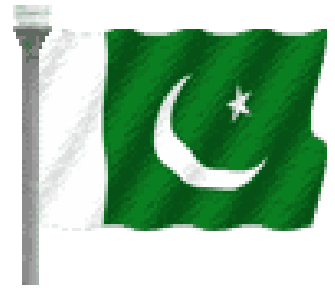


NATIONAL ELECTRIC POWER REGULATORY AUTHORITY
ISLAMIC REPUBLIC OF PAKISTAN



PERFORMANCE EVALUATION REPORT

OF

OPERATIONAL POWER PLANTS

For

FY 2022-23

Under

NEPRA PERFORMANCE STANDARDS (GENERATION) RULES, 2009

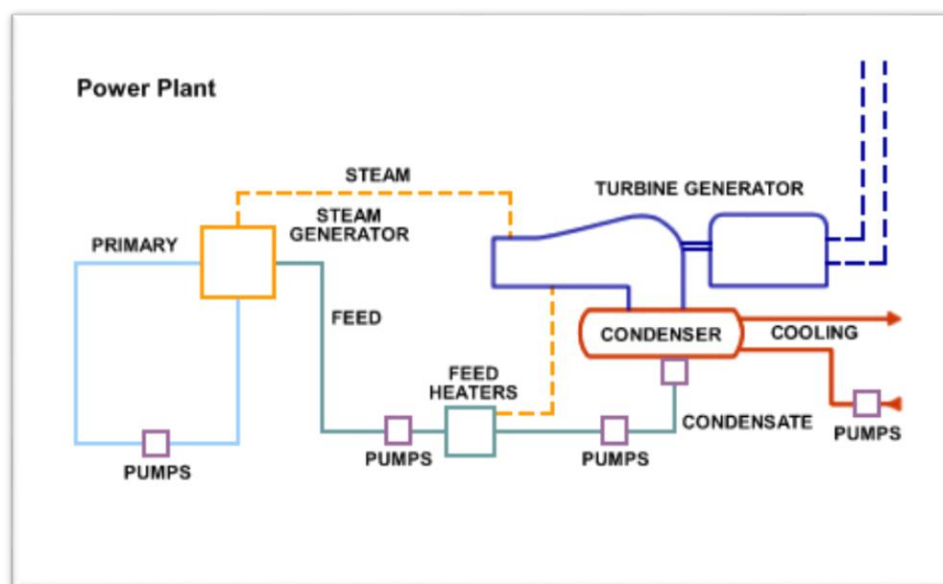


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EXECUTIVE SUMMARY

National Electric Power Regulatory Authority (NEPRA) regulates the power sector in Pakistan and protects the interests of consumers and companies providing electric power services. As such, apart from monitoring the performance of transmission and distribution licensees, NEPRA also monitors the performance of generation licensees.

NEPRA framed Performance Standards Generation Rules (PSGR) back in 2009. Under PSGR, each generation company is required to submit a quarterly report to NEPRA on regular basis, particularly with respect to parameters such as Installed Capacity, Reference Capacity, Net Generation, Service Hours, Standby Hours, Planned Outage Hours, Unplanned Outage Hours, Availability Factor, Net Capacity Factor and Net Output Factor.

Installed Capacity represents the unit's nameplate capacity, while Reference Capacity indicates the maximum generating capacity based on Initial Dependable Capacity (IDC) or Annual Initial Dependable Capacity (AIDC), minus any station service or auxiliary power requirements. Net Generation is the actual gross generation of the unit, excluding generation used for station service or auxiliary loads. Service Hours denote the duration the unit was synchronized to the system. Standby Hours encompass all hours the unit was available to the system but not synchronized for economic reasons. Planned Outage Hours include the total hours the unit was offline due to pre-planned or scheduled outages, such as annual overhauls. Unplanned Outage Hours encompass the total hours the unit was offline due to sudden, delayed, postponed, or startup failure outages. The Availability Factor is calculated as the ratio of Available Hours to Period Hours. The Net Capacity Factor is determined by dividing Net Generation by the product of Net Capacity and Period Hours. The Net Output Factor is calculated as the ratio of Net Generation to the product of Net Capacity and Service Hours.

In compliance with the above-mentioned reporting requirement, different operational power plants submitted the quarterly reports for different quarters of the FY 2022-23. Therefore, they were directed to submit a summary of their plant performance for the FY 2022-23. In response, a total number of 135 power plants have submitted the desired information. The same has been reviewed and a comprehensive Performance Evaluation Report has been prepared. The report mainly highlights the following key findings:

1. In the fiscal year 2022-23, the data reveals the distribution of Thermal, Hydel, Renewable, and Nuclear shares in the system's metrics. The Installed Capacity totaled 42,931.835 MW, with Thermal sources at 63% (27,047.56 MW), Hydel at 23% (9,986.56 MW), Renewable at 5% (2,277.715 MW), and Nuclear at 9% (3,620 MW).
2. Similarly, the Reference Capacity for the same period, recorded at 39,092.078 MW, exhibited a distribution with Thermal at 63% (24,621.88 MW), Hydel at 23% (9,007.38 MW), Renewable at 6% (2,197.3 MW), and Nuclear at 8% (3,265.518 MW).
3. Likewise, the Net Generation for the overall system during FY 2022-23, totaling 120,473,205 MWh, displayed Thermal at 58% (70,157,042 MWh), Hydel at 18% (21,218,654 MWh), Renewable at 4% (5,042,953 MWh), and Nuclear at 20% (24,054,556 MWh).

4. The share of renewable energy in the Net Generation of the NTDC system stood at 4.3%, while the corresponding figure for the KE system was only 2.4%. It is essential to note that the regulatory authority has consistently advised KE to establish renewable power plants within its service area to enhance its generation mix and reduce its overall cost. Despite KE submitting several Request for Proposals (RFPs) for NEPRA's approval in the recent past, the overall progress in incorporating renewable energy into its system has been unsatisfactory. KE continues to advocate for the inclusion of expensive plants like Tapal and Gul Ahmed in its system.
5. In FY 2022-23, the NTDC system experienced notable variations in the performance of power plants, particularly those dependent on imported fuels. Plants such as Liberty, Pakgen, Lalpir, Atlas, Nishat Power, Nishat Chunian, Saba, KAPCO, HUBCO, Hub Narowal, Attock Gen, Kohinoor, Rousch, Fauji Kabirwala, Halmore, TPS Jamshoro, TPS Muzaffargarh, Sahiwal Coal, and China Power Hub exhibited low service hours, ranging from 0.8% to 36.8%, spending considerable time on standby due to economic considerations. TPS Guddu and Guddu 747 faced low service hours attributed to unplanned outages, resulting in Availability Factors of 52% and 50.6%. Power plants, including Saba, HUBCO, Bhikki, and more, displayed low Net Output Factors (31.4% to 69.7%), indicating operation at part load as directed by the System Operator.
6. In the KE system, plants like BQPS-I, Tapal, and Gul Ahmed spent a significant portion of the year on standby due to economic factors, resulting in net capacity factors ranging from 30.4% to 47.9%. Some plants (KCCPP, KGTPS, SGTPS) exhibited lower net capacity factors (1.2% to 3%), indicating potential operational challenges. BQPS-II and Lotte Chemical demonstrated net capacity factors (60.8% to 70%). However, BQPS-III, SNPC-I and SNPC-II exhibited high availability and net capacity factors, reflecting reliability and consistent operation.
7. In FY 2022-23, several hydel power plants faced challenges, with Nandipur, Shadiwal, Chitral, Tarbela 4th Extension, Malakand-III, Pehur, Patrind, and Jagran-I experiencing low service hours of 40.3% to 56.6%. These plants operated predominantly in standby mode due to adverse hydrological conditions. Golen Gol hydel plant operated at only 33.8% service hours, mainly on standby due to the Glacial Lake Outburst Flood in 2020, resulting in diminished Net Capacity Factor (14.3%) and Net Output Factor (42.1%).
8. Jinnah and Neelum Jhelum plants had low service hours due to unplanned outages, resulting in reduced Availability Factors (56.8% and 1.3%) and Net Capacity Factors (39% and 0.001%). Gomal Zam operated at 28.5% service hours, primarily on planned outage for maintenance, leading to reduced Availability (34.5%) and Net Capacity Factor (27%). Ranolia plant remained entirely out of service.
9. Net Capacity Factors of Nandipur, Chitral, Tarbela 4th Extension, Malakand-III, and Pehur ranged from 0.4% to 34.8%, mainly due to standby periods or operating below full load. Ghazi Barotha recorded a minimal Net Capacity Factor of 0.1% due to unfavorable hydrological conditions.
10. Several hydel plants, including Ghazi Barotha, Renala, Nandipur, Rasul, Chitral, Kurram Garhi, Jinnah, Malakand-III, Daral Khwar, Tarbela 4th Extension, Reshun, Shishi, and Gulpur, had Net Output Factors below 70%, indicating operations below full load due to poor hydrology. Neelum Jhelum's Net Output Factor remained at 0.1%.
11. Wind-based power plants in the NTDC system exhibited strong availability factors between 83.2% and 100%. Their net capacity factors ranged from 14.2% to 38.6%, while the net output factor varied from 14.6% to 45%. Solar power plants in the system showed availability factors ranging from 49.3% to 98.7%, with net capacity factors between 18.3% and 31.8%, and net output factors from 25.7% to

39.3%. Bagasse-based power plants demonstrated availability factors ranging from 28.3% to 96%, with net capacity factors varying from 12.4% to 90.4%, and net output factors from 20.7% to 95.6%.

12. Solar-based power plants like Oursun and Gharo Solar in the KE system showcased near-perfect availability factors of 99.8% to 99.9%. Their net capacity factors ranged from 21% to 23.2%, with net output factors varying from 23.2% to 43.1%. The bagasse-based power plant in the KE system, i.e., International Industries Limited, displayed an availability factor of 82%, with a net capacity factor of 40%, and a net output factor of 86.2%.
13. Notably, K2 and K3, each with an installed capacity of 1145 MW, demonstrated impressive net generation figures of 7,562,274 MWh and 6,783,070 MWh, respectively, along with robust service hours of 8180 and 7394, indicating efficient operational presence. These plants exhibited high availability factors of 93.4% and 84.4%, and net capacity factors of 84.8% and 76.1%, highlighting their operational efficiency.
14. Similarly, C1, C2, C3, and C4, with installed capacities ranging from 325 MW to 340 MW, displayed consistent performance, with C3 leading in net generation at 2,500,365 MWh. These plants maintained high availability factors between 92.2% and 97.5%, emphasizing their reliability. Additionally, robust net capacity factors were observed, showcasing efficient utilization of installed capacities. The net output factors for all plants remained close to or above 90%, indicating effective power generation relative to their capacities. In summary, the data reflects commendable operational performance for the specified power plants during the reported period.

Apart from above, it is also relevant to mention here that the country experienced two power system collapses during the FY 2022-23; a partial power system collapse on 13.10.2022 and a total power system collapse on 23.01.2023. NEPRA took serious notice of both the incidents and constituted a high-powered Inquiry Committee (IC) to probe the above-mentioned matters. The IC conducted the said inquiries and inter alia observed that there was a huge delay in restoration of the NTDC system, particularly after the total power system collapse, mainly due to failed attempts of black start facilities at different power plants and owing to delay in synchronization of various power plants with the National Grid once the supply at their bus bars was restored by the System Operator. The details are mentioned in the inquiry reports which are already uploaded on the NEPRA website. Moreover, actions have been initiated against/necessary directions have been issued to all the relevant stakeholders in accordance with the recommendations of the IC.



NEPRA PERFORMANCE STANDARDS (GENERATION) RULES, 2009



1. NEPRA Performance Standards (Generation) Rules, 2009

In exercise of the powers conferred by and Clause (k) of Section 46 of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997 read with Clause (c) of sub-section (2) of Section 7 and Section 34 thereof, the National Electric Power Regulatory Authority (NEPRA), with the prior approval of the Federal Government, made the Performance Standards (Generation) Rules, 2009 to ensure that the electric generation facilities and power plants are efficiently operated to further ensure electrical service reliability and adequacy to the transmission and distribution service provider within prescribed parameters.

Quality of Supply - Rule 3 of the NEPRA PSGR, 2009 states that in order to maintain Performance Standards, the generation facilities are required to ensure that the voltage and frequency of electricity supplied to recipients shall be within normal operation limits contained in the applicable documents.

Data Requirement - Rule 4 of the NEPRA PSGR, 2009 states that as part of Generator Performance Data System, the licensee shall calculate the following key indicators and others as indicated in Forms I and II to these rules for its generating facilities and submit on regular basis, a report to the Authority under sub-rule (2) of Rule 5.

Reporting Requirement - Rule 5(2) of the NEPRA PSGR, 2009 states that reports required for the key indicators under rule 4 shall be submitted on quarterly basis and the first report thereof shall be due after the publication of these rules in the official Gazette.

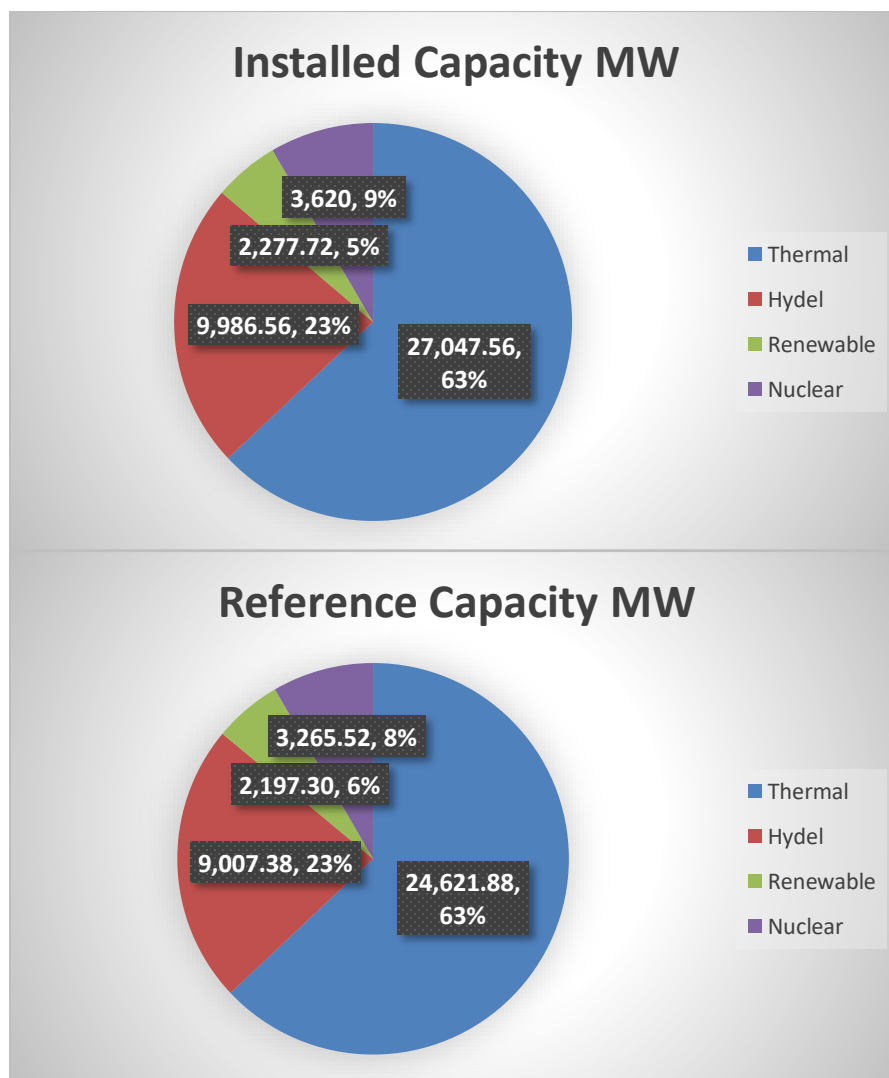
Compliance by Operational Power Plants: In compliance with the above-mentioned reporting requirement, different operational power plants submitted the quarterly reports for different quarters of the FY 2022-23. Therefore, they were directed to submit a summary of their plant performance for the FY 2022-23. In response, a total number of 135 power plants have submitted the desired information. The same has been reviewed and a comprehensive Performance Evaluation Report has been prepared.

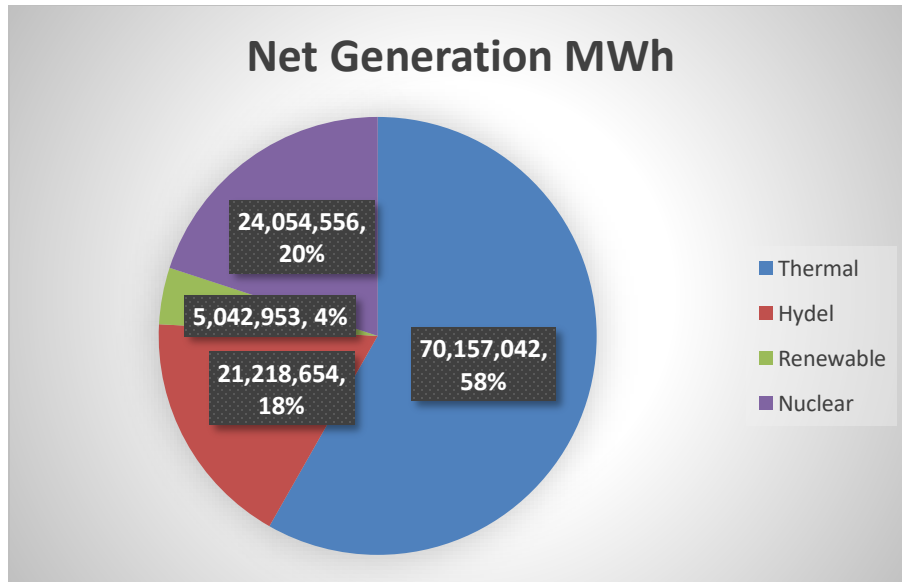
ANALYSIS

2.1 Overall

Parameter	Thermal	Hydel	Renewable	Nuclear	Total
Count	53	33	43	6	135
Installed Capacity (MW)	27,047.56	9,986.56	2,277.715	3,620	42,931.835
Reference Capacity (MW)	24,621.88	9,007.38	2,197.3	3,265.518	39,092.078
Net Generation (MWh)	70,157,042	21,218,654	5,042,953	24,054,556	120,473,205
Avg. Service Duration (Hours)	3898	4484	6677	8083	5785
Avg. Standby Duration (Hours)	3346	2500	811	0	1664
Avg. Planned Outage Duration (Hours)	502	851	464	513	582
Avg. Unplanned Outage Duration (Hours)	400	970	600	117	522
Avg. Availability Factor (%)	83.9	79.7	85.3	92.3	85.3
Avg. Net Capacity Factor (%)	36	26.9	25.6	84.1	43.2
Avg. Net Output Factor (%)	78.2	52.5	34.6	91.1	64.1

Graphical Illustration:





Inference:

The data presented in the table/graphs indicates that in the fiscal year 2022-23, the distribution of Thermal, Hydel, Renewable, and Nuclear shares in the overall Installed Capacity of the system, totaling 42,931.835 MW, was 63% (27,047.56 MW), 23% (9,986.56 MW), 5% (2,277.715 MW), and 9% (3,620 MW) respectively.

Similarly, within the overall Reference Capacity of the system, recorded at 39,092.078 MW during the same fiscal year, the distribution showed Thermal sources at 63% (24,621.88 MW), Hydel sources at 23% (9,007.38 MW), Renewable sources at 6% (2,197.3 MW), and Nuclear sources at 8% (3,265.518 MW).

Likewise, the distribution of Thermal, Hydel, Renewable, and Nuclear shares in the overall Net Generation of the system, totaling 120,473,205 MWh, during the FY 2022-23 was 58% (70,157,042 MWh), 18% (21,218,654 MWh), 4% (5,042,953 MWh), and 20% (24,054,556 MWh) respectively.



2.2 Technology-wise and Plant-wise

2.2.1 Thermal:

S #	Power Plant	Main Fuel	Instd. Cap (MW)	Ref. Cap (MW)	Net Gen (MWh)	Service Hours	Standby Hours	Planned Outage Hours	Unplanned Outage Hours	Availability Factor (%)	Net Capacity Factor (%)	Net Output Factor (%)
NTDC System												
1	Liberty Power Tech	RFO	200.26	196.139	556,146	2943	5603	92	121	98	32.3	96.3
2	PakGen	RFO	350	350	443,741	1712	6153	720	175	89.8	14.5	74
3	Lalpir	RFO	350	350	397,585	1444	5503	1416	398	79.3	13	78.7
4	Atlas Power	RFO	219.16	213.856	540,880	2706	4896	259	897.5	86.8	28.9	93.4
5	Nishat Power	RFO	202.18	195.305	552,923	2895	5343	356	166	94	32.3	97.8
6	Nishat Chunian	RFO	200	195.72	396,571	2156	5909	195	499.5	92.1	23.1	94
7	Saba Power	RFO	134	125.46	148,999	2062	5652	586	460	88	14	58
8	Hubco Narowal	RFO	219.16	213.82	469,880	2350	5692	117	600	92	25	93
9	Attock Gen	RFO	164.95	156.178	487,189	3221	5184	260	95	95.9	35.6	96.8
10	HUBCO	RFO	1292	1200	204,776	259	7829	651	20	92	2	66
11	Kohinoor Energy	RFO	131	124	339,645	2886	5715	53	106	98.2	31.3	94.9
12	Bhikki	RLNG	1180	1,119.849	4,697,549	6284	1743	720	13	91.6	48	67
13	Balloki	RLNG	1275.5	1,160.296	6,863,655	7229	1200	152	179	96.2	67.5	81.8
14	HBS	RLNG	1276.86	1,171.82	6,520,547	6520	268	462	1509.5	77.5	63.5	85.3
15	Sapphire Electric	RLNG	225	202.286	452,528	3931	4265	240	324	93.6	25.5	56.9
16	Rousch Power	RLNG	450	395	179,037	926	6516	1248	84	84.8	5.2	48.9
17	FKPCL	RLNG	157	151.5	66,327	589	7172	720	279.5	88.6	5	74.3
18	Orient Power	RLNG	223.8	202.860	604,789	4924	3207	528	101	92.8	34	61
19	Saif Power	RLNG	209.79	209.786	538,238	4538	3740	480	1	94.5	29.3	56.5



S #	Power Plant	Main Fuel	Instd. Cap (MW)	Ref. Cap (MW)	Net Gen (MWh)	Service Hours	Standby Hours	Planned Outage Hours	Unplanned Outage Hours	Availability Factor (%)	Net Capacity Factor (%)	Net Output Factor (%)
20	Halmore	RLNG	225	205.54	287,055	2597	5195	931	38	88.9	15.9	53.8
21	CCPP Nandipur	RLNG	565.65	506	1,276,531	4509	3825	420	6	95.1	29	56
22	Foundation Power	N.Gas	185	167.199	1,190,382	7983	0	705	70	91.1	81.2	89.1
23	TNB Liberty Power	N.Gas	235	220.98	1,001,186	5915	1161	1440	225	80.8	51.7	76.6
24	Uch Power	N.Gas	586	546.55	3,901,328	7759	317	495	189	92.2	81.5	92
25	Uch-II Power	N.Gas	404	360.2975	2,776,443	8304	282	0	174	98	88	98
26	Engro Powergen Qadirpur	N.Gas	226	223.8	935,958	8434	197	48	58	99	47.9	49.6
27	TPS Guddu	N.Gas	1015	910	1,968,383	2909	1646	0	2257	52	24.7	74.3
28	Guddu 747	N.Gas	747	721	2,635,920	4402	34	143	4324	50.6	41.7	83
29	TPS M/Garh	RFO/RLNG	1350	1086.65	50,558	68	5715	360	2617	66	0.5	68
30	TPS Jamshoro	RFO/RLNG	850	649.02	18,883	93	7947	720	0.0	91.8	0.3	31.4
31	KAPCO	RFO/RLNG	1600	1345	587,845	479	2403	13	56	97.7	14.8	91.2
32	Engro Thar	Coal	660	602.6	3,646,056	7121	183	1351	105	80.3	69	85
33	Port Qasim	Coal	1320	1242.95	3,203,002	3698	3913	1080	1	87	29.3	69.7
34	Sahiwal Coal	Coal	1320	1243.517	2,876,852	3198	4962	600	0	93.1	26.4	72.3
35	CPHGC	Coal	1320	1249	1,546,869	1823	6515	330	23	96	14	68
36	Lucky Electric	Coal	660	606.80	3,323,889	7262	590	520	387	89.6	62.5	75.4
37	Thal Nova	Coal	330	300.7	762,958	3157	11	0	48	99	79	80
38	Thar Energy	Coal	330	300.733	1,051,008	4032	1527	541	452	85	53	87
39	TCB-1	Coal	1320	1231	4,255,922	4149	0	0	548	88.3	73.6	83.3
Sub-Total			23,709.31	21,653.21	61,758,033	3781	3539	486	451	88.4	36.3	75.9

S #	Power Plant	Main Fuel	Instd. Cap (MW)	Ref. Cap (MW)	Net Gen (MWh)	Service Hours	Standby Hours	Planned Outage Hours	Unplanned Outage Hours	Availability Factor (%)	Net Capacity Factor (%)	Net Output Factor (%)
KE System												
1	BQPS-I	RFO/RLNG	840	693.08	1,851,704	3869	3928	700	261	89	30.4	69
2	BQPS-II	RLNG	572.67	494.53	2,634,477	6130	1909	652	67	91.7	60.8	86.9
3	BQPS-III	RLNG	942.32	900	1,438,578	1730	68	189	3	86.8	80.2	92.3
4	KCCPP	RLNG/HSD	247.50	210.77	49,742	307	8268	156	27	97.8	2.6	76.8
5	KGTPS	RLNG	107.31	92.05	10,181	134	8487	119	18	98.4	1.2	82.5
6	SGTPS	RLNG	107.31	92.72	24,409	306	8317	107	28	98.4	3	86
7	Lotte Chemical	RLNG	48	41	250,717	7548.3	360	338.4	513.26	90	70	81
8	Tapal	RFO	126	123.5	518,438	4683	3445	436	194.5	92.8	47.9	89.6
9	Gul Ahmed	RFO	136.17	127.5	521,439	4117	3622	830	189	88.4	46.6	99.3
10	FPCL	Coal	58	52	346,166	7300	0	504	955	83.3	76	91.2
11	SNPC-I	Gas	52.1	51.15	300,299	6416	82	67	341	94	85	91.5
12	SNPC-II	Gas	52.1	51.53	293,983	6134	82	151	357	92	84.85	93.01
13	International Steels Limited	Gas	19.04	18.34	68,730	3842	752	3392	640	52.4	43	97.5
14	Lucky Cement	Gas	29.73	20.5	90,146	6600	0	0	0	100	67	67
Sub-Total			3,338.25	2,968.67	8,399,009	4223	2809	546	257	89.6	49.9	86.0
Grand Total (NTDC+KE)			27,047.56	24,621.88	70,157,042	3898	3346	502	400	83.9	36	78.2

Inference:

- i. **NTDC System:** Above table clearly indicates that several power plants, predominantly those relying on imported fuels such as RFO, RLNG, and Imported Coal, experienced significantly low service hours during FY 2022-23. Plants including Liberty, Pakgen, Lalpir, Atlas, Nishat Power, Nishat Chunian, Saba, KAPCO, HUBCO, Hub Narowal, Attock Gen, Kohinoor, Rousch, Fauji Kabirwala, Halmore, TPS Jamshoro, TPS Muzaffargarh, Sahiwal Coal, and China Power Hub exhibited service hour percentages ranging from 0.8% to 36.8%. These plants spent a considerable portion of the

year on standby mode due to System Operator instructions on account of being expensive/low ranked in the Economic Merit Order, resulting in Net Capacity Factors ranging from 0.3% to 36.5%.

Similarly, TPS Guddu and Guddu 747 experienced low service hours of 33.2% and 50.3%, primarily due to unplanned outages accounting for 25.8% and 49.4% of the time, respectively, attributed to technical faults. Consequently, these plants had Availability Factors of 52% and 50.6%. In this regard, it is pertinent to highlight that each power plant is allowed certain number of unplanned outage hours in an agreement year in its Power Purchase Agreement. In case any power plant exceeds the unplanned outage allowance as specified in its Power Purchase Agreement, Liquidated Damages are usually imposed by the Power Purchaser in accordance with the relevant provisions of the Power Purchase Agreement.

Furthermore, several power plants, including Saba, HUBCO, Bhikki, Sapphire, Rousch, Orient, Saif, Halmore, TPS Jamshoro, TPS Muzaffargarh, Nandipur, Engro Powergen Qadirpur, Port Qasim, and China Power Hub, exhibited low Net Output Factors during FY 2022-23, suggesting operation at part load as directed by the System Operator. The Net Output Factors ranged from 31.4% to 69.7%.

- ii. **KE System:** Plants like BQPS-I, Tapal and Gul Ahmed exhibited service hour percentages ranging from 44.2% to 53.4%. These plants spent a considerable portion of the year on standby mode on account of being expensive/low ranked in the Economic Merit Order, resulting in net capacity factors ranging from 30.4% to 47.9%. Similarly, KCCPP, KGTPS and SGTPS show lower net capacity factors ranging from 1.2% to 3%, indicating potential challenges in operational efficiency or performance of these plants. BQPS-II and Lotte Chemical exhibit net capacity factors ranging from 60.8% to 70%.

However, BQPS-III, SNPC-I and SNPC-II demonstrate high availability factors and net capacity factors, reflecting reliability and consistent operation.



2.2.2 Hydel:

S #	Power Plant	Instd. Cap (MW)	Ref. Cap (MW)	Net Gen (MWh)	Service Hours	Standby Hours	Planned Outage Hours	Unplanned Outage Hours	Availability Factor (%)	Net Capacity Factor (%)	Net Output Factor (%)
1	Tarbela	3478	2729	12,483,699	5484	2172	1102	1.42	89.3	52.2	83.4
2	Mangla	1070	996	3,889,784	4664	1905	404	35	75	44.6	83.7
3	Ghazi Barotha	1450	1450	6,812	5156	2795	801	8	90.8	0.1	0.1
4	Warsak	242.96	217.86	907,922	4608	2369	1783	0.1	79.6	47.6	90.4
5	Chashma	184	135.26	876,125	6684	263	481	1332	79.3	73.9	96.9
6	Renala	1.1	1.1	1,803	5280	3008	454	0.0	94.6	18.7	31.1
7	Chichoki	13.2	13.2	31,364	4105	3621	7725	588	88.2	27.1	57.9
8	Nandipur	13.8	13.79	36,666	4242	3758	413	346	91.3	30.3	62.7
9	Shadiwal	13.5	9.31	33,140	3952	4317	491	0.0	94.3	40.6	90.1
10	Rasul	22	16.5	54,118	4904	2003	1242	611	78.8	37.4	66.9
11	Dargai	20	17.5	71,667	5433	2128	1148	50	86.3	46.7	75.4
12	Chitral	1	0.91	2,436	4618	4062	35	0.0	99	30.6	58.0
13	Kurram Garhi	4	4	15,828	5765	2220	235	539	91.2	45.2	68.6
14	Gomal Zam	17.4	17.4	41,184	2501	561	4718	979	34.9	27	94.7
15	Jinnah Hydel	96	57.17	206,701	4374	598	536	3251	56.8	39	58.5
16	Allai Khwar	121	102.8	224,509	2068	109	7.5	0.0	24.8	24.9	105.6
17	Duber Khwar	130	130	497	4610	3169	721.5	259	88.8	43.6	82.9
18	Khan Khwar	72	72	272,826	4494	3462	803	0.4	90.8	43.3	84.3
19	Tarbela 4 th Extension	1410	1410	44,269	3671	4151	933	6	89.3	0.4	0.9
20	Golen Gol	108	108	134,829	2962	5167	630	2	92.8	14.3	42.1
21	Jabban	22	14.4	126,272	6572	1444	569	61	93.7	100.1	133.4
22	Malakand-III	81	81	246,934	4962	3633	49	109	98.1	34.8	61.4
23	Daral Khwar	36.6	36.6	127,294	5134	2483	286	857	86.9	39.7	67.7
24	Pehur	18	18	51,269	3531	4728	480	20	94.3	32.5	80.7
25	Ranolia	17	17	0	0	0	0	8760	0	0	0
26	Reshun	4.2	4.2	11,105	7069	889	75	727	90.8	30.2	37.4
27	Machai	2.6	1.6	7,113	5374	3386	40	3346	100	50.7	82.7
28	Shishi	1.8	1.8	2,622	5691	0	1090	1304	65	16.6	25.6

S #	Power Plant	Instd. Cap (MW)	Ref. Cap (MW)	Net Gen (MWh)	Service Hours	Standby Hours	Planned Outage Hours	Unplanned Outage Hours	Availability Factor (%)	Net Capacity Factor (%)	Net Output Factor (%)
29	Gulpur	102	100.98	304,687	5232	3155	369	5	95.7	34.4	57.7
30	Neelum Jhelum	969	969	108	115	0.0	0	8645	1.3	0.001	0.1
31	Patrind	150	147	548,604	4572	4008	173.5	6	97.9	42.6	81.6
32	Jagran-I	30.4	30	111,469	4441	4033	119	168	96.7	42.4	83.7
33	New Bong Escape	84	84	344,998	5688	2914	158	0.0	98.2	46.8	72.2
Total		9,986.56	9,007.38	21,218,654	4484	2500	851	970	79.7	26.9	52.5

Inference:

Throughout FY 2022-23, the hydel power plants, including Nandipur, Shadiwal, Chitral, Tarbela 4th Extension, Malakand-III, Pehur, Patrind, and Jagran-I, faced notably low service hours ranging from 40.3% to 56.6%. These plants predominantly operated in standby mode for extensive periods, varying from 41.5% to 54%, attributed to apparent adverse hydrological conditions. Golen Gol hydel power plant operated at only 33.8% service hours, remaining on standby for 59% of the time due to the Glacial Lake Outburst Flood (GLOF) in 2020. Consequently, this led to a diminished Net Capacity Factor of 14.3% and a lower Net Output Factor of 42.1%.

Jinnah hydel and Neelum Jhelum power plants experienced low service hours of 49.9% and 1.3%, respectively, as they encountered unplanned outages for 37.1% and 98.7% of the year due to technical faults. This resulted in reduced Availability Factors of 56.8% and 1.3%, as well as diminished Net Capacity Factors of 39% and 0.001%, respectively. Gomal Zam hydel power plant operated at 28.5% service hours, primarily on planned outage for 59.3% of the year due to scheduled maintenance. This led to a reduced Availability Factor of 34.5% and a lower Net Capacity Factor of 27%. In this regard, it is pertinent to highlight that each WAPDA hydel power plant is allowed certain number of total outage hours in an agreement year in the WAPDA's Power Purchase Agreement. In case any power plant exceeds the total outage allowance as specified in the WAPDA's Power Purchase Agreement, Liquidated Damages are usually imposed by the Power Purchaser in accordance with the relevant provisions of the Power Purchase Agreement.

Ranolia hydel power plant remained entirely out of service throughout FY 2022-23 due to a flood, resulting in 0% Availability Factor, 0% Net Capacity Factor, and 0% Net Output Factor.



The Net Capacity Factors of Nandipur, Chitral, Tarbela 4th Extension, Malakand-III, and Pehur hydel power plants remained notably low, ranging from 0.4% to 34.8%, attributed to extended standby periods or operating below full load due to apparent poor hydrology. Ghazi Barotha hydel power plant recorded a minimal Net Capacity Factor of 0.1% due to unfavorable hydrological conditions.

Similarly, the Net Output Factors for several hydel power plants, including Ghazi Barotha, Renala, Nandipur, Rasul, Chitral, Kurram Garhi, Jinnah hydel, Malakand-III, Daral Khwar, Tarbela 4th Extension, Reshun, Shishi, and Gulpur, were below 70%, indicating operations below full load due to apparent poor hydrology. Additionally, the Net Output Factor of Neelum Jhelum hydel power plant remained at 0.1% during FY 2022-23.

2.2.3 Renewable:

S #	Power Plant	Main Fuel	Instd. Cap (MW)	Ref. Cap (MW)	Net Gen (MWh)	Service Hours	Standby Hours	Planned Outage Hours	Unplanned Outage Hours	Availability Factor (%)	Net Capacity Factor (%)	Net Output Factor (%)
NTDC System												
1	Sapphire Wind	Wind	52.8	52.8	81,415	7425	934	29	373	95.4	17.6	20.8
2	Zephyr Power	Wind	50	50	110,748	7348	550	80	782	90.2	25.3	30.1
3	Hydro China Dawood	Wind	49.5	49.5	92,551	8004.2	0	31	725	91.4	21.3	23.4
4	Foundation Wind-I	Wind	50	50	70,877	8130	498	37	94	98.5	16.2	17.4
5	Foundation Wind-II	Wind	50	50	100,963	8007	571	33	149	97.9	23	25.2
6	Sachal Energy	Wind	49.5	43.09	95,699	8122	546	780	2257	98.9	25.3	27.3
7	Metro Wind	Wind	60	60	202,757	7512	1132	49	67	98.7	38.6	45
8	UEP Wind	Wind	99	96.36	177,145	6944	1700	8	108	98.7	21	26.5
9	Artistic Energy	Wind	49.3	49.3	127,070	8746	0	14	0	99.8	29.4	29.5
10	Jhimpir Power	Wind	49.735	49.735	115,781	7960	695	39	106	98.8	26.6	29.2
11	Hawa Energy	Wind	49.735	49.735	117,071	7984	695	31	88	99	26.9	29.5
12	Tricon Boston – A	Wind	49.735	49.735	125,442	7670	941	24	125	98.3	28.8	32.9
13	Tricon Boston – B	Wind	49.735	49.735	121,035	7669	956	35	99	98.5	27.8	31.7
14	Tricon Boston – C	Wind	49.735	49.735	121,419	7655	965	28	112	98.4	27.9	31.9
15	Tenega Generasi	Wind	49.5	49.5	76,233	7237	1378	59	83	98.3	17.6	21.3
16	FFC Energy	Wind	49.5	49.5	77,556	6261	2251	79	149	97.2	17.9	25.0



S #	Power Plant	Main Fuel	Instd. Cap (MW)	Ref. Cap (MW)	Net Gen (MWh)	Service Hours	Standby Hours	Planned Outage Hours	Unplanned Outage Hours	Availability Factor (%)	Net Capacity Factor (%)	Net Output Factor (%)
17	3 Gorges 1 st Wind Farm	Wind	49.5	49.5	97,133	8760	0	10	0	100	22.4	22.4
18	3 Gorges 2 nd Wind Farm	Wind	49.5	49.5	109,808	8760	0	10	0	100	25.3	25.3
19	3 Gorges 3 rd Wind Farm	Wind	49.5	49.5	113,575	8760	0	10	0	100	26.2	26.2
20	Yunus Energy	Wind	50	50	93,312	6540	2110	62	47	98.7	21.3	28.5
21	ACT Wind (Tapal)	Wind	30	30	55,487	6712	1946	35	66	98.8	21	28
22	Master Wind	Wind	52.8	52.8	89,934	7909	698	42	110	98.3	19.4	21.5
23	Gul Ahmed Wind	Wind	50	50	106,880	6465	2190	35	46	98.8	14.2	14.6
24	Lucky Renewables	Wind	50	50	145,126	7145	178	123	49	83.6	33.1	40.6
25	Master Green	Wind	50	50	123,728	6849	1606	86	218	96.5	28.2	36.1
26	Quaid-e-Azam Solar	Solar	100	100	160,465	4375	0	0	4384	49.9	18.3	36.7
27	Appolo Solar	Solar	100	100	165,833	4346	0	0.4	4413	49.6	18.9	38.1
28	Best Green Energy	Solar	100	100	166,167	4316	0	0	4444	49.3	19	38.5
29	Crest Energy	Solar	100	100	169,908	4318	0	0	4448	49.3	19.4	39.3
30	Zorlu Energy	Solar	56.4	56.4	95,690	6576	407	65	1454	79.7	19.3	25.7
31	Lakeside Energy	Solar	50	50	139,459	8620	32	39	69	98.7	31.8	32.3
32	Chanar Energy	Baggase	22	20.78	49,259	2486	0	0	82	28.3	27	95.3
33	RYK Mills	Baggase	30	16.42	89,671	5725	47	793	34	65.8	62.3	95.3
34	JDW-II	Baggase	26.35	24.01	180,353	7853	0	782.85	123.28	90	86	95.6
35	JDW-III	Baggase	26.35	24.04	190,569	8366	0	362.13	31.19	96	90.4	94.7
36	Chiniot Power	Baggase	62.48	56.78	226,578	4333.5	0	4394.5	66	49.4	45.5	46

S #	Power Plant	Main Fuel	Instd. Cap (MW)	Ref. Cap (MW)	Net Gen (MWh)	Service Hours	Standby Hours	Planned Outage Hours	Unplanned Outage Hours	Availability Factor (%)	Net Capacity Factor (%)	Net Output Factor (%)
37	Fatima Energy	Baggase	118.8	108.1	312,885	4077	4177	491.9	14	94	33	71
38	Hamza Sugar Mills	Baggase	15	13.69	53,477	4446	45	1300	16.295	51.3	44.6	87.8
39	Thal Industries (Layyah)	Baggase	41	22.4	61,220	3815.5	0	4760	64	44	31.6	72
40	Al-Moiz Industries	Baggase	36	20.65	24,871	5799	0	3866	62.5	59.6	12.4	20.7
Sub-Total			2,173.455	2,093.3	4,835,150	6751	681	466	639	84.7	29.0	39.5
KE System												
1	Oursun	Solar	50	50	92,144	4274	4485	0	0	99.9	21	43.1
2	Gharo Solar	Solar	50	50	101,691	8750	0	0	9	99.8	23.2	23.2
3	International Industries Limited	Baggase	4.26	4	13,968	4047	3142	1344	228	82	40	86.2
Sub-Total			104.26	104	207,803	5690	2542	448	79	93.9	28.1	50.8
Grand Total			2,277.715	2,197.3	5,042,953	6677	811	464	600	85.3	25.6	34.6

Inference:

- i. **NTDC System:** The wind-based power plants demonstrated availability factors ranging from 83.2% to 100%. Net capacity factors ranged from 14.2% to 38.6%, with the net output factor ranging from 14.6% to 45%. Solar power plants showed availability factors of 49.3% to 98.7%. Their net capacity factors ranged from 18.3% to 31.8%, with the net output factor ranging from 25.7% to 39.3%. Baggase-based power plants exhibited availability factors ranging from 28.3% to 96%, with net capacity factors varying from 12.4% to 90.4% and net output factors ranging from 20.7% to 95.6%.
- ii. **KE System:** Solar-based power plants like Oursun and Gharo Solar showcased near-perfect availability factors of 99.8% to 99.9%. Net capacity factors ranged from 21% to 23.2%, and net output factors varied from 23.2% to 43.1%. Baggase-based power plant in the KE system i.e. International Industries Limited displayed availability factor of 82%, with net capacity factor of 40% and net output factor of 86.2%.

2.2.4 Nuclear:

S #	Power Plant	Instd. Cap (MW)	Ref. Cap (MW)	Net Gen (MWh)	Service Hours	Standby Hours	Planned Outage Hours	Unplanned Outage Hours	Availability Factor (%)	Net Capacity Factor (%)	Net Output Factor (%)
1	K2	1145	1017.5	7,562,274	8180	0	233	200	93.4	84.8	90.8
2	K3	1145	1017.5	6,783,070	7394	0	1055	173	84.4	76.1	90.1
3	C1	325	301.188	2,298,976	8127	0	598	35	92.8	87.1	93.9
4	C2	325	300.959	2,437,891	8075	0	561	124	92.2	92.5	100.3
5	C3	340	314.163	2,500,365	8542	0	135	83	97.5	90.8	93.2
6	C4	340	314.2078	2,471,980	8180	0	494.5	86	93.4	89.8	96.2
Total		3,620	3,265.518	24,054,556	8083	0	513	117	92.3	84.1	91.1

Inference:

The provided data pertains to the performance metrics of power plants K2, K3, C1, C2, C3, and C4. Notably, K2 and K3, with installed capacities of 1145 MW each, exhibited high net generation figures of 7,562,274 MWh and 6,783,070 MWh, respectively. These plants demonstrated service hours of 8180 and 7394, indicating a robust operational presence. Moreover, K2 and K3 displayed impressive availability factors of 93.4% and 84.4%, and net capacity factors of 84.8% and 76.1%, respectively, showcasing their efficiency.

Similarly, C1, C2, C3, and C4, with installed capacities ranging from 325 MW to 340 MW, demonstrated consistent performance with notable net generation figures. Particularly, C3 showcased the highest net generation of 2,500,365 MWh. The plants C1, C2, C3, and C4 displayed high availability factors ranging from 92.2% to 97.5%, underscoring their reliability. Additionally, these plants maintained robust net capacity factors, reflecting efficient utilization of their installed capacities. The net output factors for all plants remained close to or above 90%, indicating effective power generation relative to their installed capacities. Overall, the data suggests a commendable operational performance for the specified power plants during the reported period.

