འབྲུག་གློག་ཤུགས་རིང་ལུགས་ལག་ལེན་ཡིག་ཚང་།

Office of the Bhutan Power System Operator

རྒྱལ་ཤུགས་དང་རང་བཞིན་ཐོན་སྐྱེད་ལྷན་ཁག

Ministry of Energy and Natural Resources

ANNUAL TRANSMISSION SYSTEM PERFORMANCE REPORT FOR THE YEAR 2023

JANUARY-2024

Sl. No. Table of Contents Page No.

1.0 INTRODUCTION

In compliance to Grid Code Regulation 2008, Clause No. 6.14.2.1, this office prepared an annual report covering the performance of the Transmission System and details as required by the Ministry and the Authority annually for development of power system master plan and formulation of other policy decisions, thus this report contains the performance of Transmission System for the year 2023.

All the index and other calculations in this report have been executed based on the data received from substations and generating plants.

2.0 PERFORMANCE OF GENERATING STATIONS

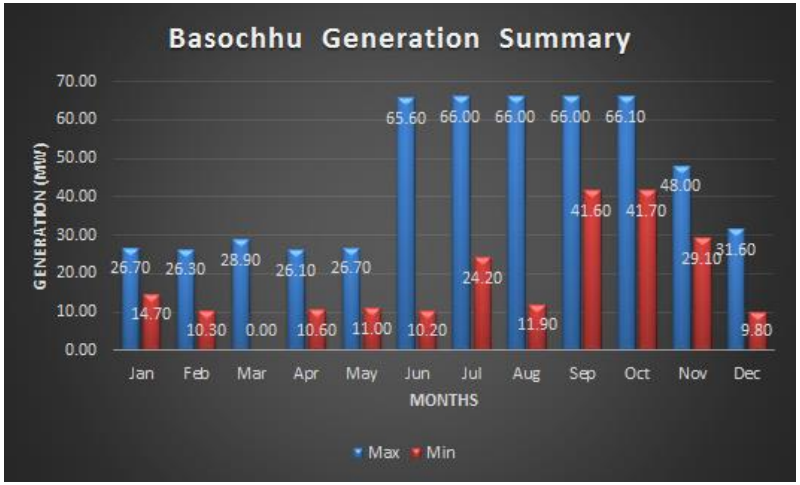
2.1 POWER GENERATION

The maximum individual plant generation was recorded as 1122.00 MW by the Tala Hydropower Plant, followed by 792.05 MW by Mangdichu Hydropower Plant.

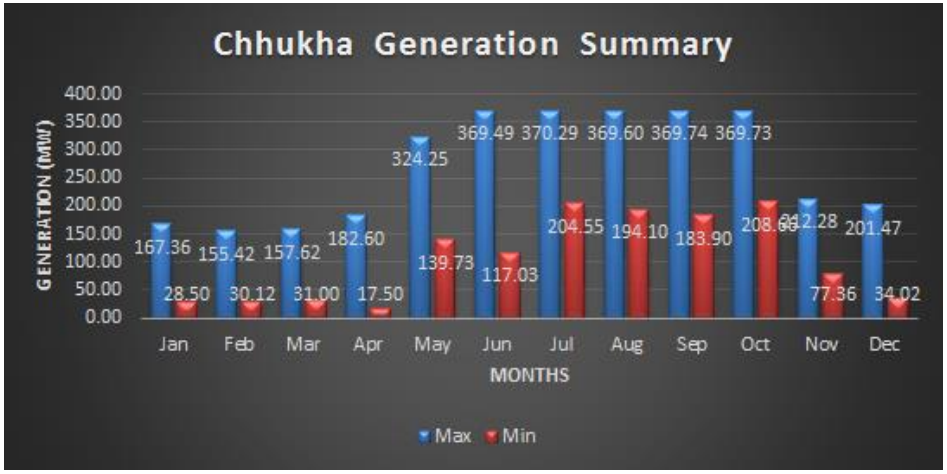
Table: 2.1.1 Monthly maximum and minimum generation summary

Sl. No	Hydropower Plant		Monthly Maximum and Minimum Generation (MW)												Max/Min of year (MW)		
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
1	BHP	Max	26.70	26.30	28.90	26.10	26.70	65.60	66.00	66.00	66.00	66.10	48.00	31.60	**66.10**		
		Min	14.70	10.30	0.00	10.60	11.00	10.20	24.20	11.90	41.60	41.70	29.10	9.80		**0.00**	BHP Shutdown on 20th March at 2:00Hrs
2	CHP	Max	167.36	155.42	157.62	182.60	324.25	369.49	370.29	369.60	369.74	369.73	212.28	201.47	**370.29**		
		Min	28.50	30.12	31.00	17.50	139.73	117.03	204.55	194.10	183.90	208.66	77.36	34.02		**17.50**	
3	THP	Max	360.00	370.00	340.00	450.00	650.00	1,122.00	1,122.00	1,122.00	1,122.00	1,122.00	460.00	555.00	**1,122.00**		
		Min	20.00	35.00	20.00	30.00	170.00	200.00	699.00	935.00	577.00	320.00	190.00	30.00		**20.00**	
4	KHP	Max	32.22	31.58	45.39	66.00	66.00	66.00	66.00	66.00	66.00	66.00	45.17	32.29	**66.00**		
		Min	10.01	10.01	10.05	0.00	11.25	16.50	15.09	16.50	15.26	16.50	13.04	11.01		**0.00**	KHP Shutdown on 1st April 2023 at 9hrs
5	DHP	Max	49.11	24.01	35.30	25.27	50.33	126.98	132.89	127.13	127.09	127.09	52.85	34.02	**132.89**		DHP Shutdown on 15th April from 7hrs till 22hrs and shutdown on 1st May 2023 from 0:00hrs till 1hrs. DHP Shutdown on 13th August at 13hrs. DHP shutdown on 6th Sept at 12hrs. DHP shutdown on 2nd Oct at 7hrs. DHP shutdown on 30th Nov at 10hrs.
		Min	19.33	17.06	15.15	0.00	0.00	13.54	59.44	0.00	0.00	0.00	0.00	24.27		**0.00**	
6	MHP	Max	325.11	325.11	334.72	396.16	570.15	794.79	793.66	793.19	790.62	787.97	320.41	305.81	**794.79**		
		Min	127.63	127.63	127.38	137.50	230.48	599.83	593.05	498.00	436.81	507.11	200.50	159.00		**127.38**	

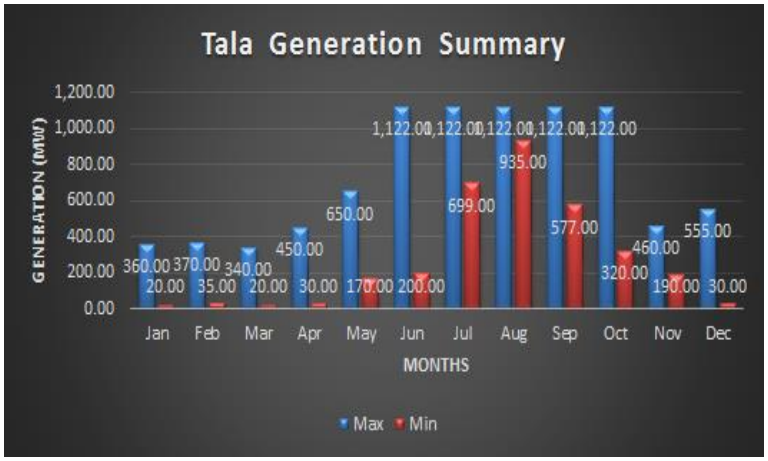
Graph: 2.1.1 Basochhu Generation Summary



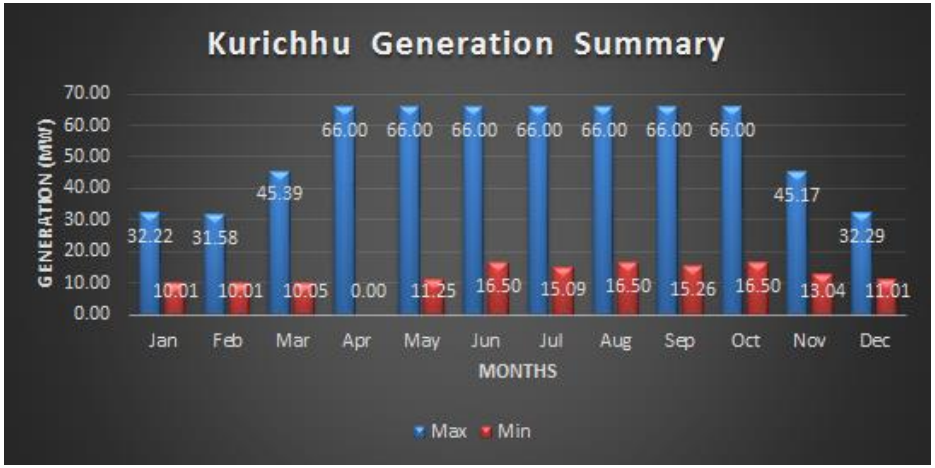
Graph: 2.1.2 Chhukha Generation Summary



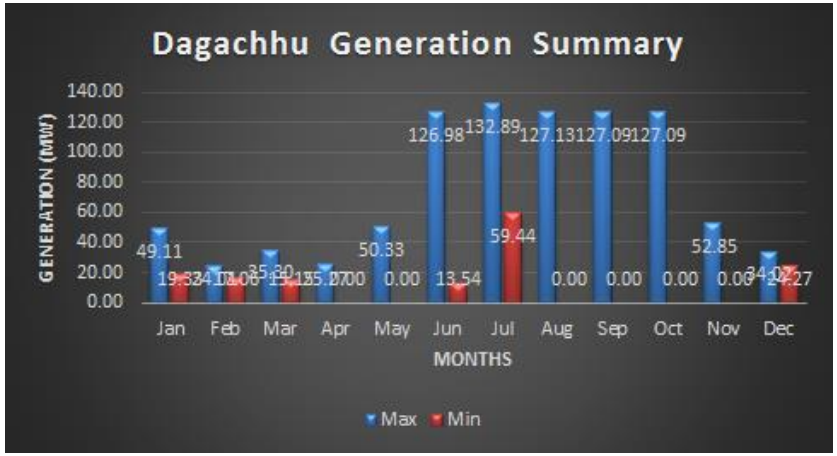
Graph: 2.1.3 Tala Generation Summary



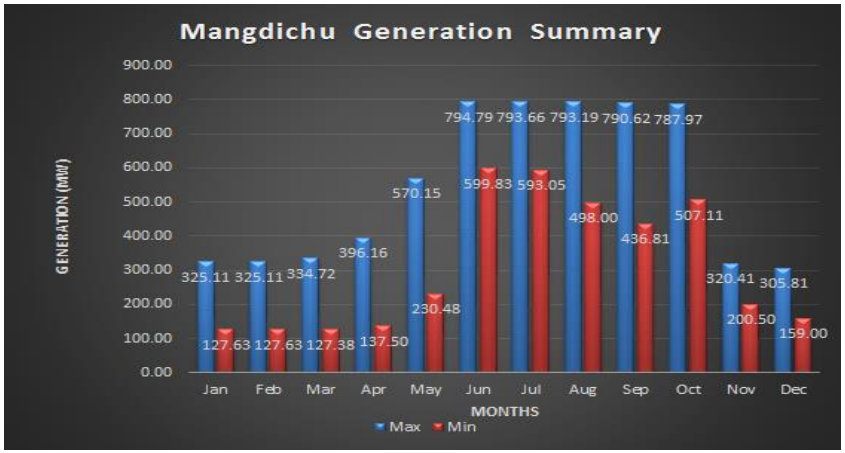
Graph: 2.1.4 Kurichhu Generation Summary



Graph: 2.1.5 Dagachhu generation summary



Graph: 2.1.6 Mangdichu generation summary



2.2 PLANT FACTOR

The plant factor of each generating plant was calculated as below:

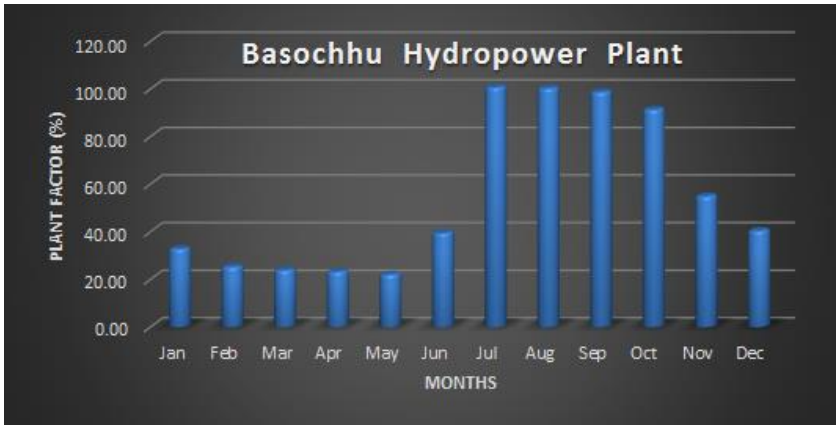
Plant factor = (Actual output of a plant over a period of time) / (Output when operated at name plate rated capacity for entire time)

= (Total energy plant has produced over a period) / (Total energy plant would produce when operated at full rated capacity)

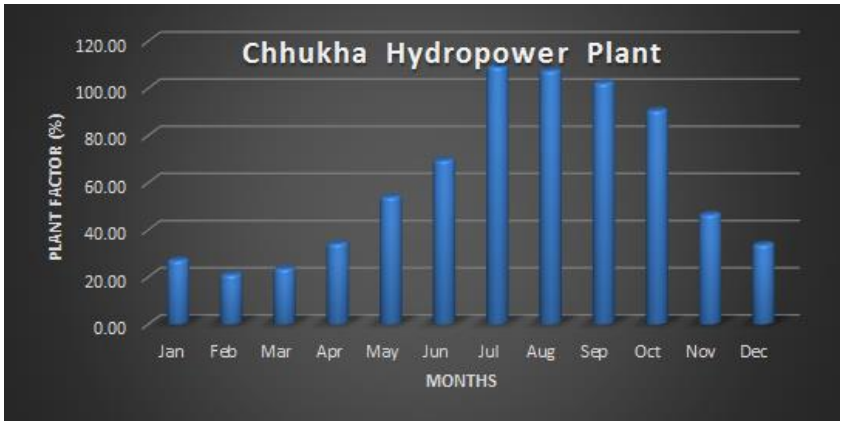
Table: 2.2.1 Monthly plant factor of the hydropower plants

Sl. No	Hydropower Plant	Monthly Plant Factor (%)												Max/Min of year (%)	
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Max	Min
1	BHP	32.87	25.27	23.92	23.26	22.02	39.51	100.73	100.37	98.72	91.35	54.97	40.46	100.73	22.02
2	CHP	27.07	20.97	23.47	34.08	53.84	69.45	109.08	107.41	102.15	90.54	46.46	33.70	109.08	20.97
3	THP	17.66	14.00	16.07	22.98	30.15	57.77	109.20	108.89	86.67	69.56	30.96	22.11	109.20	14.00
4	KHP	34.26	29.37	40.36	62.28	87.79	104.23	106.54	105.85	105.82	95.72	53.26	39.70	106.54	29.37
5	DHP	17.66	13.53	14.44	12.66	14.25	34.26	80.05	91.23	76.50	63.96	32.05	22.72	91.23	12.66
6	MHP	62.25	58.84	36.69	61.71	245.02	165.69	259.28	258.22	207.42	132.33	64.03	39.22	259.28	36.69

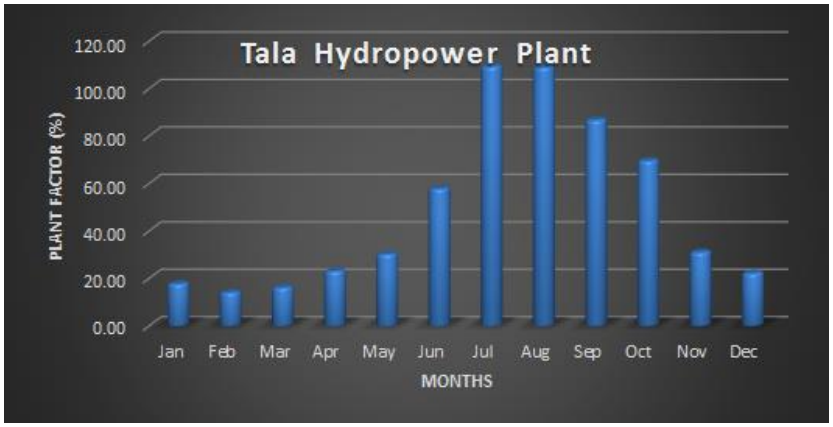
Graph: 2.2.1 Plant factor of Basochhu Hydropower Plant



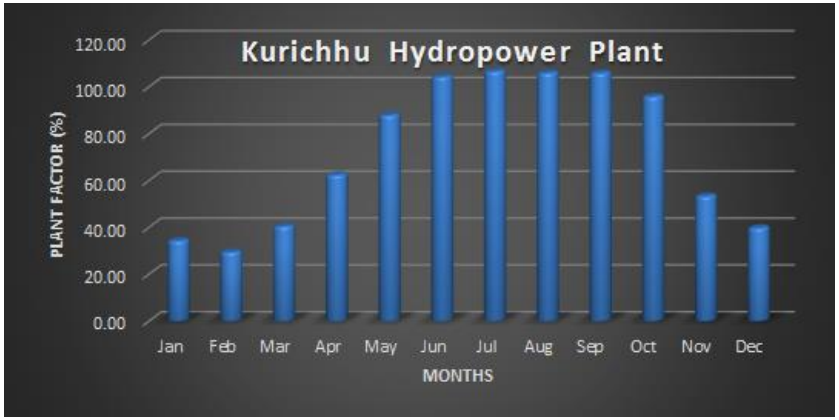
Graph: 2.2.2 Plant factor of Chhukha Hydropower Plant



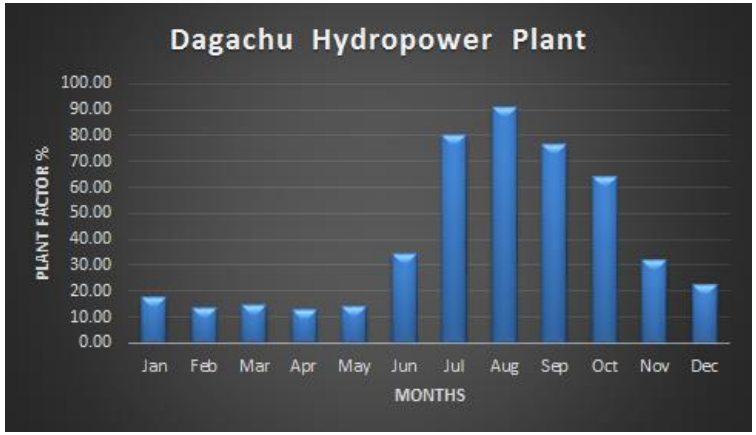
Graph: 2.2.3 Plant factor of Tala Hydropower Plant



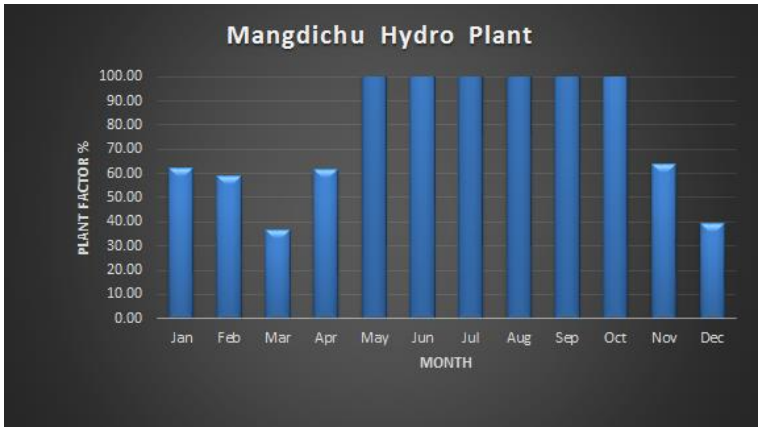
Graph: 2.2.4 Plant factor of Kurichhu Hydropower Plant



Graph: 2.2.4 Plant factor of Dagachhu Hydropower Plant



Graph: 2.2.4 Plant factor of Mangdichu Hydropower Plant



3.0 PEAK DEMAND, ENERGY AVAILABILITY AND REQUIREMENT FOR THE COUNTRY

Calculation of coincidental peak load for the eastern grid, western grid and national load, we use the following methods:

1. *National Demand = (Sum of all total generation of each plant) – (Sum of all Export/Import)*
2. *National Demand = (Sum of all feeders loading at hydropower plant) – (Sum of all Export/Import)*
3. *National Demand = (Sum of all substation loading)*

The national load calculated using method-1 is considered in the report.

3.1 NATIONAL LOAD

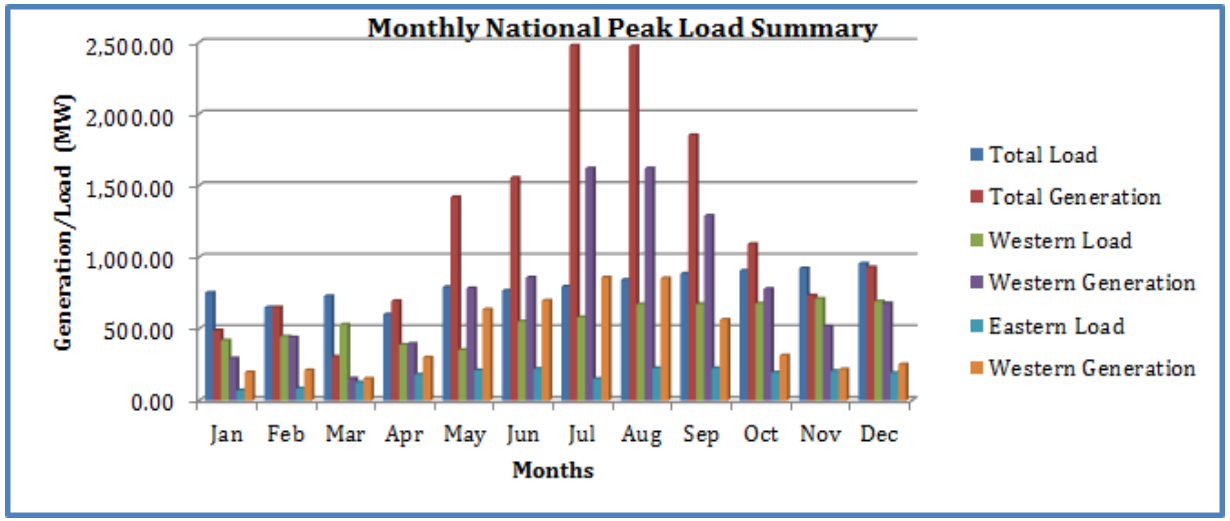
The national coincidental peak load for the year was recorded 955.51 MW (Increased by 51.76 % compare to 2022 (629.61 MW)) on December 30, 2023 at 18:00 Hrs. using method-1 (sum of all total generation each plant minus sum of export/import). The main factor contributing towards the increase in Bhutan peak load in 2023 could be because of more production by the industries numbers of new substations came up in 2023.

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Peak Load (MW)	157.36	187.05	237.17	256.95	276.24	282.44	313.94	333.41	336.52	335.87	362.09	399.35	387.66	374.53	435.35	629.61	955.51
% Growth over previous Year	-	18.87	26.79	8.34	7.51	2.24	11.15	6.20	0.93	-0.19	7.81	10.29	-2.93	-3.39	16.24	16.24	51.76

Table: 3.1.2 Monthly national peak load and corresponding generation using method- 1

Sl. No	Months	Date	Time	Total Grid (MW)		Western Grid (MW)		Eastern Grid (MW)	
				Load	Generation	Load	Generation	Load	Generation
1	Jan	24-Jan-23	22:00	751.96	488.71	418.80	293.23	70.77	195.48
2	Feb	20-Feb-23	21:00	649.26	649.51	445.79	438.79	82.96	210.72
3	Mar	29-Mar-23	13:00	727.41	304.44	529.69	152.44	126.85	152.00
4	Apr	28-Apr-23	7:00	600.00	693.61	388.55	394.94	179.46	298.67
5	May	26-May-23	20:00	791.20	1,418.49	352.29	783.30	210.00	635.19
6	Jun	7-Jun-23	20:00	765.15	1,554.00	550.81	857.00	220.00	697.00
7	Jul	8-Jul-23	18:00	794.87	2,477.43	581.39	1,619.67	149.77	857.76
8	Aug	26-Aug-23	19:00	842.31	2,472.00	671.36	1,619.00	225.00	853.00
9	Sep	28-Sep-23	19:00	885.47	1,852.63	672.47	1,289.00	224.80	563.63
10	Oct	27-Oct-23	19:00	905.21	1,091.45	676.71	778.01	194.73	313.44
11	Nov	18-Nov-23	18:37	921.87	732.79	710.50	515.89	205.22	216.90
12	Dec	30-Dec-23	18:00	955.51	929.33	691.46	677.25	191.26	252.08
National Peak Load of the year (MW)				955.51					

Graph: 3.1.2 Monthly national peak load and corresponding generation using method-1



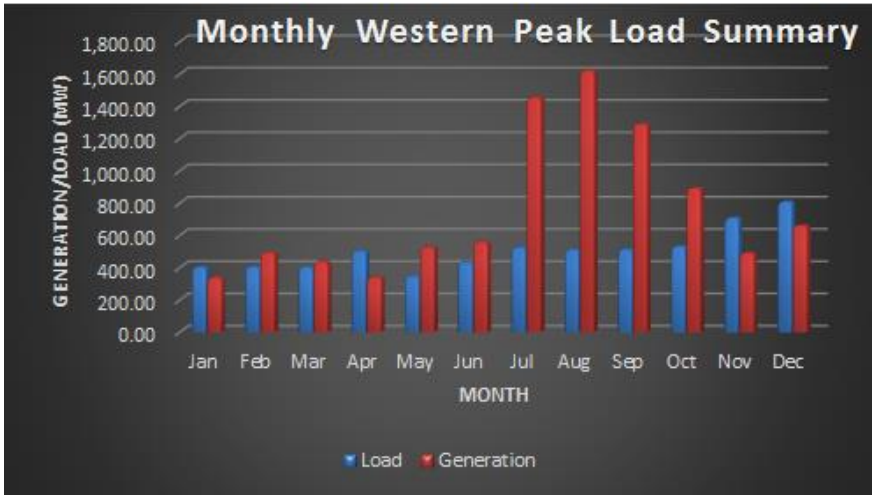
3.2 WESTERN GRID PEAK LOAD

Using method-1, the peak load for the western grid was 807.22MW which occurred on December 28, 2023.

Table: 3.2.1 Monthly western peak load and corresponding generation

Sl. No	Months	Date	Time	Western Grid (MW)	
				Load	Generation
1	Jan	17-Nov-22	19:00	402.06	338.11
2	Feb	9-Feb-23	19:00	404.47	491.41
3	Mar	2-Mar-23	19:00	401.81	436.81
4	Apr	18-Apr-23	7:00	502.24	338.11
5	May	3-May-22	20:00	346.63	525.08
6	Jun	2-May-22	20:00	432.50	558.88
7	Jul	11-Jul-22	20:00	523.23	1,452.61
8	Aug	26-Aug-23	20:00	509.73	1,619.86
9	Sep	28-Sep-23	19:00	512.04	1,289.72
10	Oct	20-Oct-23	18:00	531.16	891.08
11	Nov	24-Nov-23	20:00	706.80	489.70
12	Dec	28-Dec-23	19:00	807.22	659.41
Western Peak Load of the year (MW)				807.22	

Graph: 3.2.1 Monthly western peak load and corresponding generation



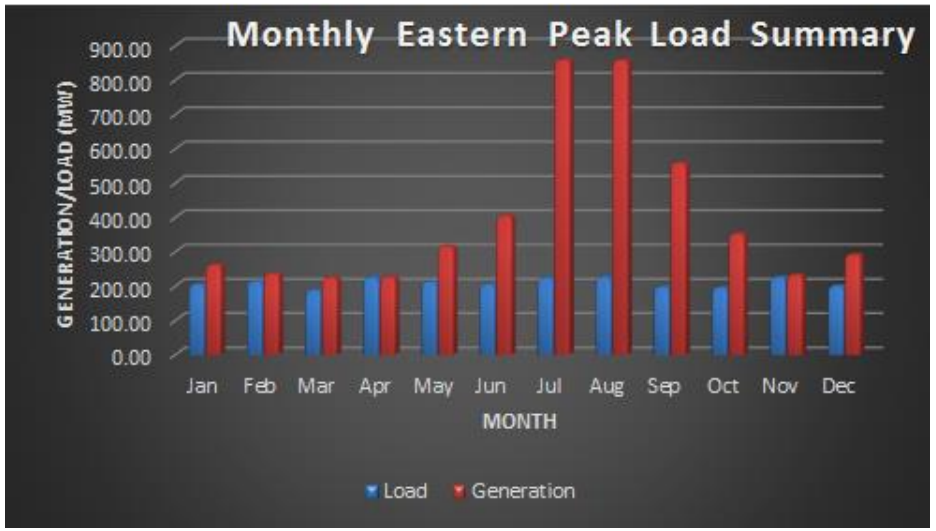
3.3 EASTERN GRID PEAK LOAD

Using method-2, the peak load for the eastern grid was 225.25MW which occurred on December 30, 2023.

Table: 3.3.1 Monthly eastern peak load and corresponding generation

Sl. No	Months	Date	Time	Eastern Grid (MW)	
				Load	Generation
1	Jan	6-Nov-22	18:00	204.24	260.64
2	Feb	13-Feb-23	19:00	212.24	235.85
3	Mar	8-Mar-23	19:00	187.51	223.38
4	Apr	27-Apr-23	0:00	224.26	225.34
5	May	10-May-22	19:00	211.14	314.57
6	Jun	8-May-22	20:00	204.16	403.88
7	Jul	20-Jul-22	18:00	223.28	857.83
8	Aug	26-Aug-23	18:00	225.00	856.86
9	Sep	19-Sep-23	19:00	196.86	557.67
10	Oct	22-Oct-23	18:00	194.48	351.15
11	Nov	14-Nov-23	8:00	225.25	231.45
12	Dec	30-Dec-23	18:00	199.83	290.94
Eastern Peak Load of the year (MW)				225.25	

Graph: 3.3.1 Monthly eastern peak load and corresponding generation



4.0 EXPORT AND IMPORT OF ELECTRICITY TO/FROM NEIGHBORING COUNTRIES

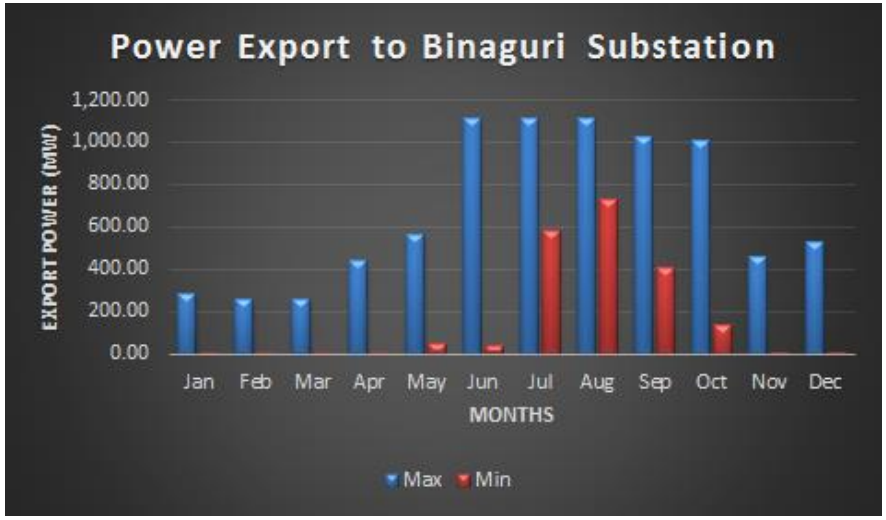
4.1 EXPORT OF ELECTRICITY TO NEIGHBORING COUNTRY

Maximum export of electricity for the year was 1,113.18MW to Binaguri substation in July, 2023, followed by 682.36MW to Alipurduar substation. The minimum export was 0.00 MW to Birpara substation.

Table: 4.1.1 Monthly power export summary

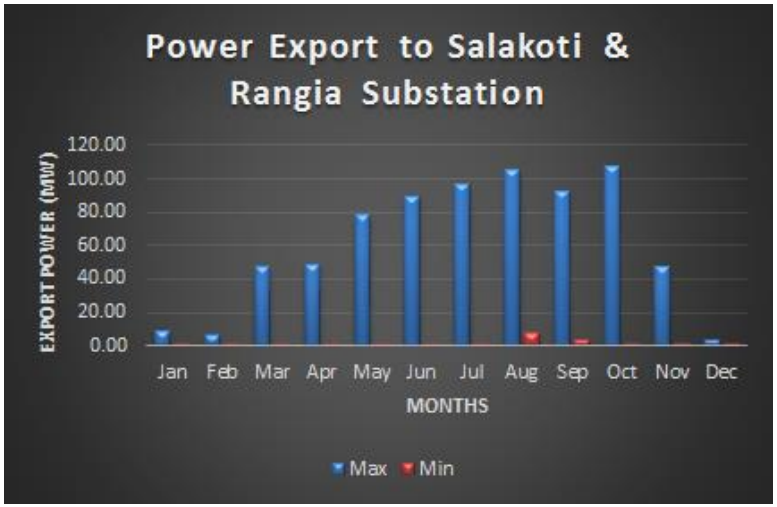
Sl. No	Substation in India		Monthly Maximum and Minimum Export (MW)												Max/Min of year (MW)	
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
1	Binaguri	Max	283.00	257.18	257.64	440.00	567.27	1,109.00	1,113.18	1,109.27	1,023.36	1,004.27	460.73	526.00	**1,113.18**	
		Min	0.55	0.09	0.82	0.36	50.54	40.64	578.36	731.27	405.00	139.00	0.36	2.18		**0.09**
2	Birpara	Max	0.00	0.00	9.26	46.29	120.92	203.28	283.82	188.54	185.59	152.62	104.70	0.00	**283.82**	
		Min	0.00	0.00	8.92	4.63	0.07	0.55	22.01	8.65	0.03	0.74	15.96	0.00		**0.00**
3	Salakoti & Rangia	Max	9.25	6.19	47.34	49.06	78.23	89.79	96.45	105.39	92.78	108.09	46.93	3.53	**108.09**	
		Min	0.01	0.27	0.04	0.13	0.12	0.69	0.27	7.74	3.60	0.12	0.12	0.02		**0.01**
4	Alipurduar	Max	160.14	172.45	149.66	320.03	158.53	682.36	707.01	740.89	710.87	728.27	507.99	507.99	**740.89**	
		Min	1.82	1.36	0.11	0.61	0.01	38.92	251.64	68.67	224.37	4.59	0.35	2.60		**0.01**

Graph: 4.1.1 Monthly power export to Binaguri substation

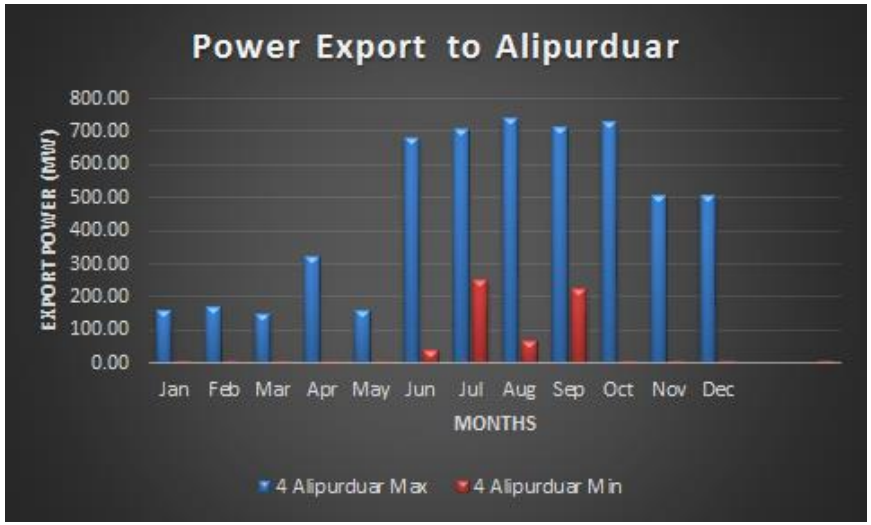


Graph: 4.1.2 Monthly power export to Birpara substation

Graph: 4.1.3 Monthly net power export to Salakoti and Rangia substation



Graph: 4.1.4 Monthly net export to Alipurduar



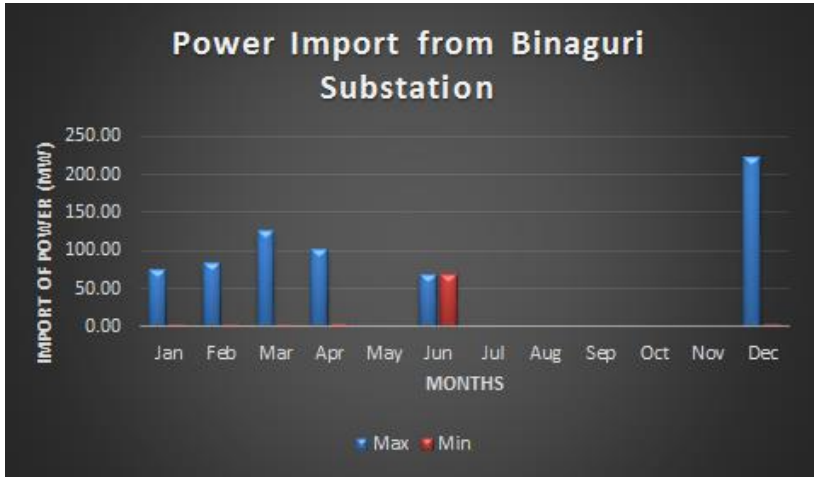
4.2 IMPORT OF ELECTRICITY FROM NEIGHBORING COUNTRY

Maximum import of power was 390.48 MW from Birpara substation which occurred in December, 2023 followed by 111.80 MW and 56.81 MW from Salakoti and Rangia and Alipurduar respectively.

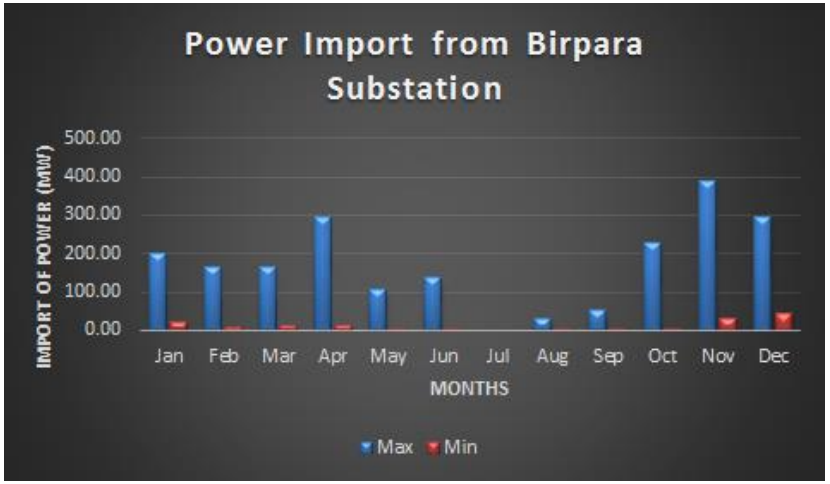
Table: 4.2.1 Monthly power import summary

Sl. No	Substation in India		Monthly Maximum and Minimum Import (MW)												Max/Min of year (MW)	
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
1	Binaguri	Max	74.36	83.36	125.45	101.36	0.00	69.00	0.00	0.00	0.00	0.00	0.00	222.64	**222.64**	
		Min	0.27	0.27	1.82	3.82	0.00	69.00	0.00	0.00	0.00	0.00	0.00	1.91		**0.00**
2	Birpara	Max	198.94	163.95	164.76	295.95	106.57	136.21	0.00	31.96	52.86	229.00	390.48	295.28	**390.48**	
		Min	22.00	9.73	12.27	14.17	0.06	1.36	0.00	2.72	0.45	1.58	32.57	44.52		**0.00**
3	Salakoti & Rangia	Max	46.58	41.20	13.82	42.48	16.34	0.00	3.19	24.19	7.80	28.45	56.81	77.83	**77.83**	
		Min	0.19	0.10	0.04	0.10	0.33	0.00	3.08	24.19	4.20	1.55	0.01	0.02		**0.00**
4	Alipurduar	Max	160.14	31.46	214.21	158.03	26.55	7.83	0.00	161.23	0.00	11.50	111.80	220.10	**220.10**	
		Min	1.82	0.40	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**

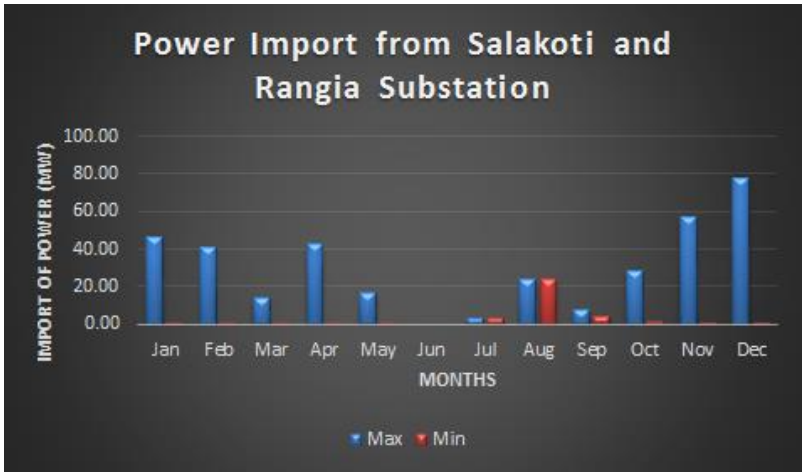
Graph: 4.2.1 Power import from Binaguri substation summary



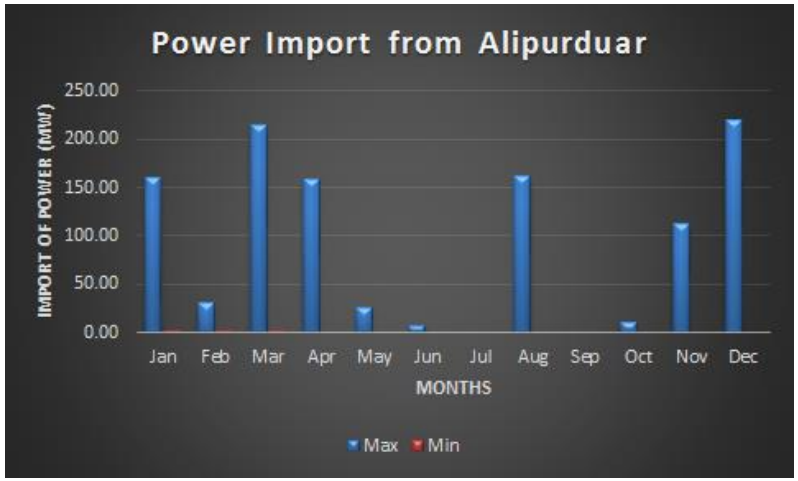
Graph: 4.2.2 Power import from Birpara substation summary



Graph: 4.2.3 Power import from Salakoti and Rangia substation summary



Graph: 4.2.4 Power import from Alipurduar



5.0 FREQUENCY PROFILE: MAXIMUM AND MINIMUM FREQUENCY RECORDED AND THE FREQUENCY DURATION IN DIFFERENT FREQUENCY BANDS

As per the Grid Code Regulation 2008, Clause 6.4.1 the transmission system frequency was classified into three different bands 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.

We base our frequency at 220kV Bus frequency at 220/66/11kV Semtokha substation in the western grid and 132kV Bus frequency at 50Hz and Kurichhu Hydropower Plant in the eastern grid.

Table: 5.0.1 Frequency profile at Semtokha substation

Sl. No	Months	220kV Bus Frequency Operation State (%)			
		Normal	Alert	Emergency	Blackout/ Other
1	Jan	100.00	0.00	0.00	0.00
2	Feb	100.00	0.00	0.00	0.00
3	Mar	100.00	0.00	0.00	0.00
4	Apr	96.10	0.00	0.00	3.90
5	May	99.87	0.00	0.00	0.13
6	Jun	96.37	0.13	0.00	3.49
7	Jul	99.87	0.00	0.00	0.13
8	Aug	97.98	0.00	0.00	2.02
9	Sep	96.77	0.00	0.00	3.23
10	Oct	97.98	0.00	0.00	2.02
11	Nov	96.77	0.00	0.00	3.23
12	Dec	97.98	0.00	0.00	2.02
Operation State for the year		98.31%	0.01%	0.00%	1.68%

Graph: 5.0.1 Frequency profile at Semtokha substation

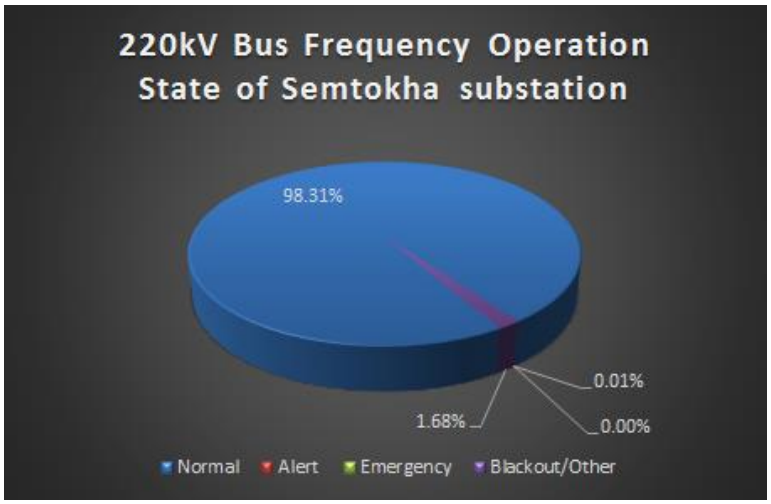
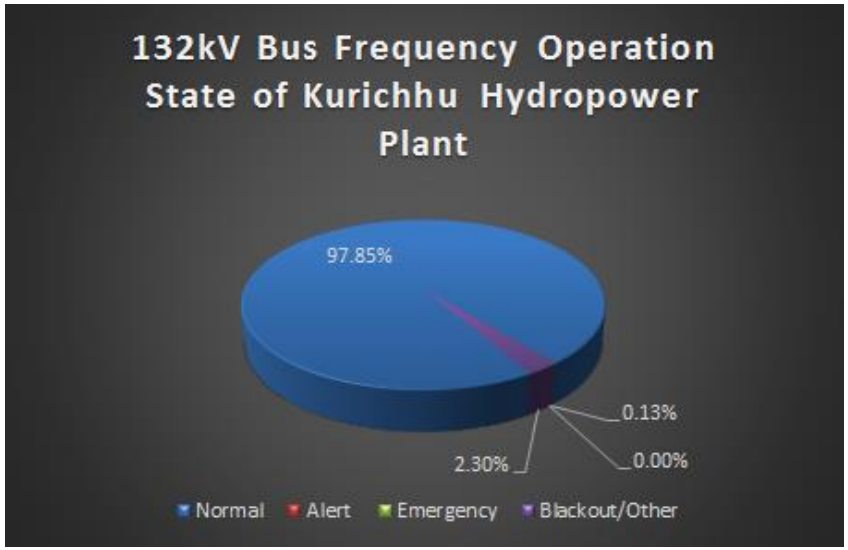


Table: 5.0.2 Frequency profile at Kurichhu Hydropower plant

Sl. No	Months	132kV Bus Frequency Operation State (%)			
		Normal	Alert	Emergency	Blackout/ Other
1	Jan	98.92	1.08	0.00	0.00
2	Feb	90.32	0.00	0.00	9.68
3	Mar	99.73	0.27	0.00	0.00
4	Apr	96.51	0.13	0.00	3.36
5	May	100.00	0.00	0.00	3.36
6	Jun	96.77	0.00	0.00	3.23
7	Jul	99.06	0.00	0.00	0.94
8	Aug	100.00	0.00	0.00	0.00
9	Sep	96.51	0.00	0.00	3.49
10	Oct	99.73	0.13	0.00	0.13
11	Nov	96.64	0.00	0.00	3.36
12	Dec	100.00	0.00	0.00	0.00
Operation State for the year		97.85%	0.13%	0.00%	2.30%

Graph: 5.0.2 Frequency profile at Kurichhu Hydropower Plant



6.0 VOLTAGE PROFILE OF SELECTED SUBSTATIONS

As the Grid Code Regulation 2008, Clause 6.4.1, the voltage at all connection points was classified into three different bands as follows:

1. *Normal state*
   The voltages at all connection point are within the limits of 0.95 times and 1.05 times of the normal values
2. *Alert state*
   The voltage at all connection points are outside the normal limit but within the limits of 0.9 times and 1.1 times of the normal values
3. *Emergency state*

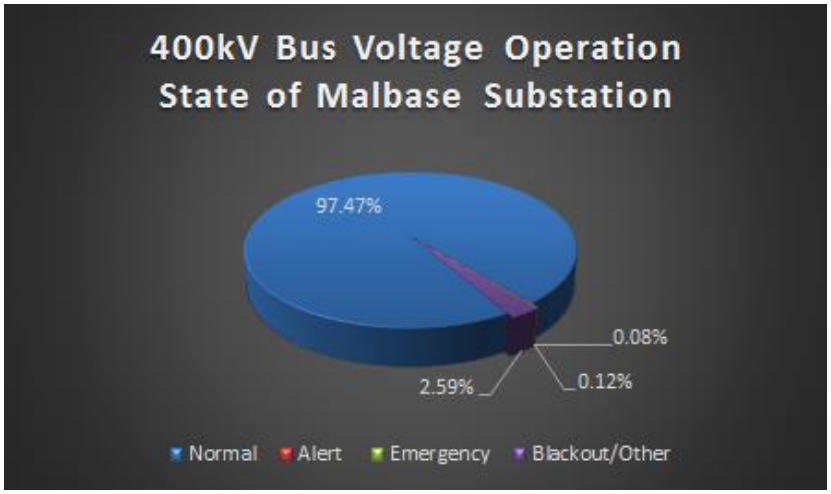
Transmission system voltages are outside the limits of 0.9 times and 1.1 times of nominal values.

The voltage profile of 400/220/66/11kV Malbase substation in western grid and 132/33/11kV Nangkhor substation in the eastern grid are considered in the report.

Table: 6.0.1 Voltage profile at Malbase substation

Sl. No	Months	400kV Bus Voltage Operation State (%)				220kV Bus Voltage Operation State (%)			
		Normal	Alert	Emergency	Blackout/ Other	Normal	Alert	Emergency	Blackout/ Other
1	Jan	97.31	0.40	0.94	1.34	99.87	0.00	0.13	0.00
2	Feb	90.05	0.27	0.00	9.68	90.32	0.00	0.00	9.68
3	Mar	99.73	0.00	0.13	3.36	99.73	0.00	0.13	0.13
4	Apr	96.64	0.00	0.00	3.63	96.51	0.13	0.00	3.36
5	May	99.06	0.00	0.00	0.94	99.19	0.54	0.00	0.27
6	Jun	96.64	0.00	0.00	3.36	96.64	0.00	0.00	3.36
7	Jul	99.73	0.00	0.00	0.27	98.92	0.81	0.00	0.27
8	Aug	99.46	0.00	0.27	0.27	99.73	0.00	0.00	0.27
9	Sep	96.64	0.00	0.00	3.36	96.64	0.00	0.00	3.36
10	Oct	99.60	0.13	0.00	0.27	98.92	0.81	0.00	0.27
11	Nov	95.30	0.00	0.13	4.57	96.37	0.40	0.00	3.23
12	Dec	99.46	0.13	0.00	0.00	97.31	0.00	2.02	0.67
Operation State for year		97.47%	0.08%	0.12%	2.59%	97.51%	0.22%	0.19%	2.07%

Graph: 6.0.1 Voltage profile at Malbase substation at 400kV bus



Graph: 6.0.2Voltage profile at Malbase substation at 220kV bus

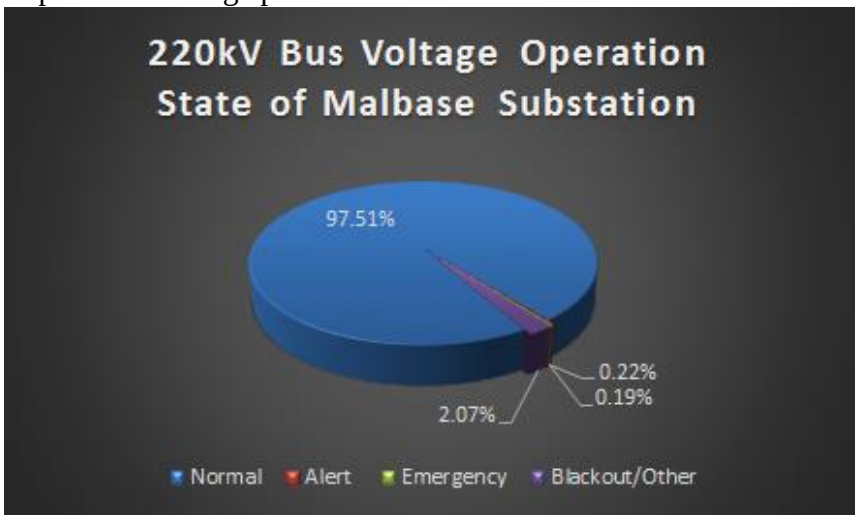


Table: 6.0.2 Voltage profile at Nangkhor substation

Sl. No	Months	132kV Bus Voltage Operation State (%)			
		Normal	Alert	Emergency	Blackout/ Other
1	Jan	100.00	0.00	0.00	0.00
2	Feb	90.32	0.00	0.00	9.68
3	Mar	99.73	0.00	0.00	0.27
4	Apr	96.51	0.00	0.00	3.49
5	May	96.24	0.00	0.00	3.76
6	Jun	96.64	0.13	0.00	3.23
7	Jul	96.77	0.00	0.00	3.23
8	Aug	96.77	0.00	0.00	3.23
9	Sep	96.64	0.00	0.00	3.36
10	Oct	100.00	0.00	0.00	0.00
11	Nov	96.77	0.00	0.00	3.23
12	Dec	96.77	0.00	0.00	3.23
Operation State for year		96.93%	0.01%	0.00%	3.06%

Graph: 6.0.3 Voltage profile at Nangkhor substation