

Ministry of Energy and Natural Resource

Bhutan Power System Operator

Thimphu: Bhutan



ANNUAL TRANSMISSION SYSTEM PERFORMANCE REPORT FOR THE YEAR 2024

JANUARY 2025



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1.0 INTRODUCTION

In compliance to Grid Code Regulation 2024, Clause No. 155, 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 2024.

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

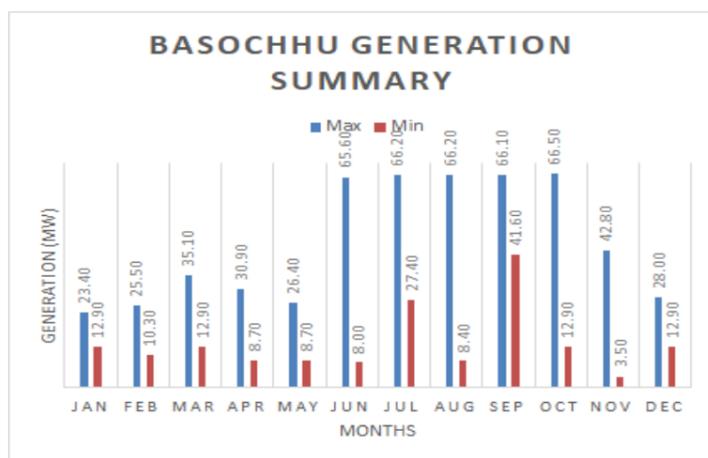
2.1 POWER GENERATION

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.

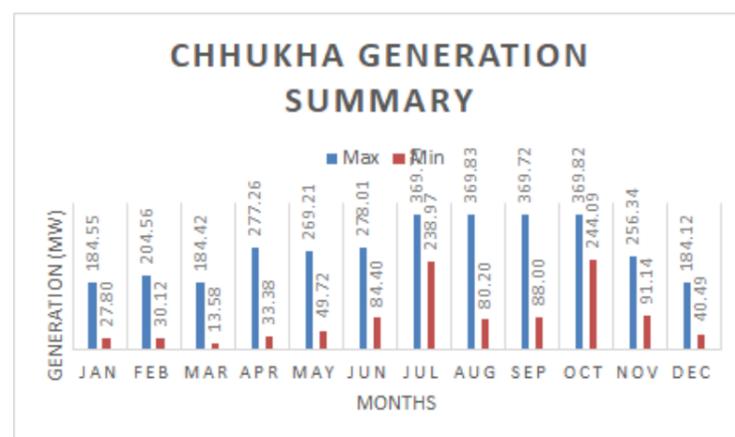
Table: 2.1.1 Monthly maximum and minimum generation summary

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		
1.00	BHP	Max	23.40	25.50	35.10	30.90	26.40	65.60	66.20	66.20	66.10	66.50	42.80	28.00	66.50
		Min	12.90	10.30	12.90	8.70	8.70	8.00	27.40	8.40	41.60	12.90	3.50	12.90	3.50
2.00	CHP	Max	184.55	204.56	184.42	277.26	269.21	278.01	369.79	369.83	369.72	369.82	256.34	184.12	369.83
		Min	27.80	30.12	13.58	33.38	49.72	84.40	238.97	80.20	88.00	244.09	91.14	40.49	13.58
3.00	THP	Max	490.00	495.00	490.00	561.00	561.00	1,122.00	1,122.00	1,122.00	1,122.00	1,122.00	545.00	544.00	1,122.00
		Min	20.00	20.00	20.00	20.00	30.00	60.00	748.00	674.00	825.00	380.00	140.00	32.00	20.00
4.00	KHP	Max	32.25	32.24	48.80	66.00	66.00	66.00	66.00	66.00	66.00	66.00	50.83	36.48	66.00
		Min	10.97	11.00	11.01	24.98	22.93	31.21	22.81	49.50	33.00	33.00	26.29	11.77	10.97
5.00	DHP	Max	45.23	25.00	103.30	67.01	77.36	126.97	127.41	127.65	127.02	127.24	60.03	60.53	127.65
		Min	18.96	16.26	14.76	8.00	12.78	14.14	60.31	42.87	59.39	59.99	7.69	19.95	7.69
6.00	MHP	Max	284.84	44.31	361.18	571.14	767.05	791.81	792.05	791.45	789.96	789.64	402.13	548.04	792.05
		Min	13.83	13.81	20.19	30.30	100.32	130.10	365.13	175.00	175.00	175.00	111.43	31.47	13.81
7.00	NHP	Max	25.00	90.11	70.51	70.51	90.11	128.97	128.46	158.04	129.88	127.14	70.15	45.06	158.04
		Min	16.00	14.92	16.97	16.97	14.92	27.93	63.98	64.01	64.00	59.99	28.00	15.00	14.92
8.00	PHP-II	Max											173.92	173.92	
		Min											18.78	18.78	

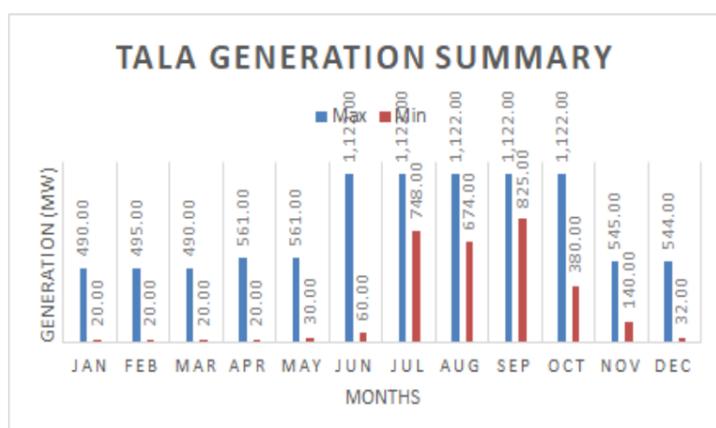
Graph: 2.1.1 Basochhu Generation Summary



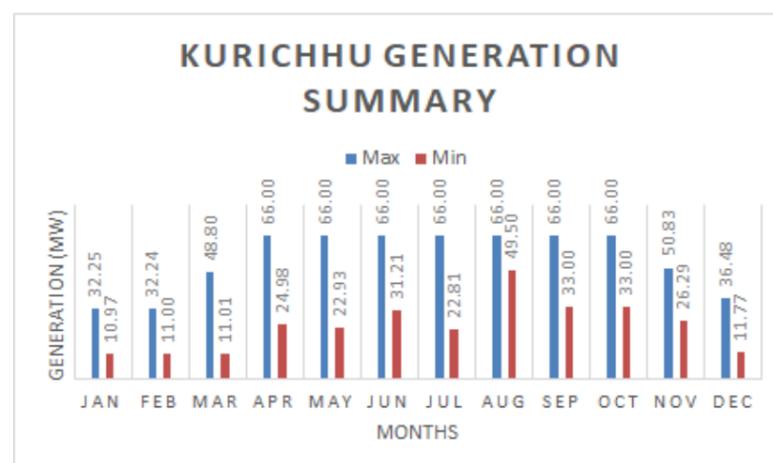
Graph: 2.1.2 Chukha Generation Summary



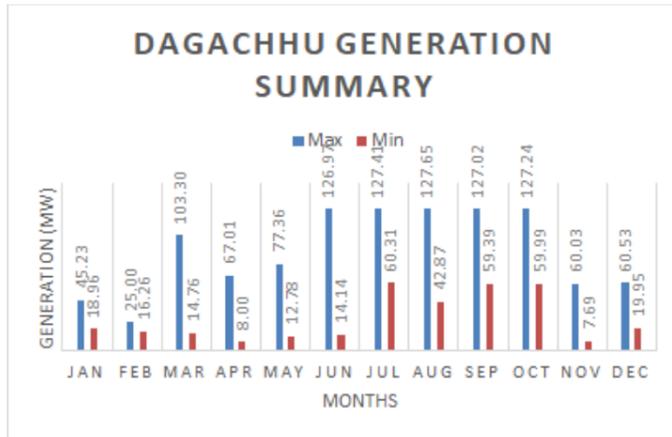
Graph: 2.1.3 Tala Generation Summary



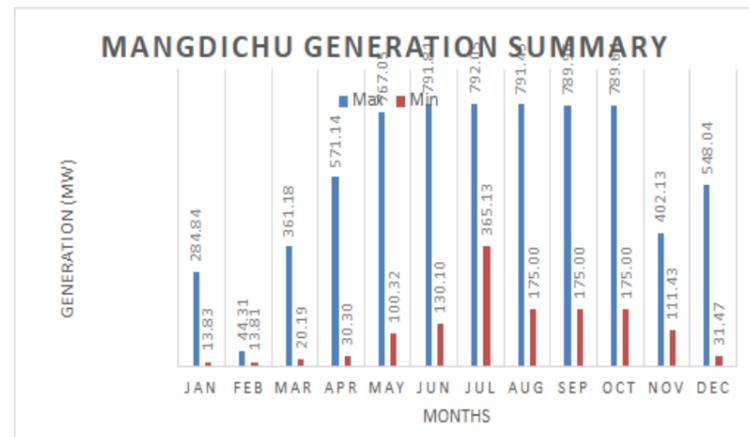
Graph: 2.1.4 Kurichhu Generation Summary



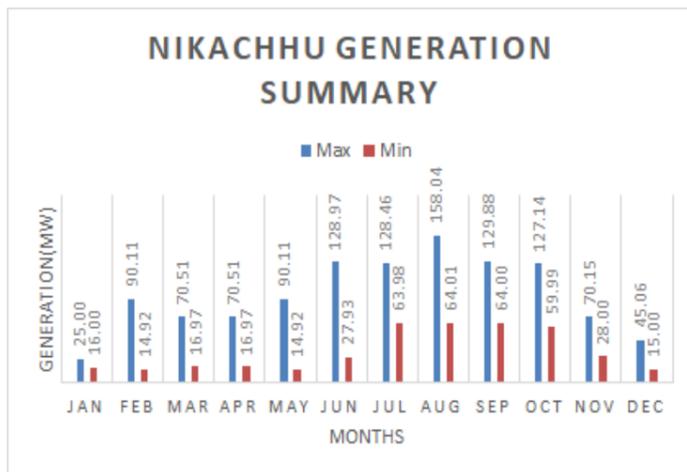
Graph: 2.1.5 Dagachhu generation summary



Graph: 2.1.6 Mangdichu generation summary



Graph: 2.1.7 Nikachhu generation summary



2.2 PLANT FACTOR

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

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

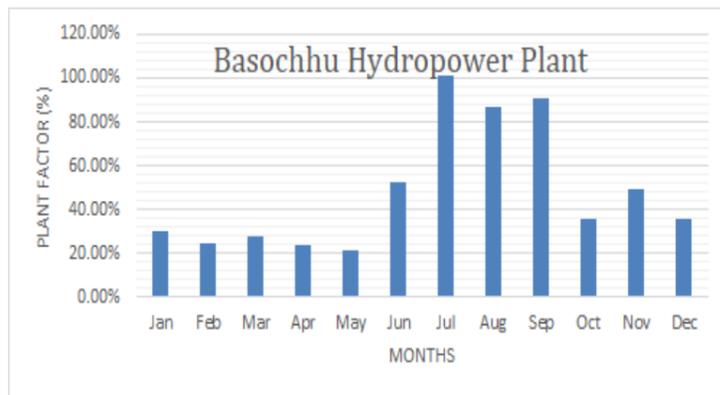
$$= (\text{Total energy plant has produced over a period}) / (\text{Total energy plant would produce when operated at full rated capacity})$$

Table: 2.2.1 Monthly plant factor of the hydropower plants

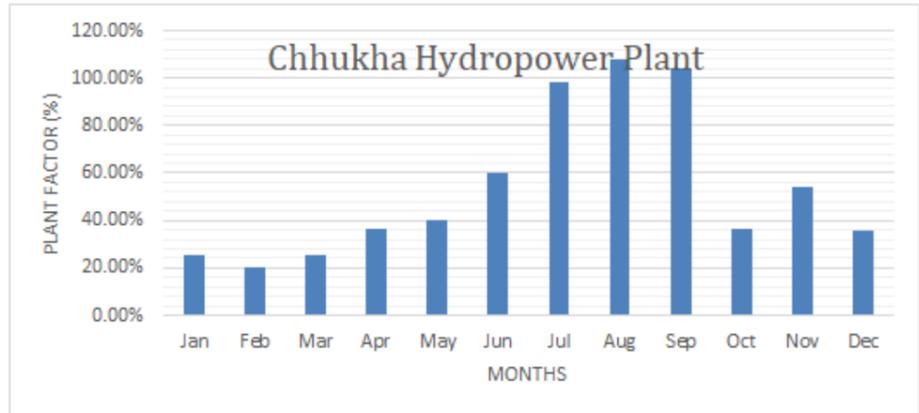
Sl. No	Hydropower Plant	Monthly Plant Factor (%)												Max/Min of year (%)	
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Max	Min
1.00	BHP	30.46%	24.55%	27.98%	23.80%	21.42%	52.18%	101.00%	87.00%	91.00%	36.00%	49.00%	36.00%	101.00%	21.42%
2.00	CHP	25.16%	20.53%	25.70%	36.10%	40.22%	59.87%	98.00%	108.00%	104.00%	36.60%	54.00%	36.00%	108.00%	20.53%
3.00	THP	17.61%	12.86%	16.56%	24.53%	25.77%	52.71%	106.00%	107.00%	100.00%	24.50%	37.00%	24.00%	107.00%	12.86%
4.00	KHP	30.67%	27.21%	41.04%	72.11%	84.39%	102.61%	106.00%	110.00%	103.00%	41.50%	59.00%	41.00%	110.00%	27.21%
5.00	DHP	18.11%	13.26%	14.60%	13.45%	13.11%	34.20%	84.00%	81.00%	70.00%	23.00%	34.00%	23.00%	84.00%	13.11%
6.00	MHP	11.53%	3.59%	40.64%	34.93%	46.97%	76.96%	106.18%	100.33%	102.22%	82.13%	37.10%	28.60%	106.18%	3.59%
7.00	NHP	2.71%	28.22%	14.84%	21.06%	28.22%	59.26%	106.89%	102.38%	100.34%	81.87%	39.36%	22.80%	106.89%	2.71%
8.00	PHP-II												0.00%		



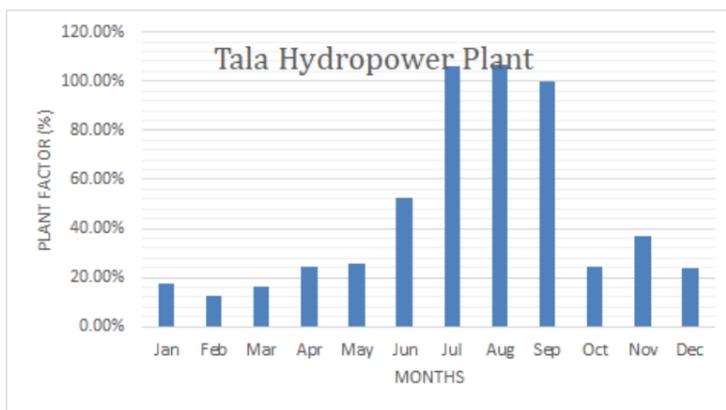
Graph: 2.2.1 Plant factor of Basochhu Hydropower Plant



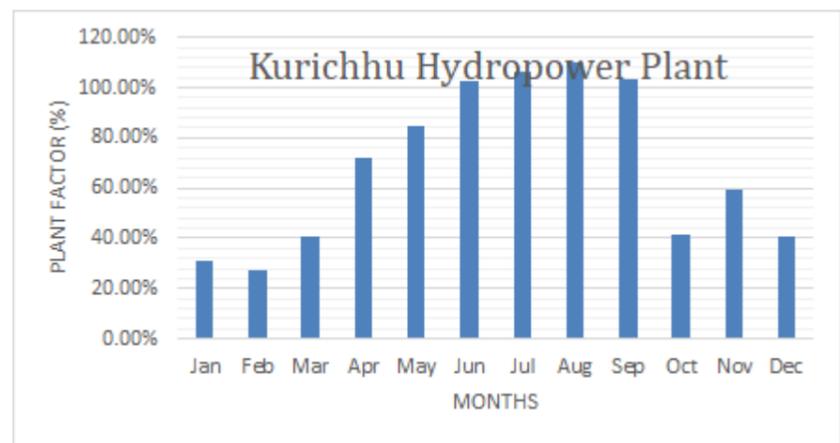
Graph: 2.2.2 Plant factor of Chhukha Hydropower Plant



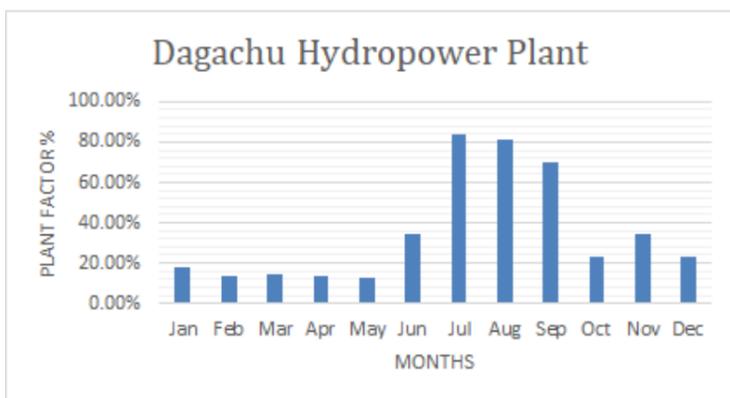
Graph: 2.2.3 Plant factor of Tala Hydropower Plant



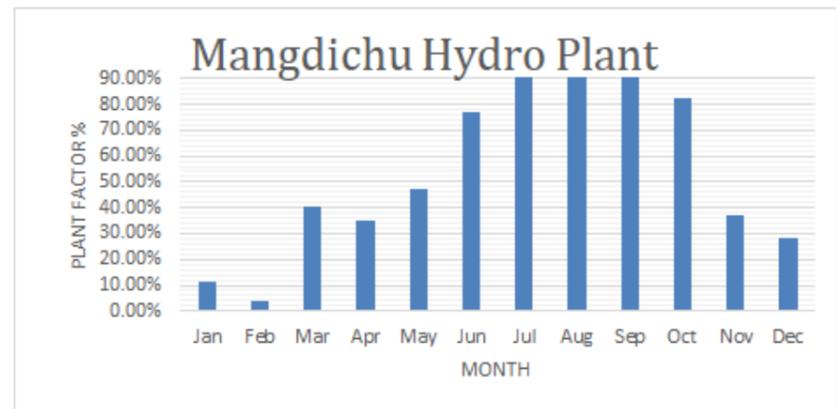
Graph: 2.2.4 Plant factor of Kurichhu Hydropower Plant



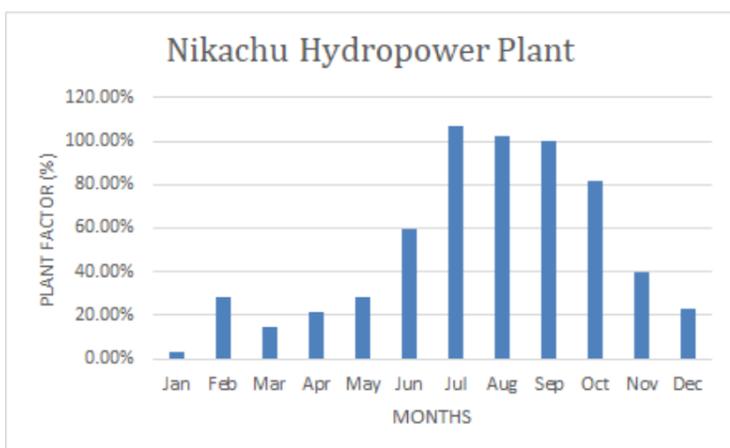
Graph: 2.2.4 Plant factor of Dagachhu Hydropower Plant



Graph: 2.2.4 Plant factor of Mangdichu Hydropower Plant



Graph: 2.2.5 Plant factor of Nikachhu 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

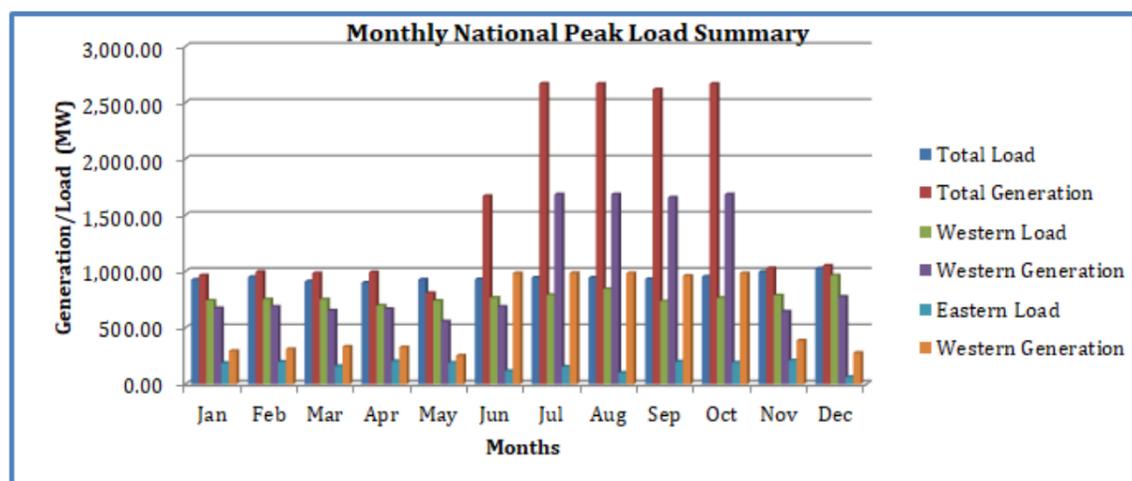
The national coincidental peak load for the year was recorded 1026.44 MW (Increased by 7.42 % compare to 2023 (955.51 MW) on December 25, 2024 at 18:38:16 Hrs. using method-1 (sum of all total generation each plant minus sum of export/import). The main factor contributing towards the increase in Bhutan peak load in 2024 could be because of more production by the industries, new number of industries came up along with numerous new generating stations and substations came up in 2024.

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
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	1026.44
% 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	44.62	51.76	7.42

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	Generatio n	Load	Generatio n	Load	Generatio n
1	Jan	19-Jan-24	12:00	926.71	963.62	741.21	671.72	185.50	291.90
2	Feb	14-Feb-24	17:00	949.30	995.50	752.15	685.50	197.15	310.00
3	Mar	25-Mar-24	19:00	910.57	983.44	751.72	651.44	158.85	332.00
4	Apr	20-Apr-24	21:00	900.07	991.43	696.73	665.93	203.34	325.50
5	May	9-May-24	9:00	927.00	806.78	738.73	555.06	188.27	251.72
6	Jun	26-Jun-24	19:00	928.69	1,668.56	765.76	685.82	115.20	982.74
7	Jul	28-Jul-24	20:00	943.93	2,667.74	790.42	1,683.17	153.51	984.57
8	Aug	6-Aug-24	3:00	943.74	2,666.38	843.84	1,683.23	99.30	983.15
9	Sep	2-Sep-24	19:00	931.76	2,616.09	733.51	1,655.80	198.25	960.29
10	Oct	2-Oct-24	18:00	953.82	2,665.90	763.82	1,683.46	190.00	982.44
11	Nov	28-Nov-24	18:00	995.44	1,028.27	786.66	642.55	208.78	385.72
12	Dec	25-Dec-24	18:38	1,026.44	1,051.05	965.25	775.31	61.19	275.74
National Peak Load of the year (MW)				1,026.44					

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





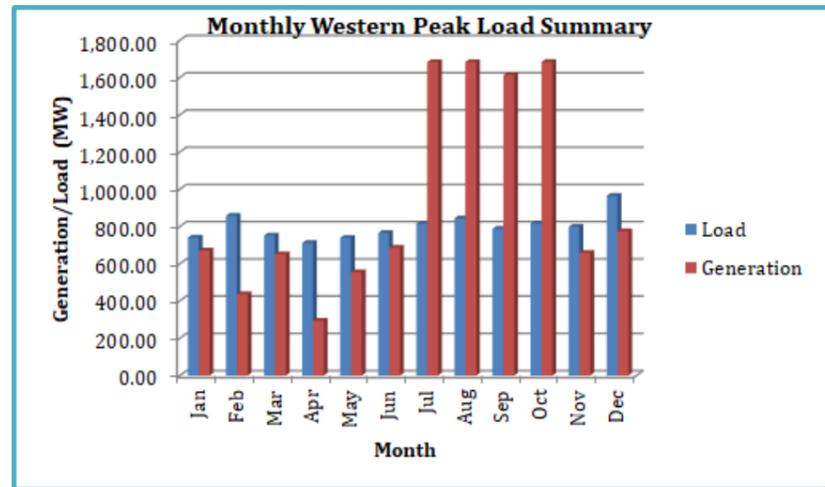
3.2 WESTERN GRID PEAK LOAD

Using method-1, the peak load for the western grid was **965.25 MW** which occurred on December 25, 2024.

Table: 3.2.1 Monthly western peak load and corresponding generation

Sl. No	Months	Date	Time	Western Grid (MW)	
				Load	Generation
1	Jan	19-Jan-24	12:00	741.21	671.72
2	Feb	23-May-24	7:00	857.99	436.29
3	Mar	25-Mar-24	19:00	751.72	651.44
4	Apr	28-Apr-24	13:00	711.54	293.99
5	May	9-May-24	9:00	738.73	555.06
6	Jun	26-Jun-24	19:00	765.76	685.82
7	Jul	12-Jul-24	19:00	815.16	1,683.08
8	Aug	6-Aug-24	3:00	843.84	1,683.23
9	Sep	4-Sep-24	16:00	788.47	1,614.22
10	Oct	9-Oct-24	16:00	816.59	1,683.70
11	Nov	18-Nov-24	18:00	798.60	658.44
12	Dec	25-Dec-24	18:38	965.25	775.31
Western Peak Load of the year (MW)				965.25	

Graph: 3.2.1 Monthly western peak load and corresponding generation



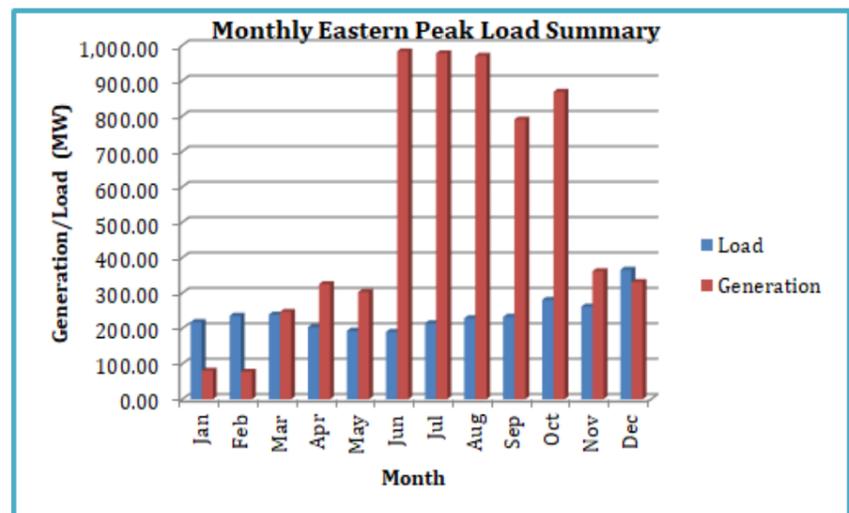
3.3 EASTERN GRID PEAK LOAD

Using method-1, the peak load for the eastern grid was **365.95 MW** which occurred on December 14, 2024.

Table: 3.3.1 Monthly eastern peak load and corresponding generation

Sl. No	Months	Date	Time	Eastern Grid (MW)	
				Load	Generation
1	Jan	7-Jan-24	6:00	218.36	80.7
2	Feb	6-Feb-24	19:00	236.00	77.7
3	Mar	17-Mar-24	18:00	238.98	246.6
4	Apr	20-Apr-24	21:00	203.34	325.5
5	May	13-May-24	11:00	193.53	302.7
6	Jun	29-Jun-24	7:00	190.13	983.4
7	Jul	1-Jul-24	20:00	214.32	978.0
8	Aug	1-Aug-24	14:00	228.60	970.6
9	Sep	22-Sep-24	17:00	233.18	790.2
10	Oct	18-Oct-24	14:00	280.91	868.8
11	Nov	30-Nov-24	20:00	261.83	361.7
12	Dec	14-Dec-24	6:00	365.95	331.1
Eastern Peak Load of the year (MW)				365.95	

Graph: 3.3.1 Monthly eastern peak load and corresponding generation



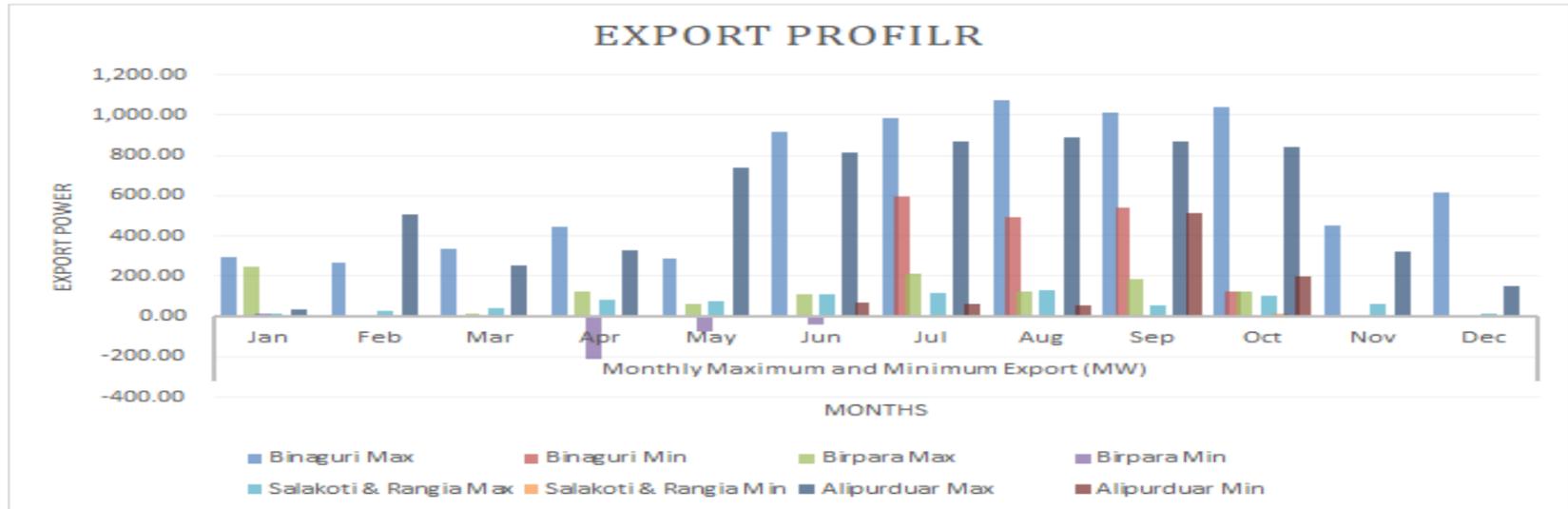
4.0 EXPORT AND IMPORT OF ELECTRICITY TO/FROM NEIGHBORING COUNTRIES

4.1 EXPORT OF ELECTRICITY TO NEIGHBORING COUNTRY

Maximum export of electricity for the year was 1,077.66 MW to Binaguri substation in August, 2024, followed by 891.02 MW to Alipurduar substation. The minimum export was 0.01 MW to Salakoti & Rangia 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		
1.00	Binaguri	Max	297.27	265.46	338.00	442.36	285.09	919.00	988.72	1,077.66	1,013.98	1,040.12	451.49	619.82	1,077.66
		Min	1.73	0.82	3.18	0.18	0.27	0.15	598.32	496.58	538.72	121.32	0.47	5.91	0.15
2.00	Birpara	Max	245.71	0.00	14.71	125.31	62.51	108.55	211.09	125.21	189.03	124.94	0.00	0.00	245.71
		Min	14.32	0.00	8.92	-213.00	-73.07	-43.15	0.09	1.60	1.50	0.44	0.00	0.00	-213.00
3.00	Salakoti & Rangia	Max	15.02	32.03	41.23	84.23	73.33	109.25	119.64	130.38	57.67	103.82	60.00	14.76	130.38
		Min	0.16	0.05	0.02	0.40	0.04	1.82	5.71	2.77	6.90	14.00	0.02	0.01	0.01
4.00	Alipurduar	Max	33.10	507.99	251.41	328.56	739.42	815.56	869.27	891.02	872.09	844.49	323.06	148.65	891.02
		Min	0.14	1.42	0.11	0.40	0.28	71.42	63.88	56.41	510.87	201.77	1.94	1.14	0.11

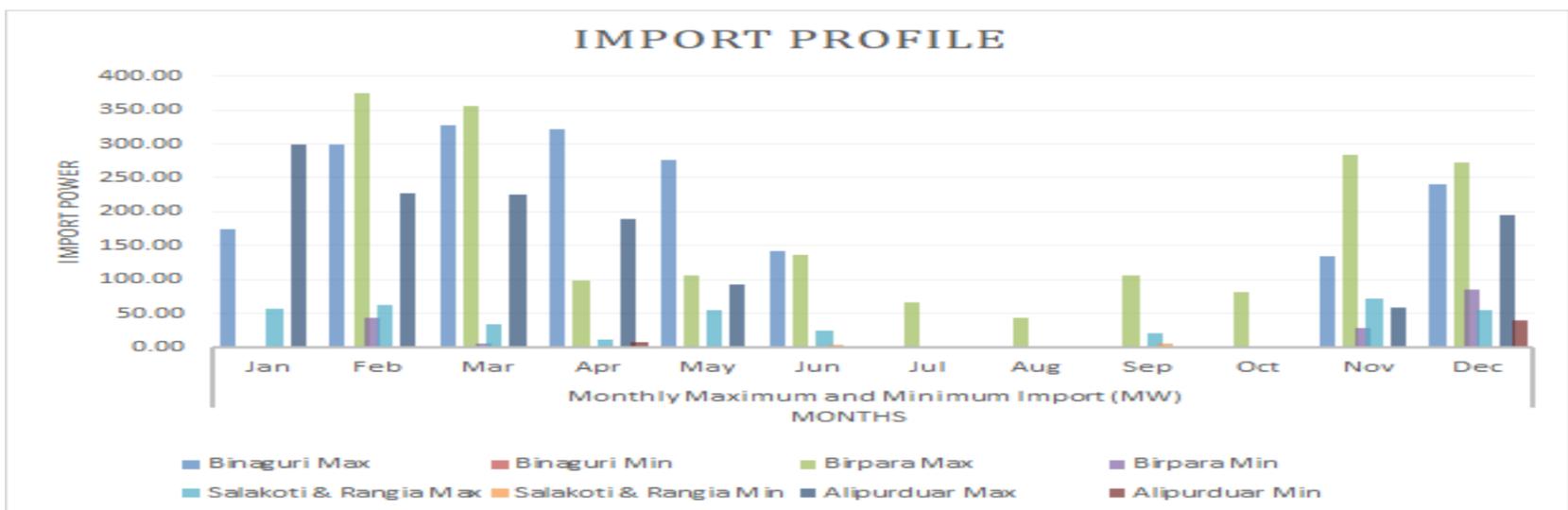


4.2 IMPORT OF ELECTRICITY FROM NEIGHBORING COUNTRY

Maximum import of power was 374.18 MW from Birpara substation which occurred in February, 2024 followed by 328.18 MW and 298.49 MW from Birpara and Salakoti & Rangia 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		
1.00	Binaguri	Max	174.18	300.00	328.18	322.18	277.00	142.63	0.00	0.00	0.00	0.00	133.92	241.02	328.18
		Min	0.55	3.00	1.82	0.64	0.45	0.29	0.00	0.00	0.00	0.00	1.57	2.41	0.00
2.00	Birpara	Max	0.00	374.18	355.71	97.88	106.57	136.21	65.97	44.00	106.41	82.37	284.08	273.60	374.18
		Min	0.00	43.28	5.73	1.76	0.03	0.11	0.07	0.16	1.50	0.27	27.80	85.70	0.00
3.00	Salakoti & Rangia	Max	57.75	62.86	34.57	10.77	56.02	25.08	0.00	0.00	21.50	0.00	71.27	55.12	71.27
		Min	0.04	0.09	0.07	0.01	0.09	4.79	0.00	0.00	5.90	0.00	0.02	0.09	0.00
4.00	Alipurduar	Max	298.49	227.46	225.83	189.97	93.88	0.00	0.00	0.00	0.00	0.00	58.60	194.46	298.49
		Min	0.00	0.00	0.00	8.34	0.39	0.00	0.00	0.00	0.00	0.00	2.28	40.96	0



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

As per the Grid Code Regulation 2024, Clause 155, 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 are below 49.0Hz.



Table: 5.0.1 Frequency profile of Bhutan

Sl. No	Months	Frequency profile of Bhutan			
		Normal	Alert	Emergency	Blackout/Other
1	Jan	100.00	0.00	0.00	0.00
2	Feb	93.55	0.00	0.00	6.45
3	Mar	100.00	0.00	0.00	0.00
4	Apr	96.77	0.00	0.00	3.23
5	May	96.77	0.00	0.00	3.23
6	Jun	96.77	0.00	0.00	3.23
7	Jul	99.73	0.00	0.00	0.27
8	Aug	99.73	0.00	0.00	0.27
9	Sep	96.77	0.00	0.00	3.23
10	Oct	100.00	0.00	0.00	0.00
11	Nov	96.64	0.00	0.13	3.23
12	Dec	100.00	0.00	0.00	0.00
Operation State for the year		98.06%	0.00%	0.01%	1.93%

6.0 VOLTAGE PROFILE OF SELECTED SUBSTATIONS

As the Grid Code Regulation 2024, Clause 155, 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 is 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

400kV Bus Voltage Operation State (%)				220kV Bus Voltage Operation State (%)				66kV Bus Voltage Operation State (%)			
Normal	Alert	Emergency	Blackout/Other	Normal	Alert	Emergency	Blackout/Other	Normal	Alert	Emergency	Blackout/Other
100.00	0.00	0.00	0.00	99.87	0.00	0.13	0.00	99.60	0.27	0.13	0.00
93.41	0.13	0.00	6.45	93.55	0.00	0.00	6.45	92.07	1.34	0.13	6.45
96.77	0.00	0.00	3.23	96.77	0.00	0.00	3.23	92.88	3.90	0.00	3.23
96.77	0.00	0.00	3.23	96.77	0.00	0.00	3.23	92.88	3.90	0.00	3.23
100.00	0.00	0.00	0.00	99.60	0.40	0.00	0.00	96.51	3.36	0.13	0.00
96.64	0.00	0.13	3.23	96.77	0.00	0.00	3.23	96.37	0.40	0.00	3.23
99.60	0.40	0.00	0.00	100.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
99.87	0.00	0.13	0.00	100.00	0.00	0.00	0.00	99.87	0.13	0.00	0.00
96.77	0.00	0.00	3.23	96.77	0.00	0.00	3.23	96.77	0.00	0.00	3.23
100.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
96.37	0.00	0.40	3.23	96.77	0.00	0.00	3.23	96.24	0.54	0.00	3.23
100.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
98.02%	0.04%	0.06%	1.88%	98.07%	0.03%	0.01%	1.88%	96.93%	1.15%	0.03%	1.88%



Table: 6.0.2 Voltage profile at Nangkhor substation

132kV Bus Voltage Operation State (%)			
Normal	Alert	Emergency	Blackout/Other
100.00	0.00	0.00	0.00
93.41	0.13	0.00	6.45
96.37	0.13	0.00	3.49
96.37	0.13	0.00	3.49
99.87	0.00	0.00	0.13
96.77	0.00	0.00	3.23
100.00	0.00	0.00	0.00
100.00	0.00	0.00	0.00
96.77	0.00	0.00	3.23
99.87	0.00	0.00	0.13
96.77	0.00	0.00	3.23
100.00	0.00	0.00	0.00
98.02%	0.03%	0.00%	1.95%