TRANSMISSION SYSTEM PERFORMANCE REPORT 2012 (First Half)

Prepared By : Public Utilities Commission of Sri Lanka

Content

1. Introduction

The electricity transmission network in Sri Lanka is solely owned and operated by Ceylon Electricity Board (CEB). CEB Transmission Licensee is responsible for the safe, secure and efficient operation of the electricity transmission in Sri Lanka. The transmission network in Sri Lanka is operated at 220kV and 132kV to transport electricity from generation points to distribution bulk supply points.

This Transmission Performance Report contains a summary of information and performance statistics of the transmission system for the first half of year 2012 and it compares the performance with year 2011's statistics. The document, moreover, takes account of availability, security of supply and quality of service of the transmission network during the reported period.

All the index and other calculations in this report have been done based on the data received through LISS and details obtained from CEB Monthly Review Reports.

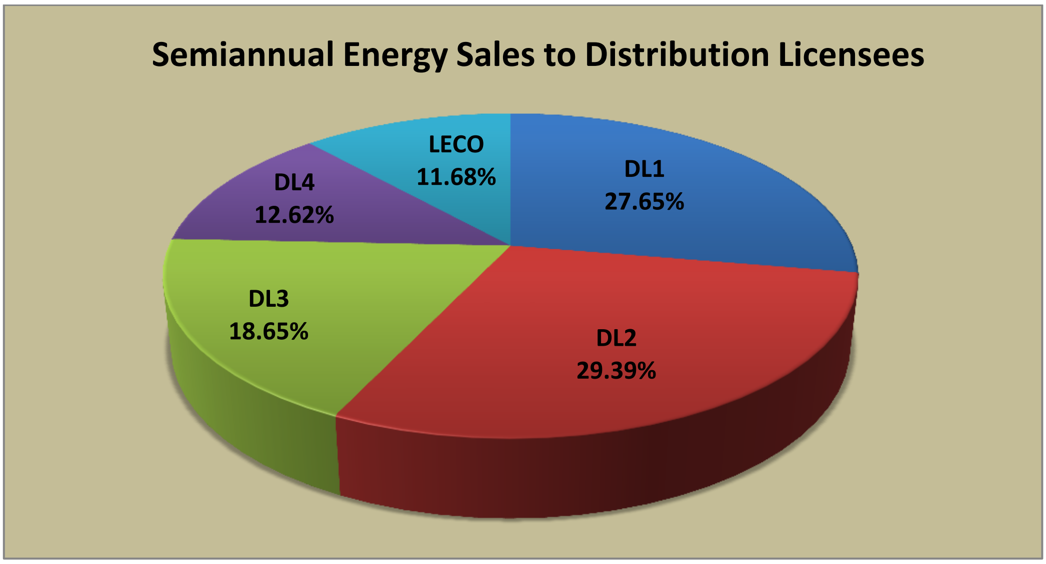
2. Energy Sales

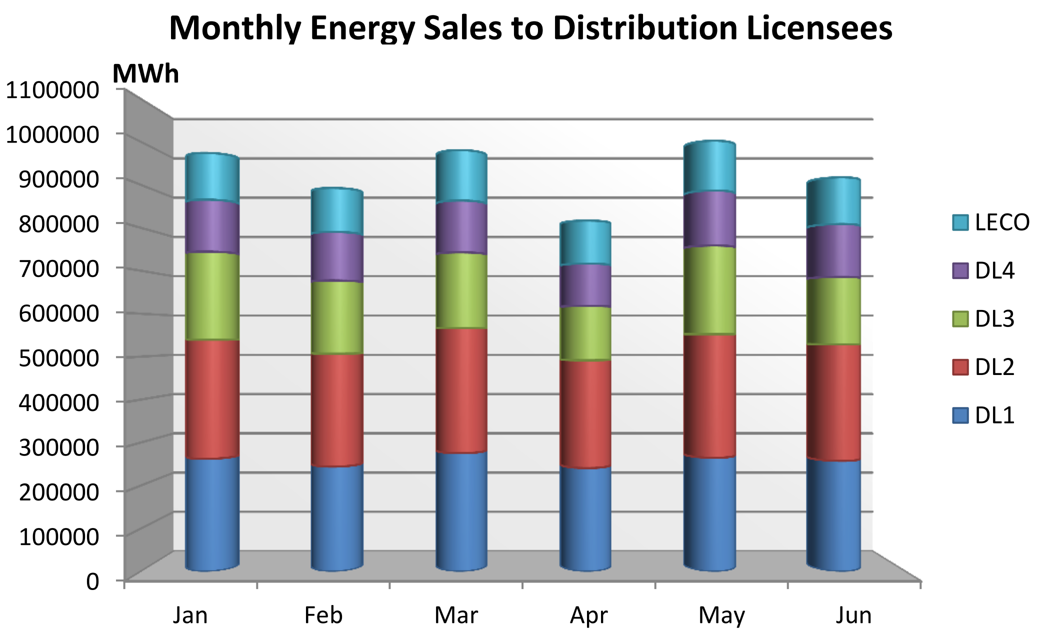
CEB sells the electricity transmitted from generation stations, to the distribution licensees. There are 5 major distribution licensees who purchase the power bulky and distribute among consumers. CEB itself owns 4 distribution licenses for four distribution regions and Lanka Electricity Company (LECO) owns one distribution license.

The charts and tables below show the monthly energy sales by transmission licensee to each distribution licensee in the first half of year 2012.

	BSOB to DL Energy Sales (MWh)					
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**
DL1	262069.9	243908.4	275302.1	240626.9	264688.53	257319.8
DL2	277050.4	262981.4	291197.8	250876.6	287545.95	271504.6
DL3	205365.7	170286	176262.5	126429.1	206281.8	156839.9
DL4	121068.7	113193.8	120614.5	98630.58	128129.54	123100.6
LECO	108563	102210.3	117121.4	100011.8	115740.72	108530
Total	**974,118**	**892,580**	**980,498**	**816,575**	**1,002,387**	**917,295**

	Sales by BSOB (MWh)				
Licensee	**Day**	**Peak**	**Off-Peak**	**Total**	**% Total**
DL1	878,911	345,348	319,656	1,543,916	27.65%
DL2	920,025	358,705	362,427	1,641,157	29.39%
DL3	583,038	248,397	210,030	1,041,465	18.65%
DL4	397,995	159,629	147,114	704,738	12.62%
LECO	374,387	132,271	145,519	652,177	11.68%
Total	**3,154,356**	**1,244,350**	**1,184,746**	**5,583,452**	





2.1 Transmission Losses

Transmission loss is calculated by taking the difference between total electrical energy received from the generating plants and the total energy supplied to all bulk supply distribution licensees. It is usual to express losses as a percentage value rather than an absolute value.

The definition of the transmission losses is defined as;

$$\%Transmission\ Loss = \frac{\sum E_G - \sum E_T}{\sum E_G} \mathrm{X}\ 100\%$$

Where;

E_G = Total Energy Purchased from generation plants (MWh) during reported period

E_T = Total Energy Sold to Distribution Licensees (MWh) during reported period

- Total Energy Loss in Sri Lankan Transmission Network during first half of year 2012 = **5.1 %**
- Total Energy Loss in Sri Lankan Transmission Network in 2011 = **4.52 %**

It can be noted that the transmission loss during the first half of year 2012 has been increased than it was in 2011.

The chart and table below show the monthly transmission losses during first half of year 2012.

Month	Purchases (MWh)	Sales (MWh)	Loss (MWh)	Monthly % loss
Jan	988671.66	974117.69	14,554	1.5%
Feb	922366.62	892579.81	29,787	3.2%
Mar	1036091.09	980498.14	55,593	5.4%
Apr	912168.74	816574.82	95,594	10.5%
May	1037297.97	1002386.54	34,911	3.4%
Jun	983921.58	917294.9	66,627	6.8%

Note: *Transmission losses were calculated totally based on the information received through LISS.*

3. System Availability

The availability of the transmission system components depends on the number of faults which occur and on the number of outages taken to allow maintenance and construction work to be undertaken. System availability is reduced whenever a circuit is taken out of operation for either planned purposes or as a result of a fault.

System availability is calculated as a percentage of actual circuit hours available in relation to total possible circuit hours available. Circuit outages that result from both planned and unplanned unavailability are taken into account.

$$\text{System Availability} = \frac{\text{The sum of all circuit hours available}}{(\text{No.of circuits})\ \text{X}\ (\text{No.of hours in period})} \text{ x } 100\ \%$$

A circuit is defined as transmission line, cable, transformer or any combination of these that connects two system bus bars.

Transmission System availability of the Transmission Licensee can be assessed through Individual Performance Indicators and Overall Performance Indicators. Individual Performance Indicators are used to measure Transmission System availability of each individual Transmission Line and each individual Grid Substation Transformer.

Overall System Performance Indices used to measure average Transmission System availability, are defined below.

3.1 Overall System Availability – Transmission Lines

This measures the average fraction of time (expressed in percent) that Transmission Lines are available in service in relation to the possible circuit hours available.

$$SA_L = \frac{\sum_{j=1}^{NL} H_j}{NL * T} \text{ x } 100$$

Where;

H_j = Available Duration of Transmission Line Circuit "j" (in hours).

NL = Total number of Transmission Line Circuits

T = Number of hours in the reported period.

- Availability of Transmission Lines during the first half of 2012 = **99.95 %**
- Availability of Transmission Lines in year 2011 = **99.65 %**
- Availability of 132kV Transmission Lines during the first half of 2012 = **99.96 %**
- Availability of 132kV Transmission Lines in year 2011 = **99.58 %**
- Availability of 220kV Transmission Lines during the first half of 2012 = **99.91 %**
- Availability of 220kV Transmission Lines in year 2011 = **99.98 %**

Note*: Vavuniya – Chunnakam 1 & 2 (formerly, New Anuradhapura-Chunnakam 1 & 2), was unavailable (beyond Vavuniya) during 2011 owing to line damages caused by war conflicts. Therefore those two lines have not been considered for the availability calculation.*

Reference for the formula: *National Electricity Transmission System Performance Report – England.*
Transmission System Performance Report of System Operator For Northern Ireland Ltd.

3.2 System Transmission Transformers Availability

This measures the average fraction of time (expressed in percent) that Transmission Transformers are available in service in relation to possible circuit hours available.

$$SA_T = \frac{\sum_{j=1}^{NT} H_j}{NT * T} \text{ x } 100$$

Where;

H_j = Available Duration of Transmission Transformer "j" (in hours)

NT = Total number of Transmission Transformers

T = Number of hours in the reported period

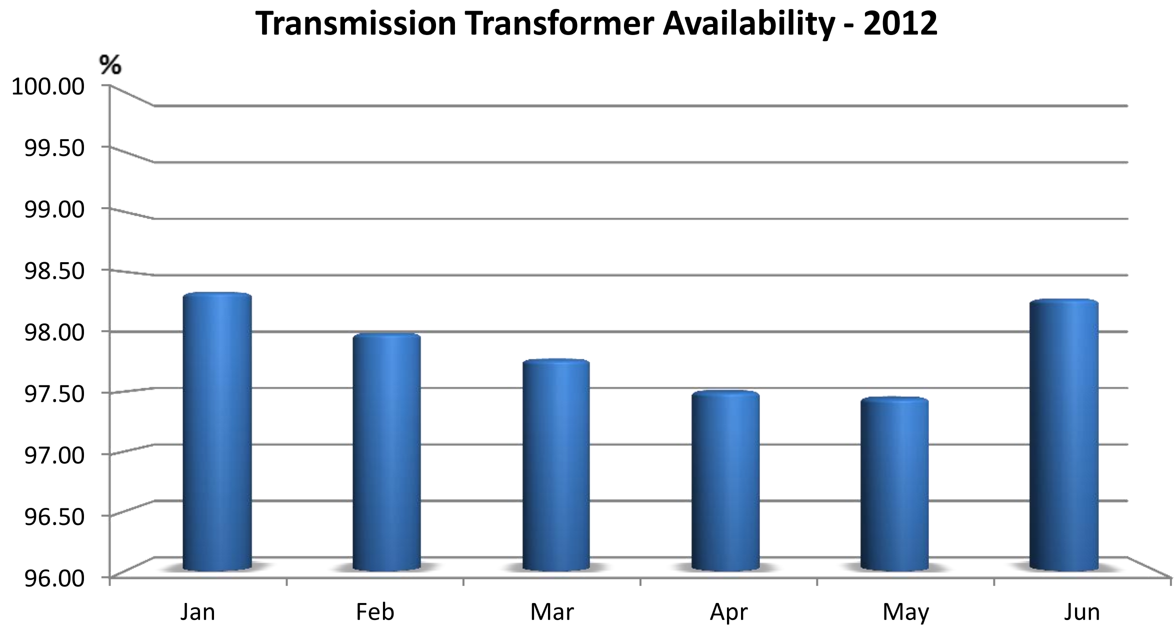
- Total System Availability of Transmission Transformers for first half of the year 2012 = **97.88 %**

- Total System Availability of Transmission Transformers in year 2011 = **97.84 %**

***Note**: Only the major outages of transformers have been considered for the availability calculation due to unavailability of data of short term transformer outages.*

3.2.1 Monthly Variation

The chart and table below show the monthly variation in total system transformer availability.



3.3 System Average Frequency of Outages per 100km of Transmission Lines

This measures the average number of Outages per 100km of Transmission Line Circuits (Expressed in number of outages per 100 km of lines)

$$SAFO\_L_{100} = \frac{\sum_{j=1}^{NL} NO_j}{\sum_{j=1}^{NL} LONG_j \big/ 100}$$

Where;

NO_j = Number of Outages of Transmission Line Circuit "j" during the reported period

NL = Total number of Transmission Line Circuits

$LONG_j$ = Length of Transmission Line Circuit "j"

- Total System Average Frequency of Outages per 100km during the first half of 2012 = **2.34**
- Total System Average Frequency of Outages per 100km during the first half of 2011 = **2.7**
- Average Frequency of Outages per 100km of 132kV lines during the first half of 2012 = **2.39**
- Average Frequency of Outages per 100km of 132kV lines during the first half of 2011 = **3.13**
- Average Frequency of Outages per 100km of 220kV lines during the first half of 2012 = **2.14**
- Average Frequency of Outages per 100km of 220kV lines during the first half of 2011 = **1.01**
- Average Frequency of Planned Outages per 100km of lines during the first half of 2012 = **0.05**
- Average Frequency of Planned Outages per 100km of lines during the first half of 2011 = **0.15**
- Average Frequency of Forced Outages per 100km of lines during the first half of 2012 = **2.28**
- Average Frequency of Forced Outages per 100km of lines during the first half of 2011 = **2.54**

Reference for the formula: *Transmission Performance Standards Code of Electricity Regulatory Commission of Jordann.*

3.4 Transmission Line Interruption Duration Index (in Hours)

This measures the average time duration per reported period where a single transmission line circuit is not available in service.

$$UD_L = \frac{\sum_{j=1}^{NL} \sum_{i=1}^{kt} H_{i,j}}{NL}$$

Where;

$H_{i,j}$ = Duration of Outage “i”, that affected Transmission Line Circuit “j” (in hours)

NL = Total number of Transmission Line Circuits

kt = Total number of Outages of Transmission Line Circuit “j” during the reported period

- Transmission Line Interruption Duration in the first half of year 2012 = **2.2 hours**
- Transmission Line Interruption Duration in the first half of year 2011 = **9.85 hours**
- 220kV Line Interruption Duration in the first half of year 2012 = **4.11 hours**
- 220kV Line Interruption Duration in the first half of year 2011 = **0.57 hours**
- 132kV Line Interruption Duration in the first half of year 2012 = **1.81 hours**
- 132kV Line Interruption Duration in the first half of year 2011 = **11.72 hours**

Reference for the formula: *Transmission Performance Standards Code of Electricity Regulatory Commission of Jordann.*

3.5 Substation Transformer Interruption Duration Index (in Hours)

This measures the average time duration per reported period where a single substation transformer is not available in service.

$$UD_T = \frac{\sum_{j=1}^{NT} \sum_{i=1}^{kt} H_{i,j}}{NT}$$

Where;

$H_{i,j}$ = Duration of Outage "i", that affected Substation Transformer "j" (in hours)

NT = Total number of Substation Transformers

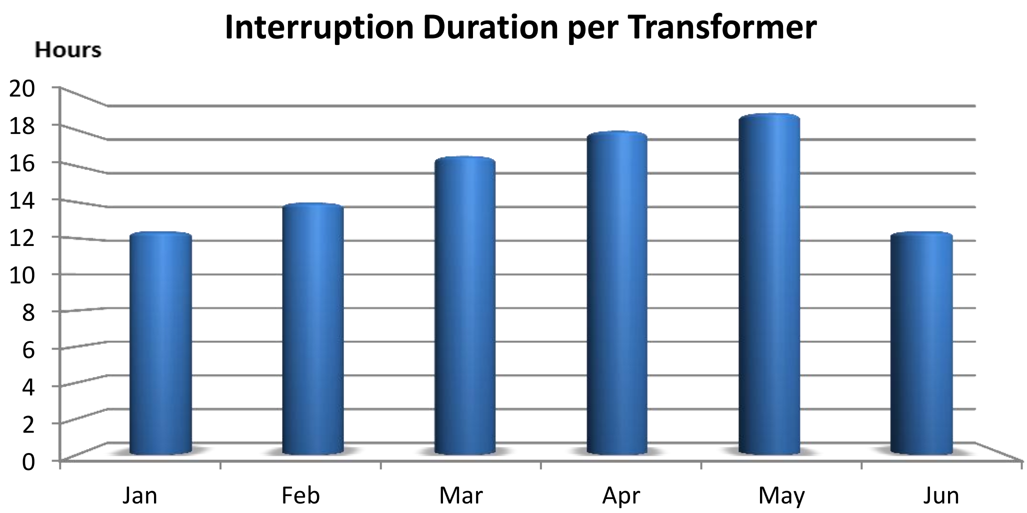
kt = Total number of Outages of Substation Transformer "j" during the reported period

- Interruption Duration per Substation Transformer for the first six months of 2012 = **92.4 hours**
- Interruption Duration per Substation Transformer for the first six months of 2011 = **91.4 hours**

Note: *Only major outages of transformers have been considered for the availability calculation due to unavailability of short term transformer outages details.*

3.5.1 Monthly Variation

The chart and table below show the monthly variation in interruption durations per substation transformer.



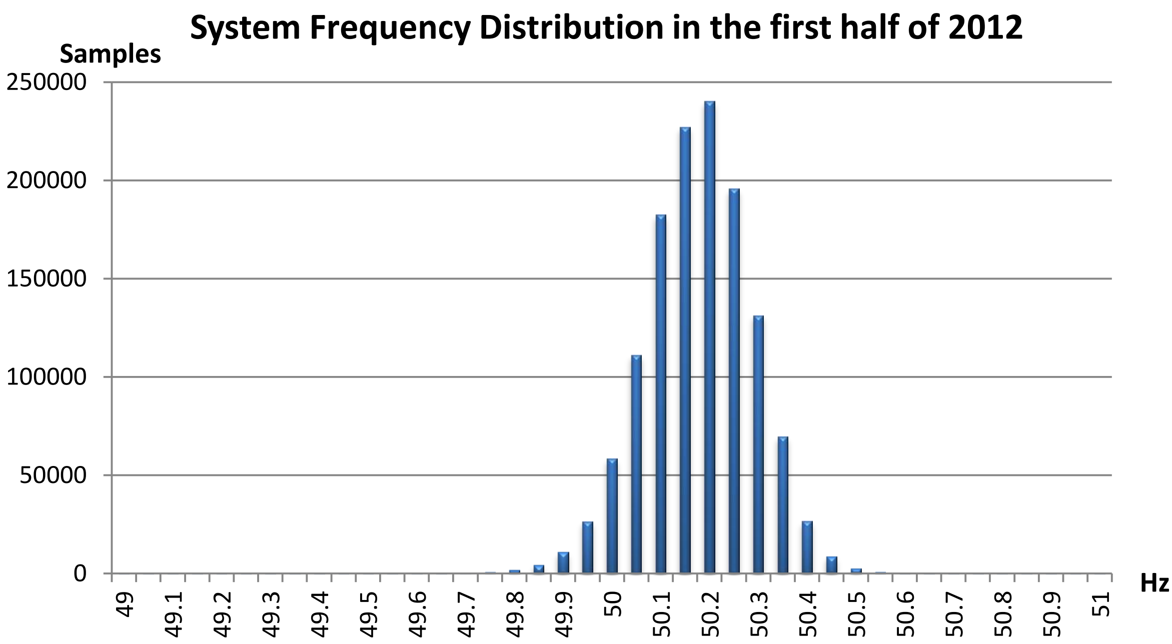
4. Transmission System Power Quality

Quality of a power system service is measured with reference to system voltage and frequency. Power quality indicators show how the transmission line parameters comply with the defined standards and limits.

4.1 Frequency Standard

Frequency variation is the deviation of frequency, beyond a certain range. The nominal allowed frequency range shall be 50 Hz ± 1% in Sri Lanka. The system is normally managed such that frequency is maintained within operational limits of 49.5 and 50.5Hz. Frequency may, however, move outside these limits under faulty conditions, or when abnormal changes to operating conditions occur. Frequency deviation indices can be defined to find the number of time or duration that the system frequency goes beyond the allowable range.

CEB System Control unit records the system frequency every 0.25 seconds. To calculate the violations, 10 second mean values have been considered. Frequency distribution during the first half of the year 2012 is plotted below with respect to 1,300,778 measurement samples.



To figure out the extent of frequency excursions, three frequency ranges can be defined as follows

1. *Normal State*
   The Transmission System frequency is within the limit of 49.5Hz to 50.5Hz

2. *Alert State*
   The Transmission System frequency is beyond the normal operating limit but within 49.0Hz to 51.0Hz

3. *Emergency State*
   There is generation deficiency and frequency is below 49.0Hz

During the first half of the year 2012 1,300,778 measurement samples were taken to assess the system frequency and the average frequency value was **50.18Hz**. According to the frequency standards the system must be normally managed such that frequency is maintained within operational limits of 49.5Hz and 50.5Hz and during the reported period system frequency has been maintained within that normal operating limit **99.7%** of the time. And the system frequency has deviated **0.3%** of the time to the Alert State and **0.002%** of the time to the Emergency State.

In the year 2011 the system frequency has been maintained within the normal operating limit **99.8%** of the time while the system frequency has deviated **0.19%** of the time to the Alert State and **0.01%** of the time to the Emergency State.

Reference to the definitions of frequency states: *Transmission System Performance Report of Bhutan Power Corporation Limited.*

4.2 Voltage Criteria

Voltage variation is the deviation of voltage in a certain range. Voltage deviations can be identified by monitoring the bus bar voltages of the grid substations. According to the defined standards, bus bar voltage magnitudes must comply with following allowed ranges of variation.

Voltage	Normal Condition	Single Contingency
220kV	± 5%	-10% to +5%
132kV	± 10%	± 10%

Voltage deviation indices can be defined to find the frequency or duration that the bus bar voltages violate above range.

By analyzing the recorded minimum bus bar voltages it could be identified that the allowable voltage limits have been violated every month during the reported period. Due to lack of data the frequency and the duration of voltage excursions could not be found.

4.3 Grid Substation Overloading

Overloading of grid substations is defined based on the loading levels of grid substation power transformers. Overloading of transformers must be avoided to avoid overheating, leading to equipment damages and reducing the life time of transformers.

During the first half of the year 2012, out of 120 grid substation transformers, 8 have been overloaded. The list of overloaded transformers is given below.

- Anuradhapura No.01 Transformer has been overloaded 7%, only in the month of April.
- Anuradhapura No.02 Transformer has been overloaded in 5 months with a maximum overloading of 10% recorded in February and March.
- Anuradhapura No.03 Transformer has been overloaded 2%, only in the month of June.
- Kelaniya No.01 Transformer has been overloaded in 4 months with a maximum overloading of 11.1% recorded in February.
- Habarana No.01 & 02 Transformers have been overloaded by 1% in March and April.
- Hambantota No.01 Transformer has been overloaded in 2 months with a maximum overloading of 5.6% recorded in April.
- Matara No.01 & 02 Transformers have been overloaded by 1.9% in March.

5. Security of Supply

Power System security is the ability of the system to withstand sudden disturbances. To secure the supply the Transmission system must be able to deliver the power even under abnormal or faulty conditions. The security of supply can be measured by estimating the energy not served to the consumers during loss of supply.

5.1 Energy Not Supplied (ENS)

This gives an estimation of the Energy not supplied to the connected Load due to the Interruptions over a year.

$$ENS = \sum_{i=1}^{kt} PD_i * H_i$$

Where;

PD_i = Power disconnected by Interruption “i” (in MW).

H_i = Duration of Interruption “i” (in hours)

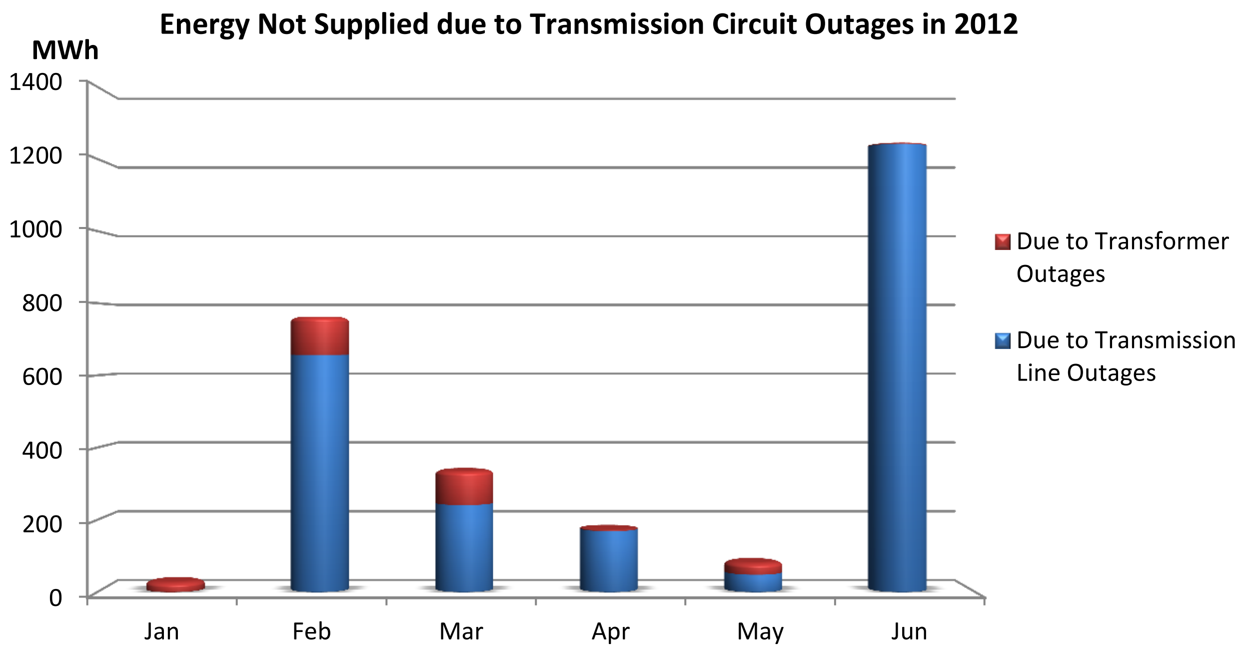
kt = Total number of Interruptions during the reported period

- Energy Not Supplied due to all transmission system circuit interruptions in 2012= **2626.4 MWh**
- Energy Not Supplied due to all transmission system circuit interruptions in 2011= **816.5 MWh**
- Energy Not Supplied due to transmission lines interruptions in 2012= **2356.4 MWh**
- Energy Not Supplied due to transmission lines interruptions in 2011= **549.9 MWh**
- Energy Not Supplied due to transmission transformer interruptions in 2012= **270 MWh**
- Energy Not Supplied due to transmission transformer interruptions in 2011 = **266.6 MWh**

Note: *Above estimations are only for the first six months of years 2012 and 2011.*

5.1.1 Monthly Variation

The chart and table below show the monthly variation in energy not supplied to the system due to transmission line and transformer interruptions.



Month	Jan	Feb	Mar	Apr	May	Jun
ENS Due to Line Outages (MWh)	0	656.5	241	168.8	48.1	1242
ENS Due to Transformer Outages (MWh)	26.8	106.7	94.7	4.5	32.7	4.6
Total ENS (MWh)	26.8	763.2	335.7	173.3	80.8	1246.6

6. Conclusion

Compared to the transmission line availability in the first half of year 2011, it can be perceived that the availability has improved fairly in the year 2012 as a result of low interruption durations of planned outages occupied during the first half of year 2012.

As in 2011, some of the substations have been overloaded in the first half of year 2012 as well. In 2011, only No.02 transformer has been overloaded in the Anuradhapura Substation. But during the first half of year 2012, over loadings of all three transformers of Anuradhapura Substation have been recorded, which shows the load improvement through that Substation. Unlike in 2011, No.01 transformer of Hambantota Substation has been overloaded in two months during the first half of year 2012.

Compared to the Unserved Energy due to transmission line interruptions during the first half of year 2011, it can be perceived that the estimated amount of Unserved Energy has been massively increased during the first half of year 2012.

The Report has moreover described and calculated a number of key performance indicators for Sri Lankan electricity transmission system. These indices can be used to measure the system performance compared with benchmarks and to illustrate the historical trends. The indicators for the present technical performance of the transmission system are useful when planning the future developments and taking the corrective actions if necessary to improve system performance and ensure a high degree of reliability of the transmission system.