,950,648	480,003	831,704	3,262,355	139,332	120,001	138,617	135,931	103%	88%	102%

Table 21: Normalized Factor – Before the tariff change

Table 22 shows the calculated values in this regard considering the data after the tariff change.

	Average Individual Consumption (kWh)				*Average Active Power (kW)*			*ADAPD (kW)*	*Normalized Factor*		
	Day	*Peak*	*Off Peak*	*Total*	*Day*	*Peak*	*Off Peak*		*Day %*	*Peak %*	*Off Peak %*
I2	58,557	10,523	14,027	83,106	4,504	2,631	2,004	3,463	130%	76%	58%
I3	1,626,934	522,646	919,375	3,068,955	125,149	130,661	131,339	127,873	98%	102%	103%

Table 22: Normalized Factor – After the tariff change

The graphical representation of above data is given in Figure 19 and in Figure 20.

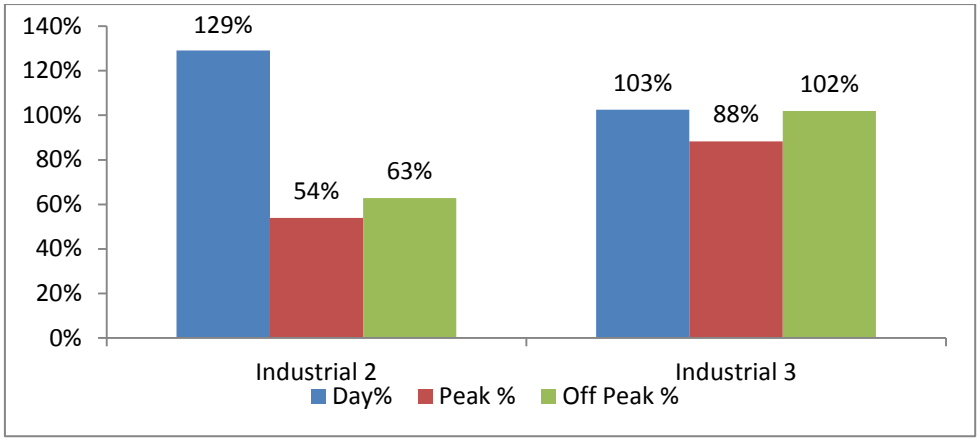

Figure 19: Normalized Factor, Before Tariff Change

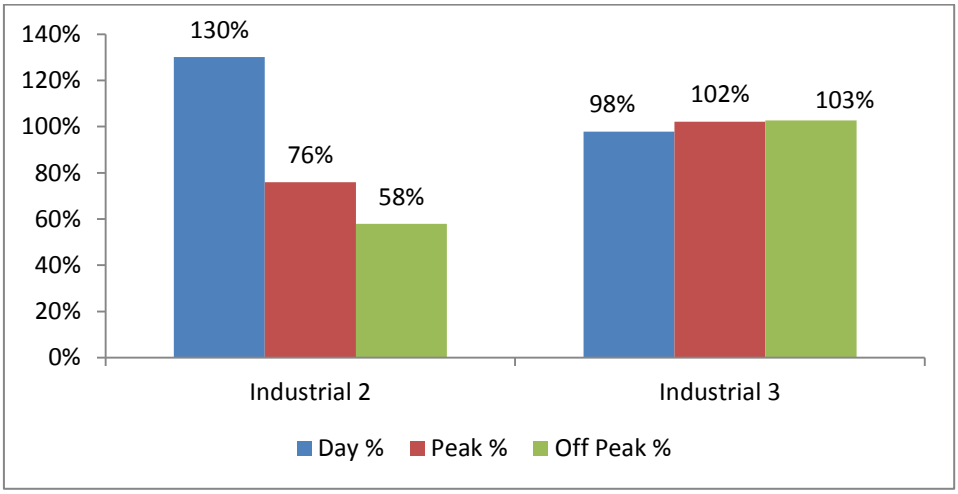

Figure 20: Normalized Factor, After Tariff Change

I2 Consumers

NF for Day interval is almost the same. NF for Peak has been increased to 76% from 54%, which is not a good sign for consumers. At the same time, NF for Off Peak has been decreased to 58%, which was 63% before the tariff change. However, with new tariff structure, I2 consumers have increased their loading during peak hours. Therefore, they have not been encouraged by the new tariff structure to reduce peak loading.

I3 Consumers

Daily consumption profile is more flat for I3 consumers, when comparing with I2 consumers. There is no significant difference in NF for all three time intervals. However, NF at peak has been increased from 88% to 102%, increasing their electricity cost. Since these consumers spend a huge amount of money on electricity, they are expected to concentrate more on load shifting to minimize their electricity cost. Present profile, which is almost flat, shows that the I3 consumers have much potential to diminish their electricity costs.

Active Power Profile of the Sample of TOU Consumers

Licensees have submitted load profiles of TOU consumers as they were asked to. Table 23 shows the sample sizes of data submitted by the Licensees.

Licensee	Sample
DL-1	33
DL-2	33
DL-3	30
DL-4	50
DL-5	41
Total	**187**

Table 23: Sample sizes

Active Power profile, of those consumers has been constructed based on the submitted data (Shown in Figure 21). Since the total sample consists with a considerable number of TOU consumers covering H2, I2 and I3 tariff categories; this profile is a fair approximation of the TOU load profile of the country.

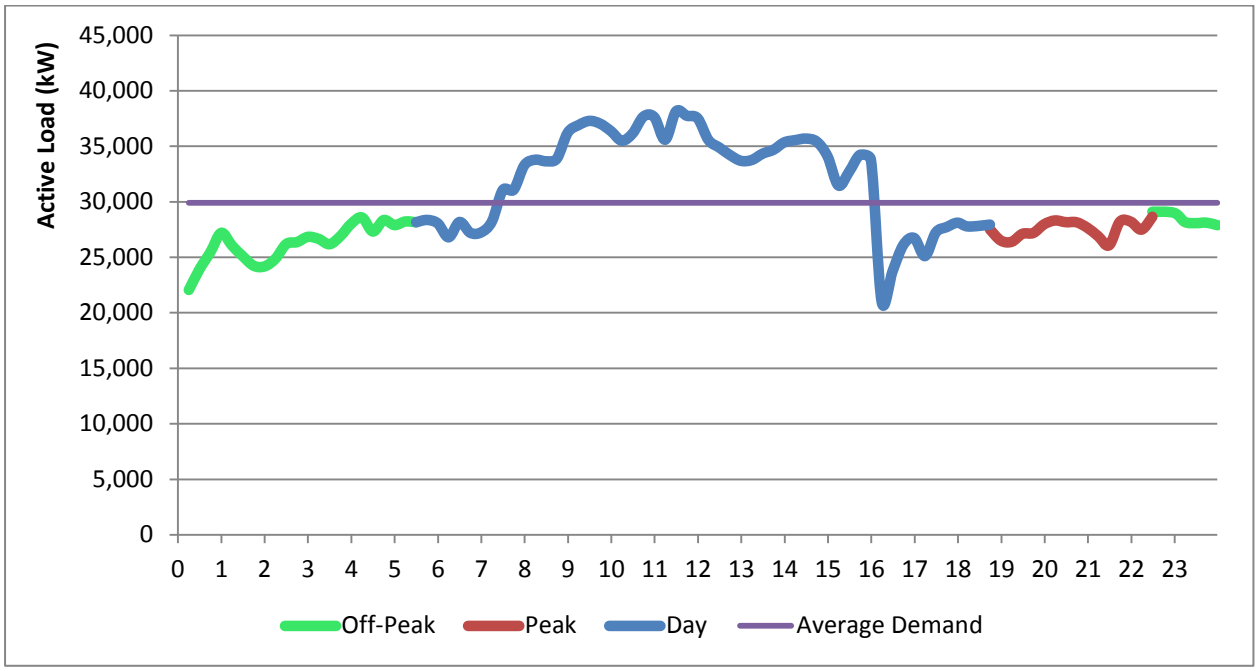

Figure 21: Total Active Power Profile (kW), Sample of 187 TOU Consumers

Maximum value of the curve occurs at "Day" interval, close to 11.30 AM. A sudden drop of the curve can be observed around 4.15 PM. However, during the period starting from 5.30 PM to 12 midnight, the Active Power demand does not show any significant difference, but remains at a lower value than the average demand. Also during the "Off-Peak" period from 12 midnight to 3.30 AM, the curve runs below the average demand, keeping a considerable margin.

Potential to Improve Power Factor

Improving power factor to reduce the demand charge has become very common at present. Consumers tend to do so since they can reduce their demand charge by improving the power factor. The energy consumption data sent by licensees include the variation in power factor with respect to time. Data related to 102 consumers out of 187 were taken into consideration for this analysis, since the power factor data interrelated to rest of 85 consumers were not available.

The sample of 102 consumers was grouped in to 7 categories taking the basis as the "value of Power Factor at maximum demand". The respective information is shown in Table 24.

	Power factor at maximum demand							Total
	Less than 0.5	***0.5 - 0.6***	***0.6 - 0.7***	***0.7 - 0.8***	***0.8 - 0.9***	***0.9 - 0.95***	***0.95-1***	
No. of Consumers	5	7	10	13	20	23	24	102
Percentages	5%	7%	10%	13%	20%	23%	24%	

Table 24: Power factor of TOU consumers at maximum demand

The graphical representation of data given in Table 24 is given in Figure 22.

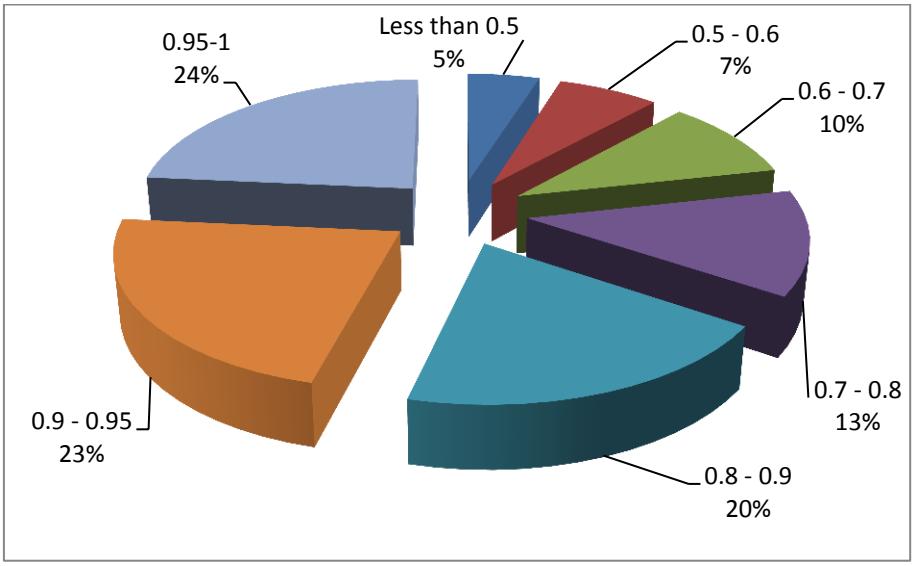

Figure 22: Power factor of TOU consumers at maximum demand

24% of the sample is having their power factor at maximum demand ranging from 0.95-1. Power factor at peak is below 0.95 for the rest 76% of the sample, including the 17% of consumers having it even below 0.6.

Out of 102 consumers the consumers having their maximum demand greater than 100 kVA was selected. There were 47 of them. Table 25 shows the power factor data for those 47 consumers.

	Power factor		Total
	Less than 0.95	0.95 - 1	
No. of Consumers	26	21	47
Percentages	55%	45%	

Table 25: Power factor of TOU consumers at maximum demand (Greater than 100 kVA)

Even though these consumers bear a considerable charge on maximum demand, 55% of them are still having their power factors at maximum demand below 0.95. Therefore a significant potential is available for a cost saving for consumers, as well as for power factor improvements for the system.

FINDINGS AND CONCLUSIONS

Findings

a. During the two year period from 2009 to 2011 there is a rapid increase in Electricity sales when comparing with electricity sales growth data before 2009. 15 year average demand increase is 6.8%

b. Electricity system Maximum demand has not shown a clear increasing trend from 2006 to 2010. However, from 2010 to 2011 maximum demand shows a rapid increase. Maximum demand growth rate is lower than sales demand growth; the 15 year average maximum demand growth rate is 6.5%.

c. Annual System Load Factor, which had been showing an increasing trend from 2008 to 2010, has decreased in 2011 to 60.8%.

d. The typical system peak at present occurs- 19.00 to 20.00; with a steep increase from 18:00 to 19:00, and depreciates with a slow rate of decreasing which takes about 3 hours. (From 19:00 to 22:00)

e. During a typical day, base active power demand of Sri Lanka is about 40% of the corresponding maximum demand. Also demand goes above 80% of the maximum demand during a period of 4 hours per day.

Conclusions

a. Time interval of Peak time coincides with the system peak hours and no further revision is required in Peak time interval.

b. Average power demand on Sundays during “Day” and “Peak” intervals is higher than the average “Off-Peak” demand of a typical weekday. Therefore, altering TOU time intervals for Sundays and Public Holidays as off-peak is inappropriate to Sri Lanka.

c. Despite natural improvements in system load factor over the past fifteen years, aggressive action is still required to curb further growth in peak demand, since an adverse trend is observed during recent past.

d. Mandating the TOU tariff for Bulk consumers has not become effective as anticipated and there is much potential for consumers to reduce their peak demand by shifting loads and improving their power factors. Peak time tariff can be increased further as an incentive to reduce system peak demand.

RECOMMENDATIONS

a. Distribution Licensees have already installed programmable meters with memory capacity, for all the bulk consumers of General Purpose category. Data from these meters shall be used to conduct a further study to analyze the implications of introducing mandatory TOU tariff scheme for bulk General Purpose consumers. Study should cover both demand shifting potential of the consumers and the revenue implications of the utilities.

b. A detailed study should be conducted on the load profiles of Domestic consumers, whom contribute heavily to the system peak demand, the possibility to adopt mandatory/ optional TOU tariff for larger domestic consumers shall be examined through this study. Since, existing metering equipment of domestic consumers is not geared for such data collection, sample data will have to be collected using data loggers.

c. Implementation of power factor charges and/or reactive energy (kVArh) charges shall be further studied to curb increasing MVAr demand, especially on the charge value and related incentive mechanism.

d. The relative rates for Time-Of-Use intervals shall be reexamined and adjusted (increase peak charges) to ensure that price signals are adequate to motivate consumers to shift demand from peak to off-peak time.

ANNEX 1.

List of References

[1] Ananth V. Iyer ,Vinayak Deshpande ,Zhengping Wu (2003) 'A Postponement Model for Demand Management'.

[2] Sustainable energy regulation and policymaking for Africa, Demand-side management Module 14

[3] Rangan Banerjee, Jyoti K Parikh, Demand Side Management in Power Planning - An Exercise for HT Industries in Maharashtra

[4] Jonathan Koomey, and Richard E. Brown, The role of building technologies in reducing and controlling peak electricity demand

ANNEX 2.

1. Historical data of the consumers

Please follow the format given below.

1.1

(a.) Historical data from three months in year 2010, for each consumer (30 Consumers from flat tariff)

Consumer Name	Tariff category	Month/Year	Consumed Energy	Max Demand	
				kVA	Time of occurrence

(b.) Historical data for three months after 30 June 2011 of the customers given in 1.1 (a.) with following details

Consumer Name	Tariff category	Month/ Year	Consumed Energy			Max Demand	
			Day	Peak	Off Peak	kVA	Time of occurrence

1.2

(a.) Historical data from three months in year 2010, for each consumer (10 Consumers from Two Part Tariff)

Consumer Name	Tariff category	Month/ Year	Consumed Energy		Max Demand	
			Peak	Off Peak	kVA	Time of occurrence

(b.) Historical data for three months after 30 June 2011 of the customers given in 1.2 (a.) with following details

Consumer Name	Tariff category	Month/ Year	Consumed Energy			Max Demand	
			Day	Peak	Off Peak	kVA	Time of occurrence

1.3

(a.) Historical data from three months in year 2010, for each consumer (10 Consumers from Three Part Tariff)

Consumer Name	Tariff category	Month/ Year	Consumed Energy			Max Demand	
			Day	Peak	Off Peak	kVA	Time of occurrence

(b.) Historical data for three months after 30 June 2011 of the customers given in 1.3 (a.) with following details

Consumer Name	Tariff category	Month/ Year	Consumed Energy			Max Demand	
			Day	Peak	Off Peak	kVA	Time of occurrence

2. Recent Load profiles of consumers, mentioned above (All together 50 Consumers) for one week.

(Maximum demand values and consumed energy values for every 15 minutes period)