Generation Performance in Sri Lanka

2011

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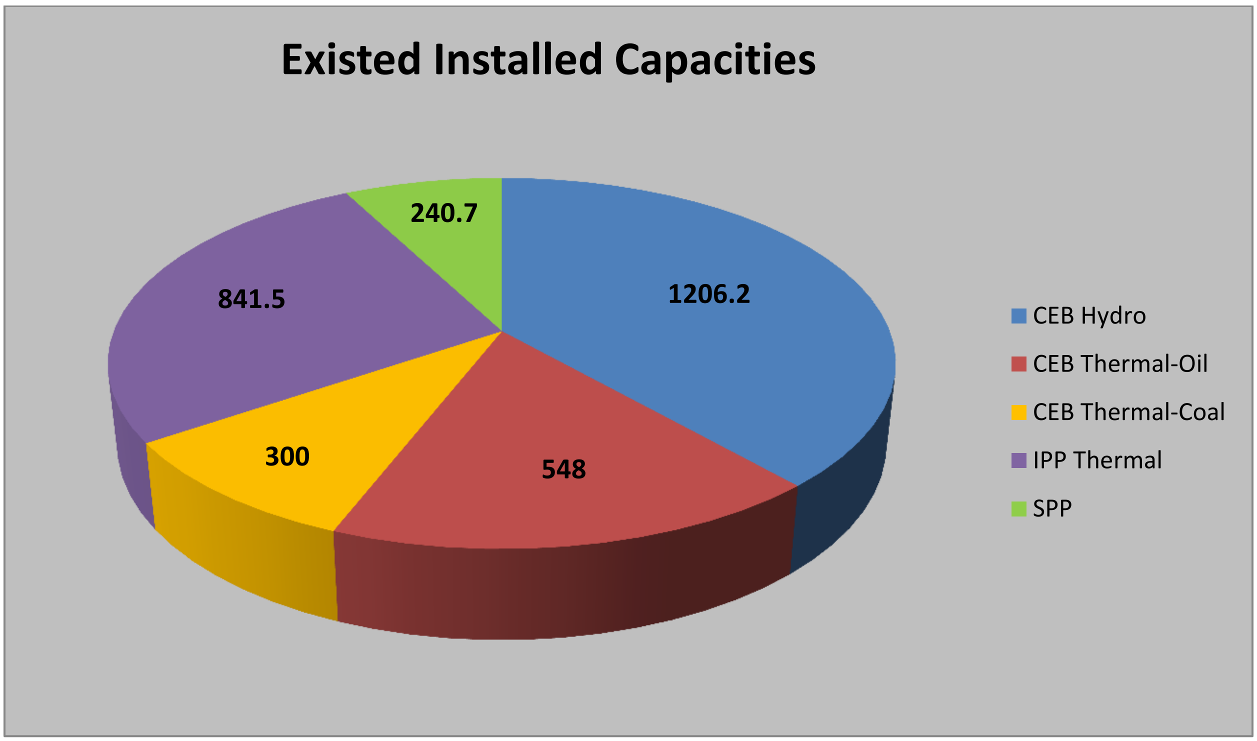
1. Introduction

In 2011 the maximum recorded electricity demand in Sri Lanka was 2163.1MW. In order to achieve that demand and to cater the electricity requirement in Sri Lanka, 139 Grid connected power plants with total installed capacity of 3140MW have been operated in 2011. Out of those power plants 23 were owned and operated by Ceylon Electricity Board including 16 hydro plants, 6 thermal plants and 1 wind power plant. And there were 11 thermal power plants operated by Independent Power Producers (IPPs) and 104 small power plants owned and operated by Small Power Producers (SPPs) including mini hydro plants, solar power plants, wind power plants and biomass power plants.

The chart below shows the existed installed capacity in MW of each type of power plants by the end of 2011.



This Generation Performance Report contains a summary of information and performance statistics of the generation units in Sri Lanka for the year 2011.

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

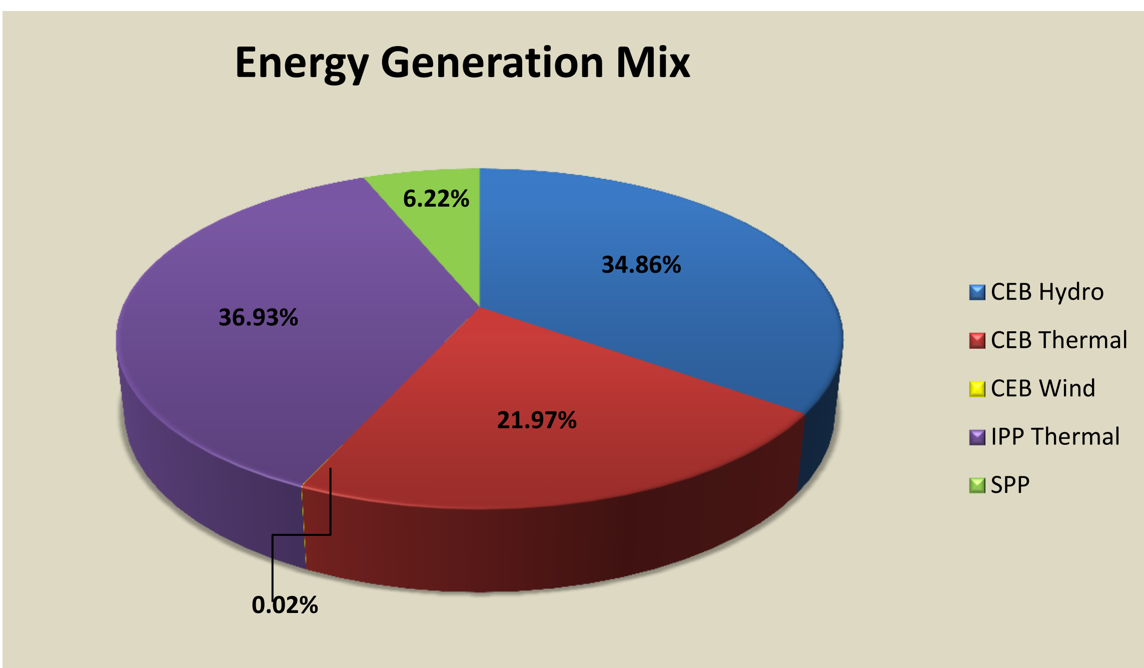
2. Energy Generation

All grid connected generation plants sell the power to the only transmission licensee in Sri Lanka to deliver the power to the consumers through distribution licensees.

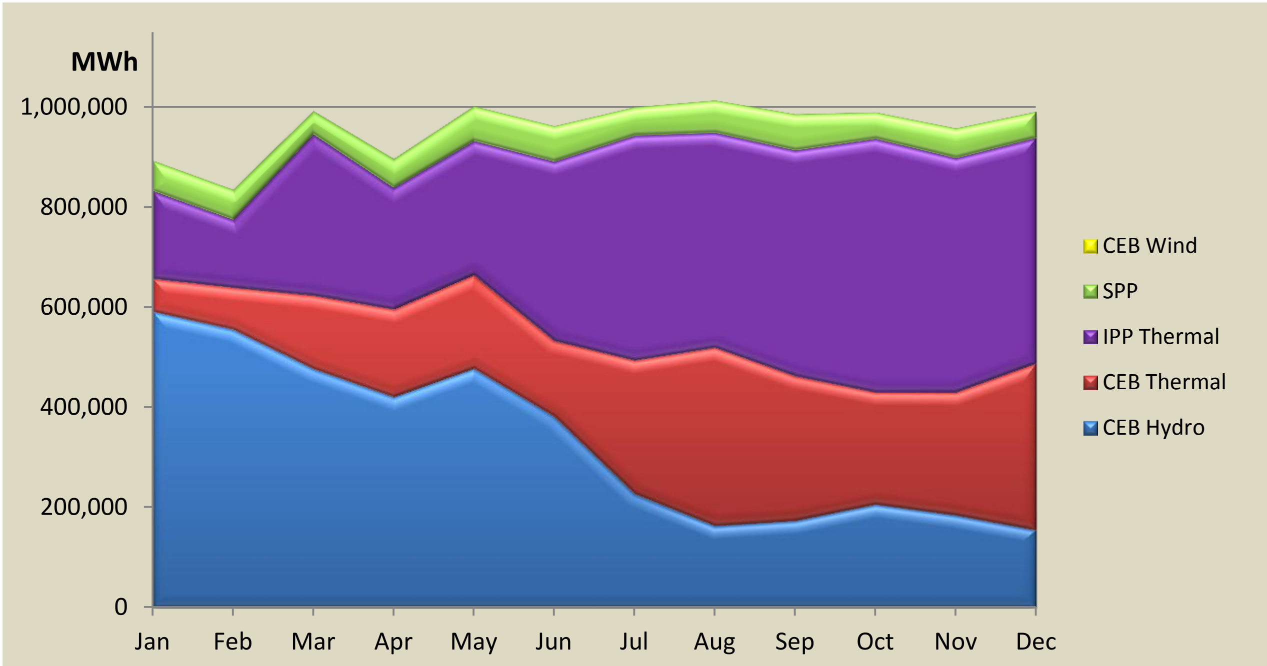
The chart below shows the annual generation figures in 2011 in MWh.

	CEB Hydro	CEB Thermal	CEB Wind	IPP Thermal	SPPs	Total
Jan	591,558	66,309	127	176,187	60,100	**894,281**
Feb	555,485	84,539	71	136,297	59,614	**836,006**
Mar	477,030	147,401	82	322,163	45,537	**992,212**
Apr	420,862	176,034	107	242,525	57,695	**897,223**
May	477,852	187,022	379	268,019	68,943	**1,002,216**
Jun	381,858	152,172	461	357,796	70,379	**962,667**
Jul	228,069	266,841	412	448,681	56,753	**1,000,756**
Aug	163,620	356,989	333	429,149	63,572	**1,013,663**
Sep	174,278	289,292	326	450,856	71,495	**986,247**
Oct	206,568	224,886	184	506,194	52,397	**990,229**
Nov	185,205	246,115	87	467,952	58,721	**958,081**
Dec	155,263	334,150	92	449,863	52,167	**991,535**
Total	**4,017,648**	**2,531,751**	**2,661**	**4,255,684**	**717,374**	**11,525,118**

The charts below show the generation mix in Sri Lanka in 2011.



Monthly Variation of Energy Generation Mix



3. Plant Factor

The plant factor of a power plant is the ratio of the actual energy output of a power plant over a period of time to its potential output if it had operated at full nameplate capacity the entire time.

Plant Factors vary greatly depending on the type of power plants and it is calculated according to the following formula.

$$Plant\ Factor = \frac{Actual\ Energy\ Production\ During\ the\ Nominal\ Period}{Potential\ Energy\ Production\ During\ the\ Period}$$

Calculated plant factors for all grid connected power plants in Sri Lanka in 2011 are listed below.

CEB Hydro

Old Laxapana	58.99%
Polpitiya	58.53%
New Laxapana	54.96%
Kukule	51.87%
Inginiyagala	50.60%

Rantambe	47.85%
Ukuwela	44.95%
Victoria	40.61%
Randenigala	38.72%
Nilambe	35.39%
Samanalawewa	27.94%

Canyon	26.32%
Wimalasurendra	23.34%
Bowatenna	22.48%
Udawalawe	21.80%
Kotmale	21.17%

CEB & IPP Thermal

Plant Factors of thermal power plants are listed below according to the calculated merit order in 2011. Power Plants in Jaffna Peninsula have been shown in a different colour.

1	Puttalam Coal	43.17%
2	Sapugaskanda 2	71.21%
3	Heladanavi	81.09%
4	Sapugaskanda 1	58.77%
5	Colombo Power - Barge	88.89%
6	Nothern Power	50.16%
7	ACE - Embilipitiya	50.47%
8	Lakdhanavi	58.29%
9	ACE - Horana	91.56%

10	ACE - Matara	86.08%
11	Asia Power	71.11%
12	Westcoast	48.70%
13	AES - Kelanitissa	40.67%
14	Aggreko Chunnakam	54.51%
15	Chunnakam	9.45%
16	KPS GT7	24.19%
17	KPS CCY	17.69%
18	KPS(Small) GT	8.74%

CEB Wind – 10.13%

SPP

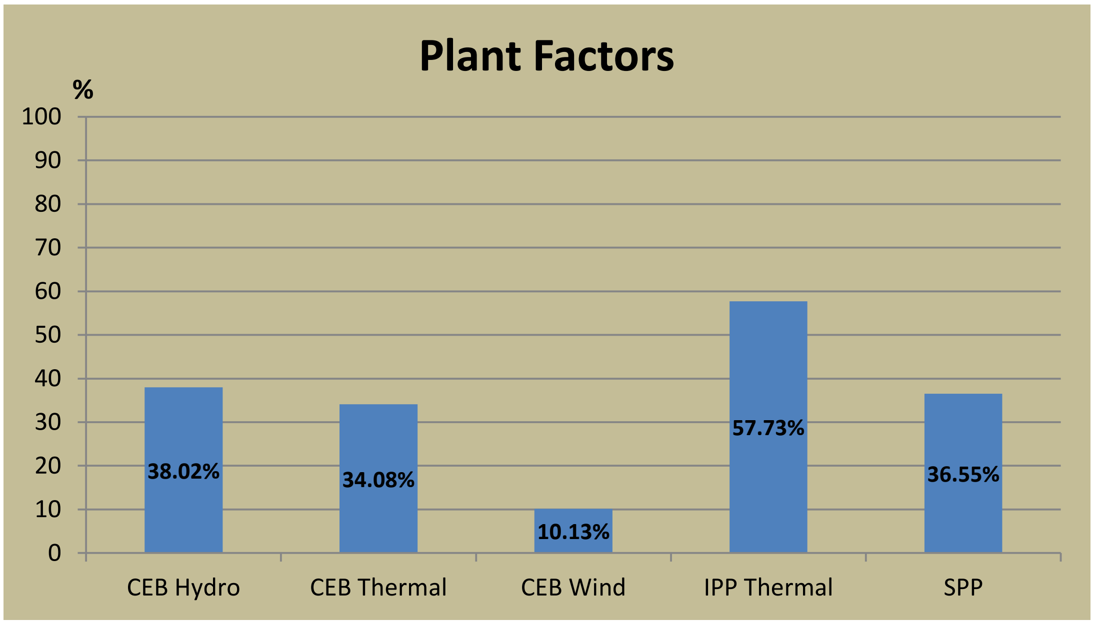
Rathganga MHP	67.56%
Hapugastenna - 2 MHP	66.70%
Somerset MHP	61.90%
Kotanakanda MHP	61.85%
Batatota MHP	58.47%
Wee Oya MHP	57.30%
Palmerston MHP	54.82%
Carolina MHP	53.28%
Delgoda MHP	52.78%
Badulu Oya MHP	51.85%
Lower Neluwa MHP	51.42%
Hapugastenna - 1 MHP	51.04%
Guruluwana MHP	50.54%
Halathura Ganga MHP	49.00%
Gampola Walakada MHP	48.06%
Sheen MHP	47.65%
Amanawala Oya MHP	47.32%
Erathna (Waranagala) MHP	47.06%
Asupiniella MHP	46.56%
Denawak Ganga MHP	46.15%
Gangaweraliya MHP	46.03%
Kotapola (Kiruwana) MHP	45.60%
Manelwala MHP	44.69%
Giddawa MHP	44.28%
Bogandana MHP	42.31%
Dunsinane MHP	41.51%
Gomala Oya MHP	41.36%
Watakelle MHP	41.36%
Kabaragala MHP	41.31%
Belihul Oya MHP	40.98%
Watawala (Carolina ii) MHP	40.45%
Alupola MHP	39.50%
Soranathota MHP	39.42%
Glassaugh MHP	39.34%
Ellapita Ella MHP	39.24%
Bambarabatu Oya MHP	39.12%

Delta MHP	38.53%
Ritigaha Oya II MHP	38.19%
Magal Ganga MHP	37.33%
Coolbawn MHP	36.85%
Barecaple MHP	36.22%
Loggal Oya MHP	36.22%
Miyanawita Oya MHP	35.80%
Atabage Oya MHP	35.72%
Kadawala II MHP	35.38%
Labuwewa MHP	34.90%
Sithagala MHP	34.42%
Kandureliya (Karawila Ganga) MHP	34.37%
Henfold (Agra Oya) MHP	34.13%
Kehelgamu Oya MHP	33.84%
Upper Korawaka MHP	33.69%
Kalupahana Oya (Lower) MHP	33.15%
Niriella MHP	32.90%
Kolonna MHP	32.63%
Aggra Oya MHP	32.05%
Radella MHP	32.01%
Black Water MHP	32.00%
Battalgala MHP	31.91%
Mandagal Oya MHP	31.88%
Pathaha MHP	31.76%
Koswatta Ganga MHP	31.18%
Adavikanda MHP	30.98%
Minuwanella MHP	30.22%
Kalupahana MHP	29.53%
Way Ganga MHP	29.48%
Kumburuteniwela MHP	29.03%
Kudah Oya MHP	28.99%
Rakwana Ganga MHP	28.83%
Ganthuna Udagama MHP	28.46%

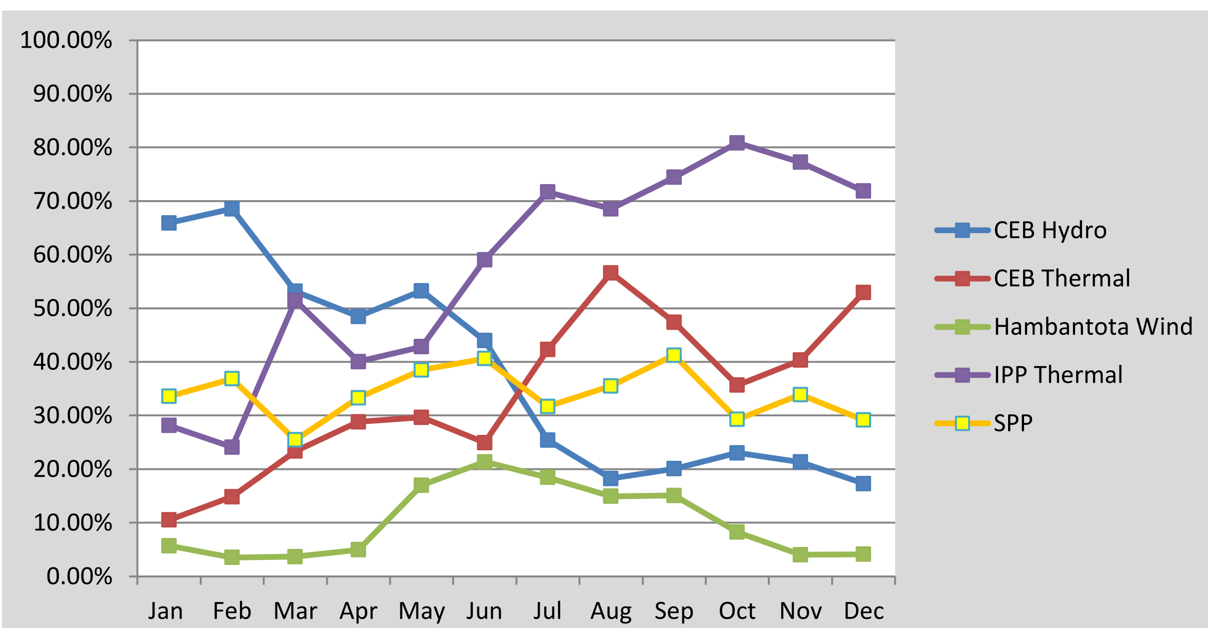
Huluganga MHP	27.16%
Galatha Oya MHP	25.79%
Nugedola MHP	25.70%
Sanquahar MHP	25.51%
Lower Atabage MHP	24.46%
Gurugoda Oya MHP	23.12%
Kadawala I MHP	22.44%
Kirkoswald MHP	22.37%
Forest Hill MHP	21.87%
Hemingford MHP	21.20%
Deiyanwala MHP	20.67%
Nilambe Oya MHP	20.63%
Dick Oya MHP	20.62%
Nakkawita MHP	19.77%
Kolapathana MHP	18.68%
Maduruoya MHP	14.65%
Bowhill (Kadiyanlena) MHP	12.66%
Kiriwan Eliya MHP	7.12%
Weddemulle MHP	6.91%
Brunswic MHP	4.31%
Seetha Eliya MHP	3.61%
Lemastota MHP	0.00%
Nirmalapura WPP	49.36%
Vidatamunai WPP	35.93%
Seguwantivu WPP	31.69%
Mampuri WPP	31.12%
Willpita WPP	13.92%
Solar PV SPP	69.56%
Gonnoruwa I SPP	13.81%
Gonnoruwa II SPP	10.68%
Tirappane SPP	0.00%
Badalgama BMP	42.93%
Tokyo BMP	26.03%
Kottamurichchana BMP	15.11%
Walapone Dendro BMP	0.00%

Note: *Plant Factors for the CEB power plants were calculated using gross generation figures*
Gross generation data for IPPs and SPPs were not available for Plant Factor calculation. Therefore the Net generation data were used to calculate the plant factors of these plants.

Annual Overall Plant Factors for the major types of generation plants in 2011 are given below.



The chart below shows the monthly variation of plant factors of different types of generation plants operated in 2011.



4. Running Plant Factor

The running plant factor of a generation unit is the ratio of the actual energy output of a generation unit over a period of time to its potential output if it had operated at full nameplate capacity during the period in which it has been operated.

Running Plant Factor shows the extent to which the generation units have been operated when they are running out of their nominal capacities.

Calculated running plant factors for CEB owned generation units in 2011 are listed below.

CEB Hydro

Ukuwela	Unit 1	90.45%
	Unit 2	93.69%
Kukule	Unit 1	106.68%
	Unit 2	89.65%
Rantambe	Unit 1	89.17%
	Unit 2	89.51%
Randenigala	Unit 1	86.92%
	Unit 2	85.10%
Victoria	Unit 1	87.52%
	Unit 2	73.27%
	Unit 3	77.22%
Old Laxapana	Unit 1	77.50%
	Unit 2	73.56%
	Unit 3	77.43%
	Unit 4	77.38%
	Unit 5	75.32%

Wimalasurendra	Unit 1	71.50%
	Unit 2	66.52%
Polpitiya	Unit 1	63.23%
	Unit 2	68.39%
New Laxapana	Unit 1	64.51%
	Unit 2	62.94%
Samanalawewa	Unit 1	64.56%
	Unit 2	57.90%
Canyon	Unit 1	58.31%
	Unit 2	57.63%
Bowatenna	Unit 1	48.10%
Kotmale	Unit 1	45.81%
	Unit 2	52.40%
	Unit 3	46.41%

CEB Thermal

Puttalam Coal	Unit 1	69.99%
Sapugaskanda 2	Unit 5	86.21%
	Unit 6	86.23%
	Unit 7	85.12%
	Unit 8	86.49%
	Unit 9	86.24%
	Unit 10	86.76%
	Unit 11	84.58%
	Unit 12	87.88%

Sapugaskanda 1	Unit 1	72.00%
	Unit 2	72.37%
	Unit 3	70.50%
	Unit 4	73.12%
KPS GT7	Unit 7	74.42%
KPS CCY	Unit 8 (GT)	75.32%
	Unit 8 (ST)	84.22%
KPS(Small) GT	Unit 1	67.84%
	Unit 2	71.63%
	Unit 3	72.95%
	Unit 4	81.32%
	Unit 5	86.66%

***Note**: Running Plant Factors for IPPs and SPPs were not calculated since the operation durations of those plants were not available.*

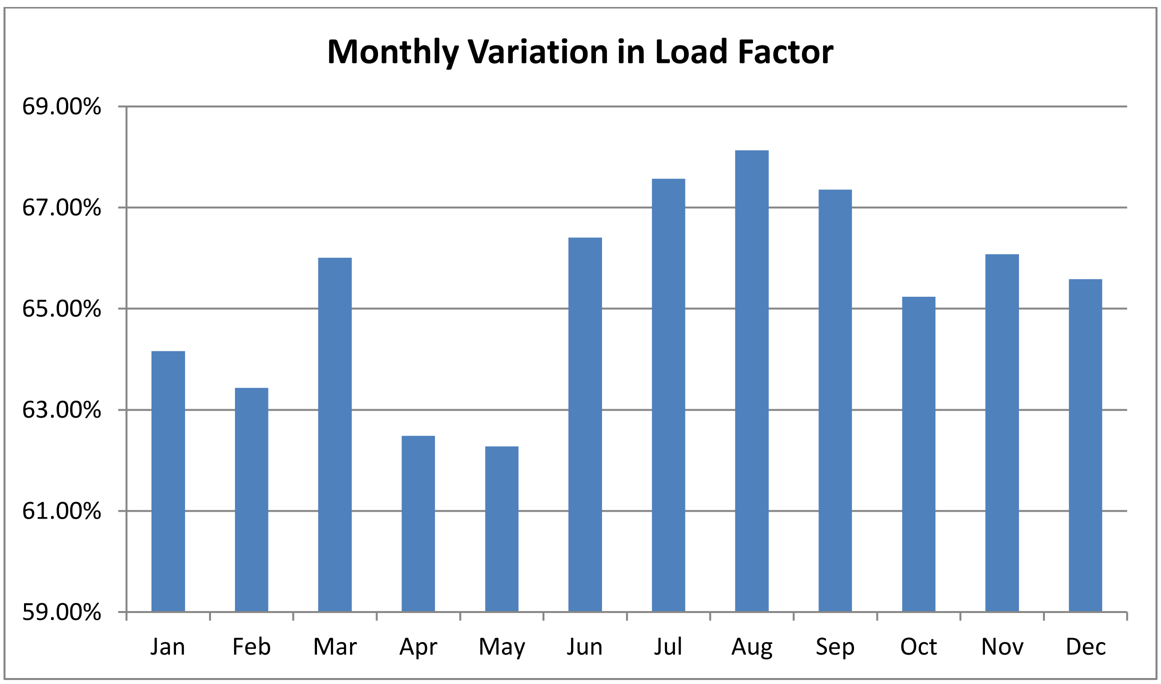
5. Load Factor

Load Factor is an indicator of how steady an electrical load is over time. It is simply the average load divided by the peak load in a system over a period of time. But normally load factor is calculated subjected to the produced energy according to the following formula.

$$Load\ Factor = \frac{Total\ Generation\ During\ the\ Nominal\ Period}{Maximum\ Demand \text{ x } No.of\ hours\ in\ the\ report\ period}$$

Calculated Load Factor for the total system in 2011 = **60.82%**

Load factor of any system must be tried to keep in its maximum by pulling down the concentrated maximum demand and shifting the loads to periods of otherwise low usage. Load factor maximization is essential in maintaining the security of supply of the countries in which meeting the concentrated maximum demand is critical. Countries which have a flat load curve own a higher load factor.



Sri Lanka has a load curve with a steep peak in the night, where starting from about 6.00 pm the load grows to about 2,000 MW by 7.30 pm and starts falling off after about 08.30 pm. Therefore the system must be comprised a substantial additional generation capacity only to meet that abrupt sharp night peak; hence the load factor in Sri Lanka is comparatively low. As a solution for that, CEB has introduced a three tier tariff plan for the industrial electricity consumers with low off peak rates and penal peak rates to smoothen the daily peak load and push some industrial activities to low demand hours, and this time-of-day tariff scheme is expected to be facilitated for the domestic consumers as well in near future.

6. Energy Unit Cost

Thermal power stations use fossil fuel for power generation. Therefore cost of producing a unit (kWh) differs with the type of fuel used and with efficiency of the generation process. This unit cost is crucial when performing economical dispatch.

Calculated average generation costs per unit in Rs/kWh for each thermal power plant operated in Sri Lanka in 2011 are listed below.

CEB Thermal

Puttalam Coal	Rs.6.39
Sapugaskanda 2	Rs.8.70
Sapugaskanda 1	Rs.9.56
Chunnakam	Rs.28.66
KPS GT 7	Rs.29.76
KPS CCY	Rs.30.18
KPS (Small) GTs	Rs.44.85

IPPs

Heladanavi	Rs.8.99
Colombo Power - Barge	Rs.9.92
Nothern Power	Rs.9.99
ACE - Embilipitiya	Rs.10.08
Lakdhanavi	Rs.10.16
ACE - Horana	Rs.10.19
ACE - Matara	Rs.10.30
Asia Power	Rs.10.41
Westcoast	Rs.12.92
AES - Kelanitissa	Rs.21.46
Aggreko Chunnakam	Rs.25.28

Note: *Average unit costs for CEB plants were calculated based only on fuel consumption.*

Average unit costs for IPPs were calculated based only on their energy charges.

Fuel costs and energy charges data in December were not available for the calculation

7. Comparison of Scheduled Dispatch and Actual Dispatch

CEB implements a generation dispatch schedule every 6 months before operation. It contains the amount of energy to be produced by each power plant for the coming year. Due to various reasons the actual dispatch could be deviated from this schedule and the comparison for the 2011 is given below.

	Capacity MW	Annual Scheduled GWh	Annual Actual GWh	Variation GWh	Scheduled PF	Actual PF
Puttalam Coal	300	1606.43	1038.2	-568.23	61.13%	39.51%
Sapugaskanda 2	80	496.64	499.05	+2.41	70.87%	71.21%
Heladhanavi	100	708.9	710.39	+1.49	80.92%	81.09%
Sapugaskanda 1	80	392.85	411.88	+19.03	56.06%	58.77%
Colombo Power Barge	60	424.71	467.2	+42.49	80.80%	88.89%
ACE Embilipitiya	100	693.66	442.16	-251.5	79.18%	50.47%
Lakdhanavi	22.5	156.09	114.89	-41.2	79.19%	58.29%
ACE Horana	20	166.97	160.41	-6.56	95.30%	91.56%
ACE Matara	20	164.03	150.81	-13.22	93.62%	86.08%
ASIA Power	51	328.88	317.68	-11.2	73.61%	71.11%
Kerawalapitiya	270	1118.58	1151.9	+33.32	47.29%	48.70%
AES Kelanitissa	163	47.87	580.73	+532.86	3.35%	40.67%
KPS GT 7	115	30	243.73	+213.73	2.98%	24.19%
KPS CCY	165	531.6	255.67	-275.93	36.78%	17.69%
KPS Small GT	100	3.61	76.6	+72.99	0.41%	8.74%
Total Grid Con. Thermal	1646.5	6870.82	6621.3	-249.52	47.64%	45.91%
Northern Power	20	157.5	87.88	-69.62	89.90%	50.16%
Aggreko	15	53.51	71.63	+18.12	40.72%	54.51%
Chunnakam	8	3.05	6.62	+3.57	4.35%	9.45%
Total Northern	43	214.05	166.13	-47.92	56.83%	44.10%
Renewable energy	243.717	630.2	719.93	+89.73	29.52%	33.72%
CEB Hydro	1206.2	3494.34	4017.65	+523.31	33.07%	38.02%
Total Generation	3139.417	11209.46	11525.01	+315.55		

Note: All Thermal Plants have been listed according to the calculated Merit order

8. Auxiliary Consumption

Auxiliary system is a major part of a power generation facility and the auxiliary consumption depends on configuration, age and related technical parameters of the plant. Purpose of an auxiliary system is to supply power for its own electricity requirements.

Normally 0.5% - 2% of power generated is consumed for the auxiliary system in hydro plants while the auxiliary consumption in fossil fuel power plants is 7% - 15% since there are different equipment like feed pumps, cooling water pumps, air fans, coal grinding mills, ash handling equipment etc. utilized in thermal plants.

Calculated percentages of auxiliary consumption out of annual gross generation of CEB power plants are as follows

- CEB Hydro 0.45%
- CEB Thermal 6.17%
- CEB Wind 0.51%

Note: *Auxiliary power consumption data are available only for CEB power plants and consumption for each plant separately are not available.*

9. Availability Factor

The evaluation of availability of a power plant is one of the most important works at any power station. To analyze plant availability performance, outages should be scrutinized to identify the causes of unplanned or forced energy losses and to reduce the planned energy losses. Reducing outages increases the number of operating hours, therefore increases the energy availability factor.

Availability Factor of a generation plant can be calculated using the formula given below.

$$Availability\ Factor = \frac{Duration\ in\ which\ the\ generation\ unit\ was\ available\ for\ opertaion}{Total\ length\ of\ the\ period}$$

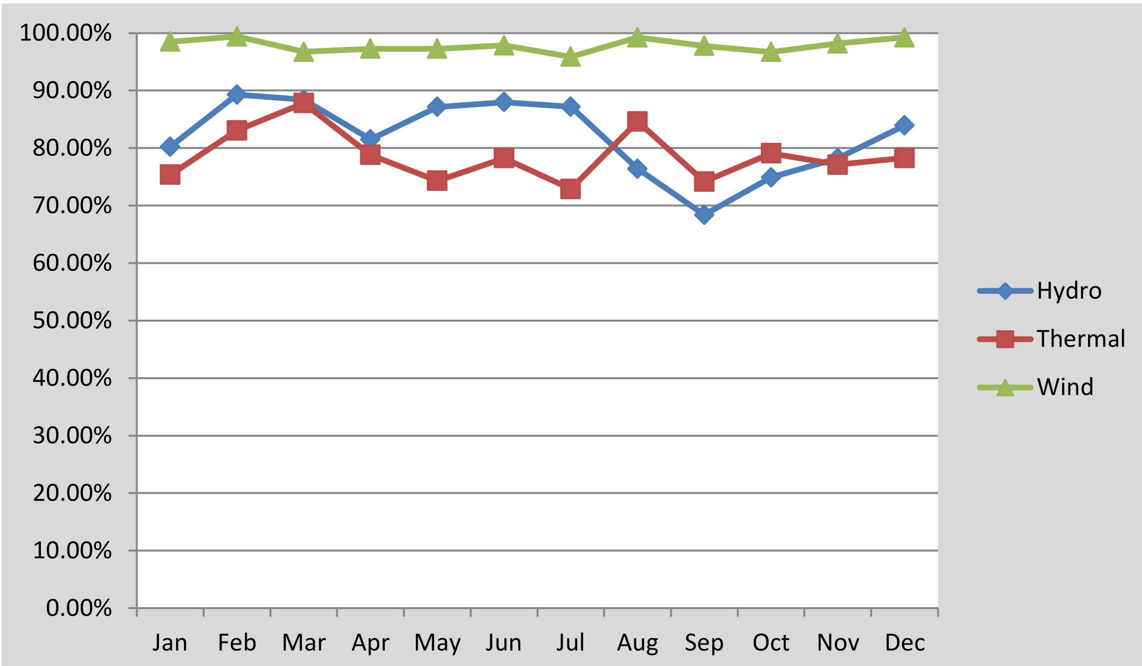
Total Availability Factor for all CEB generation Units in 2011 = **82.14%**

Availability Factor for CEB hydro generation units in 2011 = **81.93%**

Availability Factor for CEB thermal generation units in 2011 = **78.62%**

Availability Factor for CEB wind generation units in 2011 = **97.82%**

The chart below shows the monthly variation of availability of all CEB generation units in 2011



Note: *Interruption data is available only for CEB owned power plants.*

Interruption data of Norochcholai and Chunnakam power plants were not available for the above calculations.

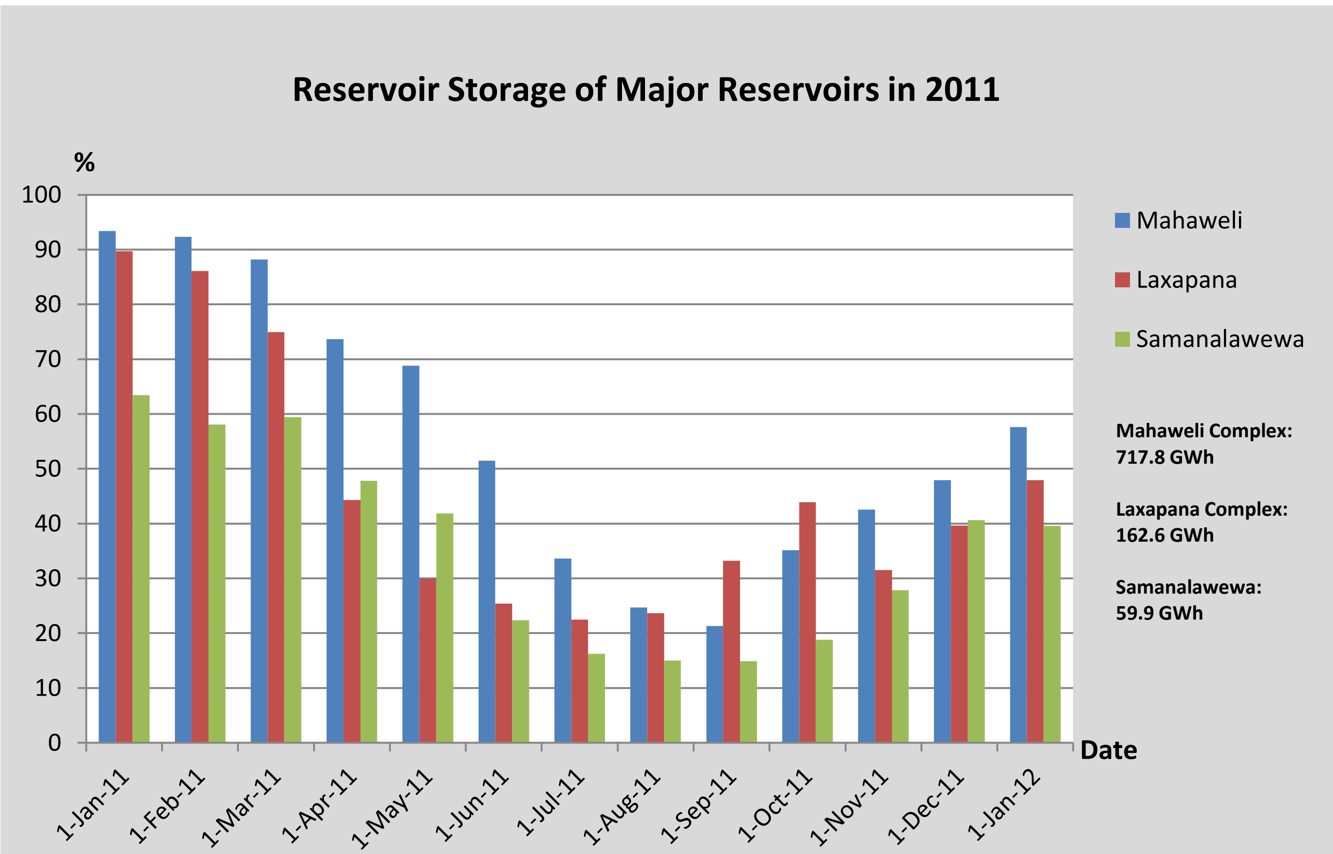
10.Reservoir Storages

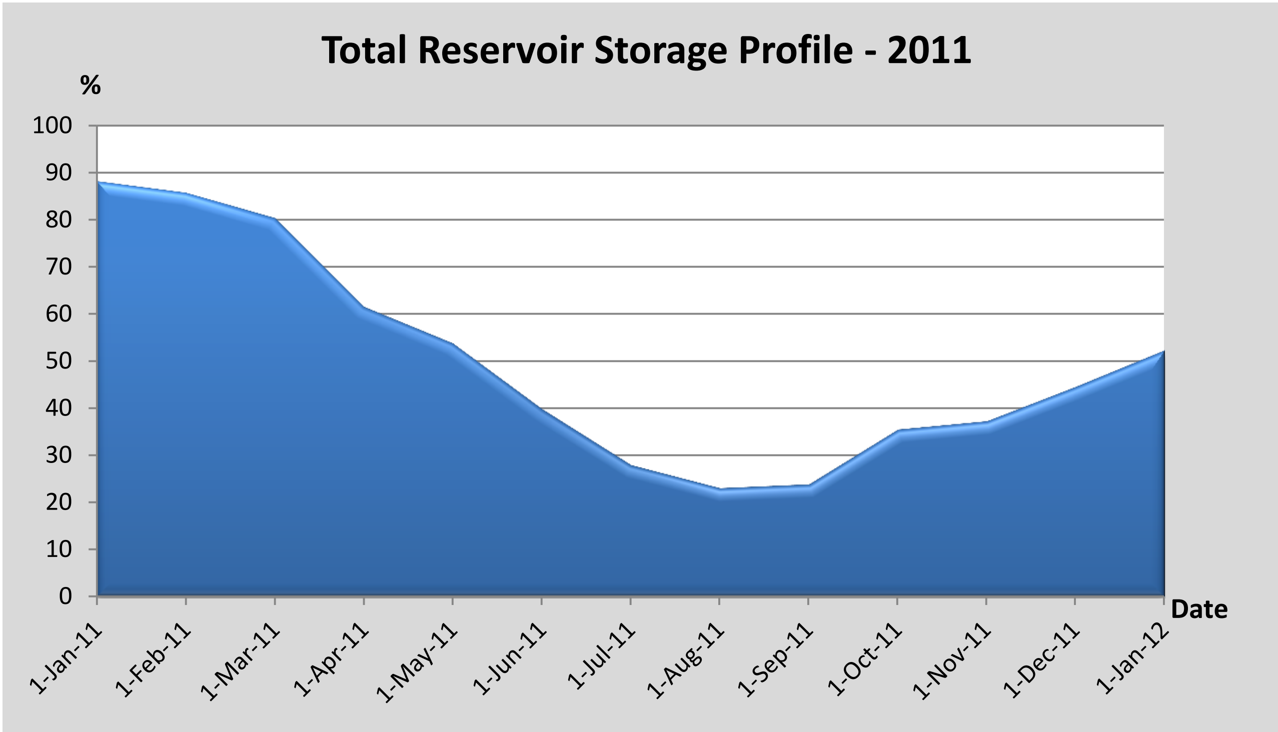
Hydro power is one of the major sources of generation in the Sri Lankan power system and most of the comparatively large scale hydro projects have been developed by CEB. In 2011 approximately 39% of the total existed capacity was installed in 16 CEB hydro stations and a contribution of 34.86% has been given to the national generation.

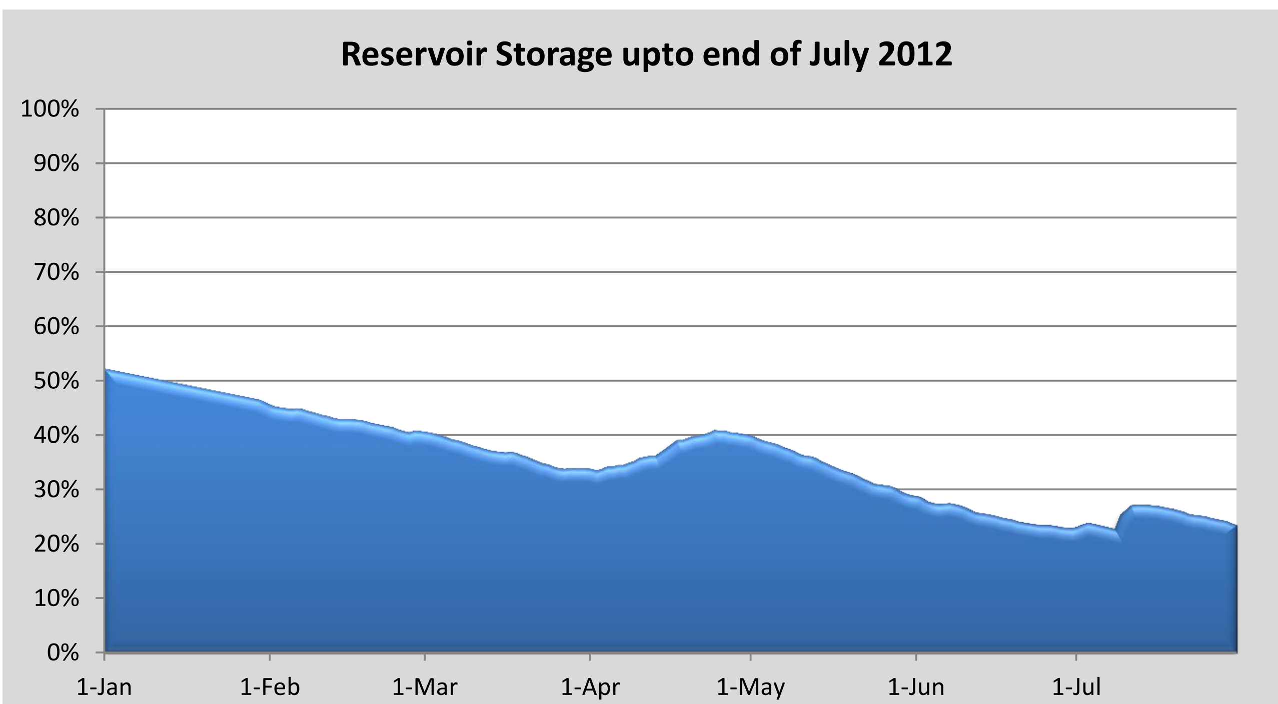
The major hydropower schemes already developed are associated with Kelani and Mahaweli river basins. Laxapana complex comprises five hydro power stations which have been built associated with the two main tributaries of Kelani River; Kehelgamu Oya and Maskeli Oya. Castlereigh and Moussakelle are the major storage reservoirs in the Laxapana complex. Mahaweli complex comprises six hydro power stations and three major reservoirs; Kotmale, Victoria and Randenigala. Other than above mentioned reservoirs Samanalawewa, which is on Walawe River, is also can be considered as a large reservoir. And all the other small reservoirs which contribute to power up the run-of-river type plants are considered as ponds.

Therefore having a satisfactory capacity of water in these reservoirs throughout the year is essential to dispatch the hydro power to a significant amount.

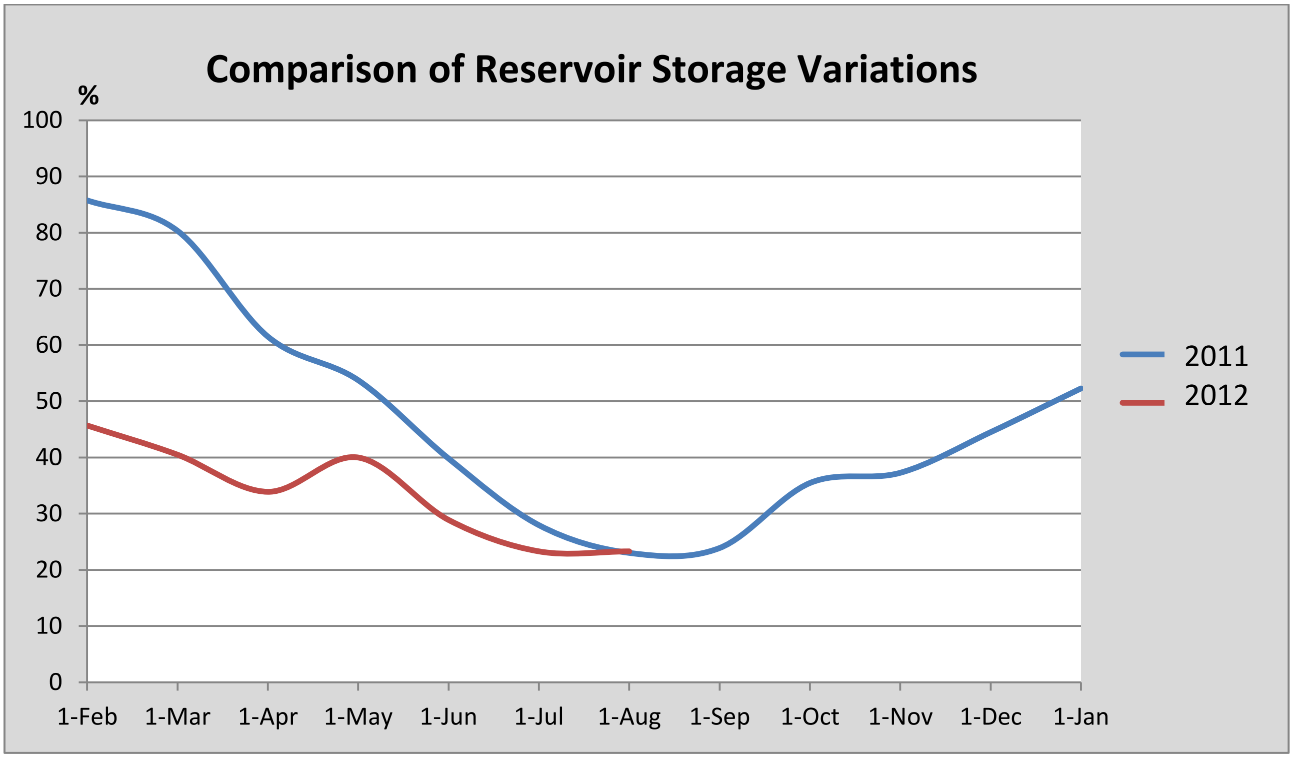
The major reservoir storage levels throughout the year, 2011 are depicted below.







Note: Only Mahaweli, Laxapana and Samanalawewa Complexes' reservoirs are considered in total reservoir storage profile.



11.Conclusion

The Report has described and calculated a number of key performance indicators for total generation system and individual generation plants operated in Sri Lanka. These indices can be used to measure the plant's performance compared with benchmarks and to illustrate the historical trends. The indicators for the present technical performance of the generation system are useful when planning the future developments and taking the corrective actions if necessary to improve the efficiency of generation.

Improving the performance of existing power plants is the most cost effective way to increase the energy producing capabilities of them. Performance indicators are very useful in identifying the areas for performance improvement. Among generation plants' performance measures plant factor, availability and auxiliary consumption are critical performance indicators, both in technical and commercial terms. Nevertheless, generator outages' details and auxiliary consumption data of IPPs are not available to assess the availability and percentage of auxiliary consumption of them. And individual auxiliary consumption data of CEB owned power plants are also not available to measure their individual performances. Therefore the availability details and auxiliary consumption data of all CEB and Private power are intended to be received through LISS in order to measure their performance.

Additionally, in environmental context the amount of Carbon dioxide per annum in thermal power generation for individual thermal power plants could be measured in future in order to take the necessary actions to help in reducing the annual global GHG emissions. And in safety context industrial safety performance could be monitored by the number of accidents that result during working period.