Section- 1: Background

1.1 Introduction:

The Tariff Policy notified by the Central Government under the Electricity Act 2003, provides that The Central Commission would, in consultation with the Central Electricity Authority, notify operating norms from time to time for generation and transmission. The Central Electricity Regulatory Commission (CERC), vide D.O. No. L-1/268/2022/CERC dated 19.05.2023**,** has requested CEA for preparation of operation norms for the tariff period commencing from 1.4.2024 (Enclosed as Appendix- 1).

In respect of thermal generating stations, CERC has requested CEA to furnish its recommendations on Target Availability, Target PLF, Gross Station Heat Rate, Specific Fuel Oil Consumption, Auxiliary Energy Consumption, transit losses and GCV loss on stocking / handling etc. in due consideration of renewable capacity addition and technical minimum operation of conventional plants. The additional operational norms have also been requested for units/ stations on account of implementation of new 'Emission norms' issued by the Ministry of Environment, Forest and Climate Change.

The analysis and recommendations of CEA on Operation Norms for Thermal Power Stations are furnished in this report.

1.2 Existing Norms:

1.2.1 Normative Annual Plant Availability Factor (NAPAF)

As per the present Tariff Regulations, the Normative Annual Plant Availability Factor (NAPAF) for all thermal generating stations was 85 % during 2019-24 period barring stations prescribed with relaxed norms. The relaxed norms provided for specific plants are as below:

M/s DVC's thermal generating stations:

Bokaro TPS	75%
Chandrapura TPS	75%
Durgapur TPS	74%

M/s NLC's pulverised lignite fired thermal generating station:

TPS- I	72%

M/s NEEPCO Gas based Thermal Generating Station:

Assam GPS	72%

Further, the CFBC technology based lignite fired generating stations and coal reject based generating stations have been provided with following norms for Normative Annual Plant Availability Factor:

a) First three years from COD : 75%

b) For next year after completion of three years of COD : 80%

1.2.2 **Normative Annual Plant Load Factor (NAPLF) for Incentive**

As per the present norms, the Normative Annual Plant Load Factor (NAPAF) for all thermal generating stations is 85 % barring stations prescribed with relaxed norms. The relaxed norms provided for specific plants are as below:

M/s DVC's thermal generating stations:

Bokaro TPS	80%
Chandrapura TPS	80%
Durgapur TPS	80%

M/s NLC's pulverised lignite fired thermal generating stations:

TPS- I	75%

1.2.3 **Gross Station Heat Rate**

A. Existing Thermal Generating Station (COD achieved before 1.4.2009):

i) Existing coal based thermal generating station, except those at (ii) & (iii) below.

200/210/250 MW sets	500 MW Sets (sub-critical)
2430 kcal/kWh	2390 kcal/kWh

In case of 500 MW and above units with electrically operated boiler feed pumps, the gross station heat rate shall be 40 kcal/kWh lower than the gross station heat rate specified above.

ii) Coal based thermal generating stations of M/s NTPC:

Talcher TPS	2830 kcal/kWh
Tanda TPS	2750 kcal/kWh

iii) Coal based thermal generating stations of M/s DVC:

Bokaro TPS	2700 kcal/kWh
Chandrapura TPS (Unit 3)	3000 kcal/kWh
Durgapur TPS	2750 kcal/kWh

iv) Lignite-fired thermal generating stations:

For lignite-fired thermal generating stations, except for TPS-I and TPS-II (Stage I & II) of NLC India Ltd, the gross station heat rates specified under sub-clause (i) above for coal-based thermal generating stations shall be applied with correction, using multiplying factors as given below:

(a) For lignite having 50% moisture: 1.10

(b) For lignite having 40% moisture: 1.07

(c) For lignite having 30% moisture: 1.04

For in- between moisture content values, the multiplying factor shall be on pro-rata basis.

v) For pulverised lignite based TPS-I, TPS-I (Expansion) and TPS-II (Stage I & II) of M/s NLCIL:

TPS-I	4000 kcal/kWh
TPS-I (Expansion)	2720 kcal/kWh
TPS-II	2890 kcal/kWh

vi) Open cycle gas turbine/ combined cycle generating stations:

Existing generating stations of NTPC Ltd and NEEPCO:

Name of generating station	Combined cycle (kcal/kWh)	Open Cycle (kcal/kWh)
Gandhar GPS	2040	2960
Kawas GPS	2050	3010
Anta GPS	2075	3010
Dadri GPS	2000	3010
Auraiya GPS	2100	3045

Faridabad GPS	1975	2900
Kayamkulam GPS	2000	2900
Assam GPS	2600	3578
Agartala GPS	2600	3578
Ratnagiri	1820	2641

B. Thermal Generating Station achieving COD on or after 1.4.2009:

Coal-based and lignite-fired thermal generating stations
= 1.05 x Design heat rate (kcal/kWh)

Where the design heat rate of a generating unit means the unit heat rate guaranteed by the supplier at conditions of 100% MCR, zero percent make up, design coal and design cooling water temperature/ condenser back pressure.

The design heat rate shall not exceed the following maximum design unit heat rates depending upon the pressure and temperature ratings of the units:

Pressure Rating (Kg/cm2)	150	170	170
SHT/RHT (^{0}C)	535/535	537/537	537/565
Type of BFP	Electrical Driven	Turbine Driven	Turbine Driven
Max Turbine Heat Rate (kCal/kWh)	1955	1950	1935
Min. Boiler Efficiency			
Sub-Bituminous Indian Coal	0.86	0.86	0.86
Bituminous Imported Coal	0.89	0.89	0.89
Max. Design Heat Rate (kCal/kWh)			
Sub-Bituminous Indian Coal	2273	2267	2250
Bituminous Imported Coal	2197	2191	2174

Pressure Rating (Kg/cm2)	247	247	270	270
SHT/RHT (^{0}C)	537/565	565/593	593/593	600/ 600
Type of BFP	Turbine Driven	Turbine Driven	Turbine Driven	Turbine Driven
Max Turbine Heat Rate (kCal/kWh)	1900	1850	1810	1800
Min. Boiler Efficiency				

Sub-Bituminous Indian Coal	0.86	0.86	0.865	0.865
Bituminous Imported Coal	0.89	0.89	0.895	0.895
Max. Design Heat Rate (kCal/kWh)				
Sub-Bituminous Indian Coal	2222	2151	2105	2081
Bituminous Imported Coal	2135	2078	2034	2022

If the boiler efficiency is below 86% for sub-bituminous Indian coal and 89% for bituminous imported coal, the same shall be considered as 86% and 89% respectively for sub-bituminous Indian coal and bituminous imported coal for computation of station heat rate.

In case of units provided with dry cooling system, the maximum turbine cycle heat rate shall be adjusted for type of dry cooling system envisaged.

In case of lignite-fired generating stations (including stations based on CFBC technology), maximum design heat rates shall be increased using factor for moisture content given in sub- clause 1.2.3(A) (iv) above.

In case of generating stations based on coal rejects, the Commission will approve the Design Heat Rate on case to case basis.

Note: In respect of generating units where the boiler feed pumps are electrically operated, the maximum design unit heat rate shall be 40 kcal/kWh lower than the maximum design unit heat rate specified above with turbine driven BFP.

D. Gas-based / liquid-based thermal generating unit(s)/ block(s) having COD on or after 1.4.2009:

= 1.05 x Design heat rate of the unit/ block for natural gas and RLNG (kcal/kWh)

= 1.071 x Design heat rate of the unit/ block for liquid fuel (kcal/kWh)

Where the design heat rate of a unit shall mean the guaranteed heat rate for a unit at 100% MCR and at site ambient conditions; and the design heat rate of a block shall mean the guaranteed heat rate for a block at 100% MCR, site ambient conditions, zero percent make up, design cooling water temperature/ back pressure.

1.2.4 **Specific Secondary Fuel Oil Consumption**

(a) For Coal-based generating stations other than at (c) below : 0.50 ml/kWh

(b) (i) For Lignite-fired generating stations except TPS-I: 1.0 ml/kWh
(ii) For TPS-I: 1.5 ml/kWh

(c) Coal-based generating stations of DVC:

Bokaro TPS	1.5 ml/ kWh
Chandrapur TPS	1.5 ml/ kWh
Durgapur TPS	2.4 ml/ kWh

(d) Generating Stations based on coal rejects : 2.0 ml/kWh

1.2.5 **Auxiliary Energy Consumption**:

(a) For Coal-based generating stations except at (b) below:

S. No.	**Generating Station**	**With Natural Draft cooling tower or without cooling tower**
(i)	200 MW series	8.50%
(ii)	300 MW and above	
	Steam driven boiler feed pumps	5.75%
	Electrically driven boiler feed pumps	8.00%

Provided that for thermal generating stations with induced draft cooling towers and where tube type coal mill is used, the norms shall be further increased by 0.5% and 0.8% respectively:

Provided further that Additional Auxiliary Energy Consumption as follows shall be allowed for plants with Dry Cooling Systems:

Type of Dry Cooling System	**(% of gross generation)**
Direct cooling air cooled condensers with mechanical draft fans	1.0%

Indirect cooling system employing jet condensers with pressure recovery turbine and natural draft tower	0.5%

Note: The auxiliary energy consumption for the unit capacity of less than 200 MW sets shall be dealt on case to case basis.

(b) For other Coal-based generating stations:

(i)	Talcher Thermal Power Station	10.50%
(ii)	Tanda Thermal Power Station	11.50%
(iii)	Bokaro Thermal Power Station	10.25%
(iv)	Chandrapur Thermal Power Station	9.50%
(v)	Durgapur Thermal Power Station	10.50%

(c) For Gas Turbine /Combined Cycle generating stations:

(i) Combined Cycle : 2.75%

(ii) Open Cycle : 1.00%

Provided that where the gas based generating station is using electric motor driven Gas Booster Compressor, the Auxiliary Energy Consumption in case of Combine Cycle mode shall be 3.30% (including impact of air-cooled condensers for Steam Turbine Generators):

Provided further that an additional Auxiliary Energy Consumption of 0.35% shall be allowed for Combine Cycle Generating Stations having direct cooling air cooled condensers with mechanical draft fans.

(d) For Lignite-fired thermal generating stations:

(i) For all generating stations with 200 MW sets and above:

The auxiliary energy consumption norms shall be 0.5 percentage point more than the auxiliary energy consumption norms of coal-based generating stations at 1.2.5(a) above.

Provided that for the lignite fired stations using CFBC technology, the auxiliary energy consumption norms shall be 1.5 percentage point more than the auxiliary energy consumption norms of coal-based generating stations at 1.2.5 (a) above.

(ii) For Barsingsar Generating station of NLC using CFBC technology: 12.50%

(iii) For TPS-I, TPS-I (Expansion) and TPS-II Stage-I&II of NLC India Ltd.:

TPS-I	12.00%
TPS-II	10.00%
TPS-I (Expansion)	8.50%

(iv) Limestone consumption for lignite-based generating station using CFBC technology:

Barsingsar : 0.056 kg/kWh
TPS-II (Expansion) : 0.046 kg/kWh

(e) Generating Stations based on coal rejects: 10%

1.3 Approach adopted for the current study

i) For collection of operational data from thermal power stations for the last five years, CEA provided CERC with two proforma: one for coal/ lignite based thermal power stations and other for gas/ liquid based thermal power stations. The plant operational data were furnished by some utilities as per CEA format and some utilities furnished the same as per CERC format as well as CEA format.

ii) Operating data and design data made available from the stations by CERC and that furnished by the utilities has been the basis of computations and analysis made in the report.

iii) The analysis has been carried out based on the data furnished for five (5) year period from 2018-19 to 2022-23 which includes the last year of tariff period 2014-19 and first four years of current tariff period 2019-24. The separate data furnished by the utilities for individual stages of a power station, as applicable, have been considered as separate stations.

iv) Based on the station wise inputs provided like consumption of fuel (Coal,Oil,Gas etc.) and its GCV, Generation, Declared Capacity, Operating Hours, Auxiliary Energy Consumption etc. the actual Plant Availability Factor (PAF), Plant Load Factor (PLF), Plant Loading, Gross Station Heat Rate (SHR), Specific Fuel Oil Consumption(SFOC), Auxiliary Energy

Consumption(AEC) parameters were calculated and compiled for the 5 year period.

v) As per Clause 43 (2) (a) of CERC Tariff regulation 2019-24, 85 Kcal/Kg of storage loss in GCV(ARB) has been provisioned. Thus, yearly Operating/Actual Station Heat Rate for the 4 years period (2019-20 to 2022-23) has been calculated based on GCV(ARB) minus 85 kcal/kg. However, for the year 2018-19 Operating/Actual Station Heat Rate has been calculated based on GCV(ARB) as the provision of 85 Kcal/Kg of storage loss in GCV(ARB) was not applicable in the CERC Tariff regulation 2014-19.

vi) In respect of PAF, PLF and SFOC, Normative values have been decided based on analysis of weighted average of 5 year average values of TPPs, year wise trend of parameters and considering other suitable factors, wherever applicable. Exceptionally high or low values have been omitted during analysis.

vii) In respect of AEC and SHR, yearly corrected Actual values have been calculated for the 5 year period as per the AEC and SHR degradations factor mentioned at point no. F of current recommendations. Further, the weighted average of 5 year average corrected actual values of AEC and SHR of TPPs, year wise trend of these parameters, etc. have been analysed to arrive at the Normative values in different categories based on unit size, COD dates and different configurations etc. Exceptionally high and low values have been omitted in the analysis

viii) The concept of station specific relaxed norms adopted by CERC for specific stations in view of their lower performance, due to the reason beyond the control of generating station, is continued to be followed. The norm for such stations has been reviewed as per performance evaluation on individual station basis.

ix) The principle of setting normative heat rate on the basis of design heat rate for stations having COD on or after 1.4.2009 has been continued to be followed. Similarly, for stations having COD before 1.4.2009, single heat rate norm as per unit size has been continued.

x) In respect of additional operational norms as requested by CERC for units/ stations on account of implementation of new ‘Emission norms’ issued by the Ministry of Environment, Forest and Climate Change, since no operational data has been made available by utilities for last five years i.e. 2018-19 to 2022-23(except by Jhajjhar Power Ltd. (Apraava Energy)), the norms already recommended for the tariff period 2019-2024 have been retained as such.

1.4 Data Received

1.4.1 The plant operating data for the last five years for the central sector generating stations, some state sector and private sector stations were received from different utilities as per CERC format and CEA format over a period of time. The data has been received for 136 generating stations/ station stages (henceforth referred as

stations), comprising of 114 coal/ lignite based stations and 22 gas/ liquid fuel based stations. The coal/ lignite based stations comprise of 46 stations of NTPC including its one JV, 10 stations of DVC including its one JV, 6 lignite based stations of NLCIL, 46 state sector stations and 6 IPP stations. The gas/ liquid fuel based stations comprises of 7 stations of NTPC, 3 stations of NEEPCO, 10 state sector stations, 1 OTPC CCGT station and 1 private sector stations. The 136 stations comprise of 73 central sector stations, 56 state sector stations and 7 private sector stations. The list of the stations from where data was received are furnished in Table- 1.1 below:

Table- 1.1: Details of thermal power stations for which plant operation has been received

Sl. No.	**Power Station**	**Utility**	**Details of Units Installed (MW)**	**Capacity* (MW)**
	Coal/ lignite based stations			
1	Barh- I	NTPC	2x660	1320
2	Barh- II	NTPC	2x660	1320
3	Bongaigaon	NTPC	3x250	750
4	Dadri Thermal, Stage- I	NTPC	4x210	840
5	Dadri Thermal, Stage- II	NTPC	2x490	980
6	Farakka, Stage-I & II	NTPC	3x200+2x500	1600
7	Farakka, Stage-III	NTPC	1x500	500
8	Kahalgaon, Stage- I	NTPC	4x210	840
9	Kahalgaon, Stage- II	NTPC	3x500	1500
10	Korba, Stage-I & II	NTPC	3x200+3x500	2100
11	Korba, Stage-III	NTPC	1x500	500
12	Mouda, Stage- I	NTPC	2x500	1000
13	Mouda, Stage- II	NTPC	2x660	1320
14	Ramagundam-I & II	NTPC	3x200+3x500	2100
15	Ramagundam-III	NTPC	1x500	500
16	Rihand, Stage-I	NTPC	2x500	1000
17	Rihand, Stage-II	NTPC	2x500	1000
18	Rihand, Stage-III	NTPC	2x500	1000
19	Simhadri, Stage- I	NTPC	2x500	1000
20	Simhadri, Stage- II	NTPC	2x500	1000

21	Singrauli	NTPC	5x200+2x500	2000
22	Sipat, Stage-I	NTPC	3x660	1980
23	Sipat, Stage-II	NTPC	2x500	1000
24	Talcher, Stage-I	NTPC	2x500	1000
25	Talcher, Stage-II	NTPC	4x500	2000
26	Tanda, Stage-I	NTPC	4x110	440
27	Tanda, Stage-II	NTPC	2x660	1320
28	Unchahar, Stage- I	NTPC	2x210	420
29	Unchahar, Stage- II	NTPC	2x210	420
30	Unchahar, Stage- III	NTPC	1x210	210
31	Unchahar, Stage- IV	NTPC	1x500	500
32	Vindhyachal, Stage- I	NTPC	6x210	1260
33	Vindhyachal, Stage- II	NTPC	2x500	1000
34	Vindhyachal, Stage- III	NTPC	2x500	1000
35	Vindhyachal, Stage- IV	NTPC	2x500	1000
36	Vindhyachal, Stage- V	NTPC	1x500	500
37	Barauni Stage-II	NTPC	2x250	500
38	Darlipali STPS	NTPC	2x800	1600
39	Gadarwara STPS	NTPC	2x800	1600
40	Kanti-II/Muzaffpur	NTPC (estwhile KBUNL)	2x195	390
41	Khargone STPS	NTPC	2x660	1320
42	Kudgi STPS	NTPC	3x800	2400
43	Lara STPS	NTPC	2x800	1600
44	Nabinagar STPS	NTPC	3x660	1980
45	Solapur STPS	NTPC	2x660	1320
46	Vallur	NTPC -TECL JV	3x500	1500
47	Bokaro	DVC	3x210+1x500	500
48	Chandrapura	DVC	2x250	500
49	Durgapur Steel	DVC	2x500	1000
50	Koderma	DVC	2x500	1000
51	Maithon	DVC + MPL	2x525	1050
52	Mejia Unit 1-3	DVC	3x210	630

53	Mejia Unit 4	DVC	1x210	210
54	Mejia Unit 5-6	DVC	2x250	500
55	Mejia Unit 7-8	DVC	2x500	1000
56	Raghunathpur	DVC	2x600	1200
57	Barsingsar (CFBC)	NLCIL	2x125	250
58	TPS I Expansion	NLCIL	2x210	420
59	TPS II Stage- I	NLCIL	3x210	630
60	TPS II Stage- II	NLCIL	4x210	840
61	TPS-II Expansion (CFBC)	NLCIL	2x250	500
62	NNTPPS	NLCIL	2x500	1000
63	Dr N Tatarao TPS Stage-I	APGENCO	2x210	420
64	Dr N Tatarao TPS Stage-II	APGENCO	2x210	420
65	Dr N Tatarao TPS Stage-III	APGENCO	2x210	420
66	Dr N Tatarao TPS Stage-IV	APGENCO	1x500	500
67	Gandhinagar TPP	GSECL	3x210	630
68	Sikka TPP	GSECL	2x250	500
69	Panipat TPS	HPGCL	210+2x250	710
70	Deen Bandhu Chhotu Ram TPP, Yamuna Nagar	HPGCL	2x300	600
71	Rajiv Gandhi TPP	HPGCL	2x600	1200
72	Bhusawal Stage-II	MAHAGENCO	1x210	210
73	Bhusawal Stage-III	MAHAGENCO	2x500	1000
74	Khaperkheda	MAHAGENCO	1x500	500
75	Koradi	MAHAGENCO	1x210	210
76	Koradi	MAHAGENCO	3x660	1980
77	Nasik	MAHAGENCO	3x210	630
78	Paras	MAHAGENCO	2x250	500
79	Parli	MAHAGENCO	3x250	750
80	GHTP Stage-I	PSPCL	2x210	420

81	GHTP Stage-II	PSPCL	2x250	500
82	Kota STPS	RVUN	2x110+3x210+ 2x195	1240
83	Suratgarh TPS	RVUN	6X250	1500
84	Chhabra TPP	RVUN	4x250	1000
85	Kalisindh TPP	RVUN	2x600	1200
86	Chhabra Super Critical TPP	RVUN	2x660	1320
87	Suratgarh STPS	RVUN	2 X 660	1320
88	Kakatiya TPP,Stg-I	TSGENCO	1X500	500
89	Kakatiya TPP,Stg-II	TSGENCO	1X600	600
90	Kothagudem TPS Stg-V	TSGENCO	2X250	500
91	Kothagudem TPS Stg-VI	TSGENCO	1 X 500	500
92	Kothagudem TPS Stg-VII	TSGENCO	1X800	800
93	Bhadradri TPS, Manuguru	TSGENCO	4X270	1080
94	Anpara ATPS	UPRVUNL	3x210	630
95	Anpara BTPS	UPRVUNL	2x500	1000
96	Anpara DTPS	UPRVUNL	2x500	1000
97	Harduaganj TPS Stage-I	UPRVUNL	2x250	500
98	Harduaganj TPS Stage-II	UPRVUNL	1x660	660
99	Obra BTPS	UPRVUNL	5x200	1000
100	Paricha BTPS	UPRVUNL	2x210	420
101	Paricha CTPS	UPRVUNL	2x250	500
102	Kolaghat TPS	WBPDCL	6x210	1260
103	Bakreswar TPS	WBPDCL	5x210	1050
104	Santaldih TPS	WBPDCL	2x250	500
105	Mettur TPS-I	TANGEDCO	4 X 210	840
106	Mettur TPS-II	TANGEDCO	1x600	600
107	Tuticorin TPS	TANGEDCO	5 X 210	1050
108	North Chennai-I	TANGEDCO	3x210	630
109	Mahadev Prasad STPP	Adhunik Power	2 x 270	540
110	IL&FS	IL&FS	2* 600	1200

111	Rajpura TPP	Nabha Power Ltd.	2 X 700	1400
112	Singareni TPP	Singareni Collieries Company Ltd.	2 X 600	1200
113	Sasan TPP	RELIANCE POWER LTD.	6x660	3960
114	Mahatma Gandhi TPP,Jhajjar (Jhajjar Power Ltd)	Apraava Energy Private Ltd.	2x660	1320
	Gas/ liquid fuel based stations			
1	Assam GBP	NEEPCO	291	3x (2x 33.5 + 1x 30)
2	Agartala GBP	NEEPCO	135	2x (2x 21 + 1x 25.5)
3	Tripura GBP	NEEPCO	101	1x (1x 65.42 + 1x 35.58)
4	Anta CCGT	NTPC	419.33	1x (3x 88.71 + 1x 153.2)
5	Faridabad CCPP	NTPC	431.6	1x (1x137.758 + 1x 156.07)
6	Auriya CCPP	NTPC	663.36	2x (2x 111.19 + 1x 109.3)
7	Dadri gas CCPP	NTPC	829.78	2x (2x 130.19 + 1x 154.51)
8	Gandhar CCPP	NTPC	657.39	3x (2x 111.19 + 1x 109.3)
9	Kawas CCPP	NTPC	656.2	2x (2x 106 + 1x 116.1)
10	Kayamkulam CCPP	NTPC	359.58	1x (2x 115.2 + 1x 129.18)
11	Palatana CCPP	ONGC (OTPCL)	726.6	2x (1x 232.3 + 1x 131)
12	Pragati CCPP	PPCL	1371.2	2x (2x 216 + 1x 253.6)
13	Ramgarh Gas	RVUNL	270.5	(1x 35.5+1x 37.5+1x 37.5) and (1x 110+ 1x 50)
14	Thirumakkottai (k)	TANGEDCO	107.8	1x 69.65 + 1x 38.23

15	Dhuravan CCPP-I	GSECL	106.617	1x 67.85 + 1x 38.76
16	Dhuravan CCPP-II	GSECL	112.45	1x 72.51 + 1x 39.94
17	Dhuravan CCPP-III	GSECL	376.1	1x 245.10 + 1x 131
18	Utran CCPP-II	GSECL	374.571	1x 229.24 + 1x 145.3
19	Kuttalam Gas	TANGEDCO	101.035	1x 64.21 + 1x 36.82
20	Valuthur Gas Phase-I	TANGEDCO	95	1x 59.9+ 1x 35.1
21	Valuthur Gas Phase-II/	TANGEDCO	92.2	1x 58.5 + 1x 33.7
22	Uran TPS	MAHAGENCO	672	4x 108 + 2x 120

* Maximum capacity in 5 year period 2018-23.

1.4.2 In addition to the data received from utilities, the inputs furnished by the utilities as per issues discussed with them and specific design data of OEM were also considered in formulation of operation norms proposed in this report.

1.5 Computations made

Based on the analysis carried out, the following details have been computed:

- Annual plant availability factor (PAF)
- Secondary fuel oil consumption (only for coal/ lignite based stations)
- Station/ plant loading
- Gross station heat rate
- Heat rate degradation factors on account of part load operation
- Deviation of corrected station heat rate from design heat rate
- Auxiliary energy consumption
- Admissible degradation in auxiliary energy consumption on account of part load operation
- Corrected auxiliary energy consumption on the basis admissible degradation calculation in AEC
- Station/ Plant load factor (PLF)

The above computations have been made for year to year basis as well as averaged over 5 year period considered.

Section- 2: Data Analysis and Recommendations

2.1 Annual Plant Availability Factor (PAF)

2.1.1 The data for annual plant availability factor (PAF) has been analysed for 5 year period from 2018-19 to 2022- 23 as per plant operation data received for 111 generating stations/ station stages (henceforth referred as stations), comprising of 89 coal/ lignite based stations and 22 gas/ liquid fuel based stations. The coal/ lignite based stations comprises of 46 stations of NTPC including its one JV, 10 stations of DVC including its one JV (considering various stages of Mejja TPP as separate stations), 6 lignite based stations of NLCIL, 2 stations each of GSECL and HPGCL, 6 stations of RVUN, 4 stations of TSGENCO, 7 stations of UPRVUNL and 6 IPP stations. The gas/ liquid fuel based stations comprises of 7 stations of NTPC, 3 stations of NEEPCO, 1 station each of ONGC and MAHAGENCO, 2 stations of RGPPL, 4 stations each of TANGEDCO and GSECL. The separate data furnished by the utilities for individual stages of a power station, as applicable, have been considered as separate stations. The normative annual plant availability factor (NPAF) for the central sector generating stations has been taken as 85% as per existing applicable norms with relaxed norms for some specific stations. The annual PAF has been calculated as per data furnished for declared Ex Bus generation (MU)/ capacity (MW) by the utility and applicable rated capacity of the plant & normative auxiliary energy consumption.

2.1.2 The details of annual PAF for all 111 generating stations for the five (5) year period from 2018- 19 to 2022- 23 is given at Annexure- 1. Relaxed norms have been prescribed in respect of four (04) NLC plants i.e. TPS-II Expansion (500 MW), TPS-II Stage-I (630 MW), TPS-II Stage-II (840 MW), Barsingsar (250 MW). Relaxed norms have also been prescribed in respect of one (01) NEEPCO gas plants i.e. Assam GBP (291 MW). These plants have not been considered in the PAF analysis.

While doing data analysis, average values of PAF is taken for the last 5 years. Further, five (05) gas-based plants which includes, Ratnagiri Gas station (RGPPL) (1967 MW), Ramgarh Gas station (RVUNL) (270.5 MW), Thirumakkottai (K) Gas station (TANGEDCO) (107.80 MW), Kuttalam Gas (TANGEDCO) (101 MW), Uran TPS (MAHAGENCO) (672 MW) for which five year average PAF is found to be low have not been considered in the analysis.

The weighted average of annual PAF for the 101 stations is found to vary between 85.2% for year 2021- 22 to 88.6% for 2020- 21. The five year weighted average of annual PAF for individual stations is found to vary in the range 63.4% for Gandhinagar TPP to 99.7% for GSECL's Utran Gas station. The overall weighted average of annual PAF for all the 101 stations for 5-year period is 86.3%.

2.1.3 Annual PAF of *pithead and non-pithead* coal/lignite based generating stations:

i) The analysis of annual PAF for pithead coal/lignite based generating stations of different utilities is indicated in Table- 2.1 below:

Table- 2.1: Analysis of Annual PAF for pithead coal/lignite based generating stations

Sl. No.	Power Station	Capacity (MW)	PAF norm (%)	PAF achieved (%)					
				2018-19	2019-20	2020-21	2021-22	2022-23	Average over 5 year period
NTPC Stations									
1	Farakka, Stage-I & II	1600	85	87.97	80.98	94.12	83.73	91.49	**87.66**
2	Farakka, Stage-III	500	85	90.65	77.87	97.54	87.98	80.71	**86.95**
3	Kahalgaon, Stage- I	840	85	91.31	88.66	79.46	90.18	89.38	**87.80**
4	Kahalgaon, Stage- II	1500	85	89.44	87.73	70.34	89.28	96.59	**86.68**
5	Korba, Stage-I & II	2100	85	87.94	88.72	95.47	95.79	97.61	**93.10**
6	Korba, Stage-III	500	85	93.19	87.57	101.49	98.59	88.66	**93.90**
7	Ramagundam-I & II	2100	85	90.33	90.68	88.19	86.37	86.94	**88.50**
8	Ramagundam-III	500	85	86.97	91.98	81.01	101.91	84.83	**89.34**
9	Rihand, Stage-I	1000	85	88.59	87.91	84.31	95.73	88.46	**89.00**
10	Rihand, Stage-II	1000	85	91.89	88.49	97.41	80.53	103.51	**92.37**
11	Rihand, Stage-III	1000	85	93.26	101.14	94.05	96.46	96.61	**96.30**
12	Singrauli	2000	85	87.60	87.85	84.89	83.47	89.34	**86.63**
13	Sipat, Stage-I	1980	85	93.06	87.83	94.21	79.17	87.31	**88.31**
14	Sipat, Stage-II	1000	85	92.00	90.58	90.12	98.68	96.65	**93.61**
15	Talcher, Stage-I	1000	85	79.87	74.32	92.13	87.74	90.54	**84.92**
16	Talcher, Stage-II	2000	85	84.12	81.21	90.82	90.40	96.29	**88.57**
17	Vindhyachal, Stage- I	1260	85	90.70	86.93	90.73	91.62	88.00	**89.60**
18	Vindhyachal, Stage- II	1000	85	92.19	84.82	93.69	87.61	96.26	**90.91**
19	Vindhyachal, Stage- III	1000	85	94.92	90.46	99.06	89.94	91.73	**93.22**
20	Vindhyachal, Stage- IV	1000	85	96.40	92.12	87.85	92.26	102.02	**94.13**
21	Darlipali STPS	1600	85		64.03	70.16	83.42	83.62	**75.31**

22	Lara STPS	1600	85		86.35	80.44	91.01	94.43	**88.06**
NLCIL Stations									
23	TPS I Expansion	420	85	81.59	96.16	78.07	92.16	87.71	**87.14**
24	NNTPS	1000	85		51.24	60.37	73.26	86.92	**67.95**
IPP Stations									
25	Sasan TPP	3960		93.39	94.74	94.70	92.96	84.922	**92.14**
	Weighted Average PAF (Capacity considered as weight)			**90.11**	**86.07**	**88.12**	**89.02**	**91.06**	**88.58**

* Relatively lower values not considered in the analysis.

ii) The analysis of annual PAF for non-pithead coal/lignite based generating stations of different utilities is indicated in Table- 2.2 below:

Table- 2.2: Analysis of Annual PAF for non-pithead coal/lignite based generating stations

Sl. No.	**Power Station**	**Capacity (MW)**	**PAF norm (%)**	**PAF achieved (%)**					
				2018-19	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**Average over 5 year period**
NTPC Stations									
1	Barh- I	600	85					81.01	**81.01**
2	Barh- II	1320	85	90.62	85.23	96.00	89.14	97.93	**91.78**
3	Bongaigaon	750	85	86.26	94.34	95.30	92.67	94.24	**92.56**
4	Dadri Thermal, Stage-I	840	85	90.28	99.49	97.78	81.07	98.71	**93.47**
5	Dadri Thermal, Stage-II	980	85	91.83	90.09	100.27	92.93	95.45	**94.11**
6	Mouda, Stage- I	1000	85	85.48	100.14	95.66	92.01	95.42	**93.74**
7	Mouda, Stage- II	1320	85	78.72	89.49	97.85	89.44	98.42	**90.79**
8	Simhadri, Stage- I	1000	85	89.15	89.40	93.57	89.93	93.95	**91.20**
9	Simhadri, Stage- II	1000	85	85.56	90.94	95.88	87.82	93.67	**90.77**
10	Tanda, Stage-I	440	85	91.33	92.74	95.65	91.90	93.22	**92.97**
11	Tanda, Stage-II	1320	85		91.41	93.48	93.66	97.03	**93.89**

12	Unchahar, Stage- I	420	85	96.58	95.01	100.22	85.76	90.69	**93.65**
13	Unchahar, Stage- II	420	85	96.82	98.69	95.27	93.59	93.32	**95.54**
14	Unchahar, Stage- III	210	85	92.91	103.25	95.02	96.16	101.75	**97.82**
15	Unchahar, Stage- IV	500	85	22.28*	95.63	88.49	90.01	101.13	**93.82**
16	Barauni Stage-II	500	85		92.36	93.54	87.72	91.17	**91.20**
17	Gadarwara STPS	1600	85		97.03	92.58	85.79	99.34	**93.69**
18	Kanti-II/Muzaffpur	390	85	83.98	92.66	92.61	90.00	97.33	**91.32**
19	Khargone STPS	1320	85		98.56	88.67	86.50	89.44	**90.79**
20	Kudgi STPS	2400	85	79.57	92.71	95.79	83.74	89.79	**88.32**
21	Nabinagar STPS	1980	85		88.36	92.03	91.29	89.34	**90.25**
22	Solapur STPS	1320	85	87.39	94.68	96.10	91.21	93.63	**92.60**
23	Vindhyachal, Stage- V	500	85	92.28	97.49	95.53	89.66	96.64	**94.32**
24	Vallur	1500	85	74.44	87.21	89.71	89.57	88.90	**85.96**
DVC Stations									
25	Bokaro BTPS	500	75	72.42	75.71	90.36	78.90	86.73	**80.82**
26	Chandrapura CTPS	500	75	83.41	87.21	89.48	95.46	76.17	**86.35**
27	Durgapur Steel DSTPS	1000	85	78.41	88.93	93.08	89.09	89.98	**87.90**
28	Koderma KTPS	1000	85	77.00	90.00	98.52	89.79	84.14	**87.89**
29	Maithon	1050	85	86.24	87.52	89.06	92.66	89.78	**89.05**
30	Mejia Unit 1-3	630	85	59.01	82.85	97.93	84.88	76.94	**80.32**
31	Mejia Unit 4	210	85	55.67	87.83	84.38	95.33	85.84	**81.81**
32	Mejia Unit 5-6	500	85	73.13	89.70	93.78	92.39	78.95	**85.59**
33	Mejia Unit 7-8	1000	85	71.39	75.34	91.98	89.94	85.88	**82.90**
34	Raghunathpur RTPS	1200	85	31.59*	69.63	91.42	75.05	56.48	**73.15**
IPP Stations									
35	Mahadev Prasad STPP	540		88.33	76.80	86.22	91.73	86.88	**85.99**
36	IL&FS	1200		45.08*	77.48	79.59	79.88	40.15*	**64.44**
37	Rajpura TPP	1400		85.65	86.59	86.54	89.92	91.07	**87.96**
38	Singareni TPP	1200		83.64	95.80	88.13	93.14	89.78	**90.10**

39	Mahatma Gandhi TPP,Jhajjar (Jhajjar Power Ltd)	1320		77.19	90.60	90.32	80.55	84.71	**84.68**
	Weighted Average PAF (Capacity considered as weight)			**82.62**	**89.65**	**92.76**	**88.28**	**90.19**	**88.82**

* Relatively lower values not considered in the analysis.

iii) The average of annual PAF for all pithead stations in individual year is found to vary between 86.1% in 2019- 20 to 91.1% in 2022- 23. The overall average of annual PAF for all the pithead stations for 5-year period is 88.6%. Similarly, the average of annual PAF for all non-pithead stations in individual year is found to vary between 82.6% in 2018- 19 to 92.8% in 2020- 21. The overall average of annual PAF for all the non-pithead stations for 5-year period is 88.8%. *Based on the performance observed, annual PAF norm of 85% is proposed for both the pithead and non-pithead stations.*

2.1.4 Annual PAF for coal based generating stations of NTPC:

i) The analysis of annual PAF for coal based generating stations of NTPC is indicated in Table- 2.3 below:

Table- 2.3: Analysis of Annual PAF for coal based generating stations of NTPC.

Sl. No.	**Power Station**	**Capacity (MW)**	**PAF norm (%)**	**PAF achieved (%)**					
				2018-19	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**Average over 5 year period**
1	Barh- I #	1320	85	-	-	-	-	81.01	**81.01**
2	Barh- II	1320	85	90.62	85.23	96.00	89.14	97.93	**91.78**
3	Bongaigaon	750	85	86.26	94.34	95.30	92.67	94.24	**92.56**
4	Dadri Thermal, Stage-I	840	85	90.28	99.49	97.78	81.07	98.71	**93.47**
5	Dadri Thermal, Stage-II	980	85	91.83	90.09	100.27	92.93	95.45	**94.11**
6	Farakka, Stage-I & II	1600	85	87.97	80.98	94.12	83.73	91.49	**87.66**
7	Farakka, Stage-III	500	85	90.65	77.87	97.54	87.98	80.71	**86.95**
8	Kahalgaon, Stage- I	840	85	91.31	88.66	79.46	90.18	89.38	**87.80**
9	Kahalgaon, Stage- II	1500	85	89.44	87.73	70.34	89.28	96.59	**86.68**

10	Korba, Stage-I & II	2100	85	87.94	88.72	95.47	95.79	97.61	**93.10**
11	Korba, Stage-III	500	85	93.19	87.57	101.49	98.59	88.66	**93.90**
12	Mouda, Stage- I	1000	85	85.48	100.14	95.66	92.01	95.42	**93.74**
13	Mouda, Stage- II	1320	85	78.72	89.49	97.85	89.44	98.42	**90.79**
14	Ramagundam-I & II	2100	85	90.33	90.68	88.19	86.37	86.94	**88.50**
15	Ramagundam-III	500	85	86.97	91.98	81.01	101.91	84.83	**89.34**
16	Rihand, Stage-I	1000	85	88.59	87.91	84.31	95.73	88.46	**89.00**
17	Rihand, Stage-II	1000	85	91.89	88.49	97.41	80.53	103.51	**92.37**
18	Rihand, Stage-III	1000	85	93.26	101.14	94.05	96.46	96.61	**96.30**
19	Simhadri, Stage- I	1000	85	89.15	89.40	93.57	89.93	93.95	**91.20**
20	Simhadri, Stage- II	1000	85	85.56	90.94	95.88	87.82	93.67	**90.77**
21	Singrauli	2000	85	87.60	87.85	84.89	83.47	89.34	**86.63**
22	Sipat, Stage-I	1980	85	93.06	87.83	94.21	79.17	87.31	**88.31**
23	Sipat, Stage-II	1000	85	92.00	90.58	90.12	98.68	96.65	**93.61**
24	Talcher STPS Stage-I	1000	85	79.87	74.32	92.13	87.74	90.54	**84.92**
25	Talcher STPS Stage-II	2000	85	84.12	81.21	90.82	90.40	96.29	**88.57**
26	Tanda, Stage-I	440	85	91.33	92.74	95.65	91.90	93.22	**92.97**
27	Tanda, Stage-II #	1320	85	-	91.41	93.48	93.66	97.03	**93.89**
28	Unchahar, Stage- I	420	85	96.58	95.01	100.22	85.76	90.69	**93.65**
29	Unchahar, Stage- II	420	85	96.82	98.69	95.27	93.59	93.32	**95.54**
30	Unchahar, Stage- III	210	85	92.91	103.25	95.02	96.16	101.75	**97.82**
31	Unchahar, Stage- IV #	500	85	22.28*	95.63	88.49	90.01	101.13	**93.82**
32	Vindhyachal, Stage- I	1260	85	90.70	86.93	90.73	91.62	88.00	**89.60**
33	Vindhyachal, Stage- II	1000	85	92.19	84.82	93.69	87.61	96.26	**90.91**
34	Vindhyachal, Stage- III	1000	85	94.92	90.46	99.06	89.94	91.73	**93.22**
35	Vindhyachal, Stage- IV	1000	85	96.40	92.12	87.85	92.26	102.02	**94.13**
36	Vindhyachal, Stage- V	500	85	92.28	97.49	95.53	89.66	96.64	**94.32**
37	Barauni Stage-II #	500	85	-	92.36	93.54	87.72	91.17	**91.20**
38	Darlipali STPS #	1600	85	-	64.03	70.16	83.42	83.62	**75.31**
39	Gadarwara STPS #	1600	85	-	97.03	92.58	85.79	99.34	**93.69**
40	Kanti-II/Muzaffpur #	390	85	83.98	92.66	92.61	90.00	97.33	**91.32**

41	Khargone STPS #	1320	85	-	98.56	88.67	86.50	89.44	**90.79**
42	Kudgi STPS #	2400	85	79.57	92.71	95.79	83.74	89.79	**88.32**
43	Lara STPS #	1600	85	-	86.35	80.44	91.01	94.43	**88.06**
44	Nabinagar STPS #	1980	85	-	88.36	92.03	91.29	89.34	**90.25**
45	Solapur STPS #	1320	85	87.39	94.68	96.10	91.21	93.63	**92.60**
46	Vallur	1500	85	74.44	87.21	89.71	89.57	88.90	**85.96**
	Weighted Average PAF (Capacity considered as weight)			**88.09**	**89.00**	**91.07**	**89.00**	**92.69**	**89.83**

* Relatively lower values not considered in the analysis.

Newly commissioned stations

ii) From the above table, it is seen that the average of annual PAF for all stations has been in the range 88.1% for year 2018- 19 to 92.7% for 2022- 23. Out of 46 stations of NTPC, 26 stations have annual PAF more than 85% consistently in each year for the 5 year period (or for 4 year period in newly commissioned stations). The overall average of annual PAF for 5 year period for individual station is more than 85% except for Barh- I (81.0%; data available for 2022-23 only), Talcher STPS Stage-I (84.9%), and Darlipali STPS (75.3% for period 2019-23). For a total of 29 stations, the average of annual PAF for the five (5) year period (or for 4 year period in newly commissioned plants) is more than 90% with 3 stations having the average of annual PAF for the five (5) year period as more than 95%. On year on year basis, 30 stations have annual PAF lower than 85% (2018-19 – 6 stations, 2019-20 – 6 stations, 2020-21 – 7 stations, 2021-22 – 7 stations and 2022-23 – 4 stations). Further, 20 stations have achieved annual PAF lower than 83% on year on year basis (2018-19 – 4 stations, 2019-20 – 5 stations, 2020-21 – 5 stations, 2021-22 – 3 stations and 2022-23 – 2 stations).

iii) It is observed that the overall average of annual PAF for all the above 46 NTPC stations for 5 year period is 89.8%, *which indicates that 85% normative PAF can be retained for NTPC stations.*

iv) It is observed that all the thermal stations, except Darlipali STPS, Barh-I and Kudgi STPS have been able to achieve 85% annual PAF in the first financial year after COD. *Based on the performance observed for new stations from the above table, the target annual PAF of new stations in the first financial year after COD is proposed to be kept at 85%.*

2.1.5 Annual PAF for coal based generating stations of DVC:

i) The analysis of annual PAF for coal based generating stations of DVC is indicated in Table- 2.4 below:

Table- 2.4: Analysis of Annual PAF for coal based generating stations of DVC.

Sl. No	Power Station	Capacity (MW)	PAF norm (%)	PAF achieved (%)					
				2018-19	2019-20	2020-21	2021-22	2022-23	Average over 5 year period
1.	Bokaro BTPS #	500	75	72.42	75.71	90.36	78.90	86.73	**80.82**
2.	Chandrapura CTPS #	500	75	83.41	87.21	89.48	95.46	76.17	**86.35**
3.	Durgapur Steel DSTPS	1000	85	78.41	88.93	93.08	89.09	89.98	**87.90**
4.	Koderma KTPS	1000	85	77.00	90.00	98.52	89.79	84.14	**87.89**
5.	Maithon	1050	85	86.24	87.52	89.06	92.66	89.78	**89.05**
6.	Mejia Unit 1-3	630	85	59.01	82.85	97.93	84.88	76.94	**80.32**
7.	Mejia Unit 4	210	85	55.67	87.83	84.38	95.33	85.84	**81.81**
8	Mejia Unit 5-6	500	85	73.13	89.70	93.78	92.39	78.95	**85.59**
9	Mejia Unit 7-8	1000	85	71.39	75.34	91.98	89.94	85.88	**82.90**
10	Raghunathpur RTPS	1200	85	31.59*	69.63	91.42	75.05	56.48	**73.15**
	Weighted Average PAF (Capacity considered as weight)			**75.23**	**82.57**	**92.62**	**87.36**	**80.30**	**83.55**

Bokaro Unit#3 has retired in 2021 and Chandrapura Unit#3 in 2020.

* Relatively lower values not considered in the analysis.

ii) From the above table, it is seen that 2 old stations namely, Bokaro and Chandrapura stations have been provided with relaxed target annual PAF of 75% for tariff period 2019- 24. For the above DVC stations, the average annual PAF has been in the range of 31.59% for Raghunathpur TPS in 2018- 19 to 98.5% for Koderma TPS in 2020- 21. The average of annual PAF for all stations in individual year is found to vary between 75.2% in 2018- 19 to 92.6% in 2020- 21. The 5-year average of annual PAF for DVC stations is found to vary from 73.1% for Raghunathpur TPS to 87.9% for both Durgapur Steel TPS and Koderma TPS.

iii) In case of Bokaro TPS, 210 MW unit- 3 has been retired w.e.f. 01.04.2021. As such, the present capacity of the station is 500 MW (Unit-4). The variation of annual PAF is in the range of 72.4% in 2018-19 to 90.4% in 2020-21 and the 5 year average of annual PAF for the station is 80.82%. As per performance *observed, the annual PAF norm of 85% is proposed for 500 MW unit- 4 of the station.*

iv) As regards Chandrapura TPS, the station had a capacity of 630 MW at the beginning of existing norm period (i.e. FY 2019-24), consisting of 130 MW + 2x250

MW units. The 130 MW unit- 3 has been retired w.e.f. 19.03.2020 . As such, present capacity of the station is 500 MW. The variation of annual PAF is in the range of 76.2% in 2022-23 to 95.5% in 2021-22. The 5 year average of annual PAF for the station is 86.3%. As per performance observed, *the annual PAF norm of 75% is proposed to be revised to 85% for the station.*

v) In case of Raghunathpur TPS, Coal Shortage/ coal transportation related issues has been indicated as system constraint for low annual PAF achieved.

vi) Durgapur TPS (Unit-4 of 210 MW) had been provided with relaxed norms of 74% for the tariff period 2019- 24. However, the Unit- 4 has been retired w.e.f. 19.12.2022. *As such the station has not been considered for the tariff period 2024-29.*

2.1.6 Annual PAF for lignite based generating stations of NLCIL:

i) The analysis of annual PAF for lignite based generating stations of NLCIL is indicated in Table- 2.5 below:

Table- 2.5: Analysis of Annual PAF for lignite based generating stations of NLCIL

Sl. No.	Power Station	Plant capacity (MW)	PAF norm (%)	PAF achieved (%)					
				2018-19	2019-20	2020-21	2021-22	2022-23	Average over 5 year period
1	Barsingsar (CFBC)	250	80	61.64	69.14	65.96	73.77	78.55	**69.81**
2	TPS I Expansion	420	85	81.59	96.16	78.07	92.16	87.71	**87.14**
3	TPS II Stage- I	630	85	87.57	93.64	76.07	85.42	59.46	**80.43**
4	TPS II Stage- II	840	85	90.57	90.15	44.87	76.65	67.09	**73.87**
5	TPS-II Expansion (CFBC)	500	80	44.44	38.00	48.15	46.11	40.53	**43.44**
6	NNTPS#	1000	85	--	51.24	60.37	73.26	86.92	**67.95**
	Weighted Average PAF (Capacity considered as weight)			**76.95**	**72.15**	**60.26**	**74.63**	**70.74**	**70.45**

COD of Unit-1 on 28.12.2019 & Unit-2 on 10.02.2021

ii) The average annual PAF has been in the range 38.0% for TPS-II Expansion (CFBC) in 2019- 20 to 96.2% for TPS- 1 Expansion in 2019- 20. The average of

annual PAF for all stations in individual year is found to vary between 60.26% in 2020- 21 to 76.95% in 2018-19. The 5 year average of annual PAF for NLCIL stations is found to vary from 43.4% for TPS- II Expansion to 87.1% for TPS- I Expansion. The overall weighted average of annual PAF for all 06 stations for during the 5 year period is 70.4%.

vii) As regards NLCIL's TPS- I, the station had been provided with relaxed norm of 75% annual PAF. The station had a capacity of 500 MW at the beginning of existing norm period 2019- 24, consisting of 6x50 MW + 2x100 MW units. The 50 MW Unit- 1 & 100 MW Unit- 9 have been retired w.e.f. 31.03.2020. Unit- 2, Unit- 4 and Unit- 8 having combined capacity of 200 MW have been retired w.e.f. 08.07.2020. Unit- 3, unit- 5 and unit- 6 each 50 MW capacity have been retired w.e.f. 30.07.2020, 28.09.2020 and 30.09.2020 respectively. *As such, the station has not been considered for the tariff period 2024- 29.*

iii) For NLCIL' TPS- I Expansion, the average of annual PAF for 5 year period has been more than 85%. *Based on performance observed, the target PAF for TPS- I Expansion is proposed to be retained to 85%.*

iv) For NLCIL' TPS- II Stage- I & Stage- II stations, the average of annual PAF for the five (5) year period is 80.4% and 73.9% respectively. The average PAF of both the stations is found to be 77.2%. Based on performance observed, *the target PAF for TPS- II Stage- I & Stage- II stations is proposed to be reduced to 80% from the existing norm of 85%.*

v) In case of Barsingsar TPS, a CFBC technology-based lignite fired station, the normative annual PAF of 80% is applicable. The annual PAF of the station has increased from 61.6% for 2018-19 to 78.6% for 2022-23, *based on which the target PAF for the station is proposed to be reduced to 75%.*

vi) In case of TPS- II Expansion (CFBC), the normative annual PAF of 80% is applicable. During the period 2018- 23, the annual PAF of the station has been in the range of 38% to 48.2%, while the average of annual PAF for five (5) year period is 43.4%. Based on observed performance of these stations, *the target annual PAF for CFBC technology-based lignite fired stations is proposed to be relaxed and reduced to 50% from existing norm of 80%.*

vii) NNTPS has been installed in the current tariff period and its availability has improved from the level of 51% in initial period 2019- 20 to level of 87% in the year 2022- 23. Therefore, based on the observed performance, the existing norm of 85% is proposed for the station.

viii) In case of CFBC technology based lignite fired stations and generating stations based on coal rejects, as operational data is not available, it is proposed to retain the existing annual PAF norm of 68.5% for initial 3 year after COD and 75% subsequent to 3 year after COD.

2.1.7 Annual PAF for gas/ liquid fuel based thermal generating stations:

i) The analysis of annual PAF for gas/ liquid fuel based central sector along with state sector thermal generating stations is indicated in Table- 2.6 below:

Table- 2.6: Analysis of Annual PAF for gas/ liquid fuel based generating stations.

Sl. No.	Power Station	Utility	Plant capacity (MW)	PAF norm (%)	PAF achieved (%)					
					2018-19	2019-20	2020-21	2021-22	2022-23	Average over 5 year period
1	AGBP, Gas#	NEEPCO	291.00	72	64.36	69.44	64.62	71.52	73.35	**68.66**
2	AGTCCP, Gas	NEEPCO	135.00	85	58.07	74.70	82.81	79.71	81.40	**75.34**
3	TGBP, Gas	NEEPCO	101.00	85	78.66	87.04	62.94	83.90	85.97	**79.70**
4	Anta, Gas	NTPC	419.33	85	94.44	86.44	95.39	86.66	87.56	**90.10**
5	Faridabad, Gas	NTPC	431.59	85	93.70	98.26	97.02	88.03	91.66	**93.73**
6	Auraiya, Gas	NTPC	663.36	85	94.04	94.95	95.02	89.38	90.37	**92.75**
7	Dadri, Gas	NTPC	829.78	85	90.45	92.03	95.39	90.91	86.50	**91.06**
8	Gandhar, Gas	NTPC	657.39	85	85.87	95.66	93.57	86.16	86.97	**89.65**
9	Kawas, Gas	NTPC	656.20	85	96.05	94.35	97.17	87.81	93.60	**93.80**
10	Kayamkulam, Gas	NTPC	359.58	85	95.00	94.66	93.82	96.03	96.03	**95.11**
11	Tripura, Gas	ONGC	726.60	85	74.09	62.30	80.99	64.53	77.14	**71.81**
12	Ratnagiri, Gas*	RGPPL	1967.08	85	29.38	33.64	34.48	25.23	21.83	**28.91**
Weighted Average PAF (central sector gas/liquid based stations)					**88.50**	**88.56**	**92.26**	**85.14**	**87.72**	**88.44**
13	Ramgarh Gas*	RVUNL	270.50	85	41.94	32.02	24.09	60.39	57.37	**43.16**
14	THIRUMAKKOTTAI (K) GAS*	TANGEDCO	107.80	85	29.66	30.50	23.94	15.02	18.69	**23.56**

15	Dhuravan CCPP-I Gas	GSECL	106.62	85	35.20	57.91	75.23	77.34	87.86	**66.71**
16	Dhuravan CCPP-II Gas	GSECL	112.45	85	76.18	25.19*	78.58	76.82	88.69	**80.07**
17	Dhuravan CCPP-III Gas	GSECL	376.10	85	95.52	68.26	60.96	38.14	95.81	**71.74**
18	Kuttalam Gas*	TANGEDCO	101.04	85	46.19	50.14	60.76	50.51	69.64	**55.45**
19	Valuthur Gas Phase-I	TANGEDCO	95.00	85	74.49	88.91	92.14	86.44	86.18	**85.63**
20	Valuthur Gas Phase-II	TANGEDCO	92.20	85	75.17	76.27	68.93	57.80	56.99	**67.03**
21	Uran TPS*	Mahagenco	672.00	85	43.77	44.11	34.08	35.18	25.31	**36.49**
Weighted Average PAF of all state sector stations					**57.34**	**51.60**	**48.11**	**47.30**	**57.09**	**52.62**
Weighted Average PAF of all stations (excluding outliers and stations with relaxed norms)					**87.29**	**86.43**	**89.26**	**81.35**	**87.76**	**86.39**

* The stations and values have been omitted from the calculation of average PAF, as their PAF is below 60%.
# AGBP, NEEPCO has been provided relaxed norms of 70% in the current recommendation and is omitted from the above analysis.

ii) In the gas/ liquid fuel based stations, the average of annual PAF for all stations is found to vary between 81.4% for year 2021- 22 to 87.8% for 2022- 23. The overall average of annual PAF for five (5) year period for individual station is found to vary in the range 67.0% (for TANGEDCO's Valuthur Gas Phase-II) to 93.8% (for NTPC Kawas). The average of annual PAF for 5-year period is more than 85% for 08 stations which include all seven (07) NTPC stations, and TANGEDCO's Valuthur Gas Phase-I Gas stations.

iii) The average of annual PAF for the twelve (12) central sector stations, excluding Ratnagiri Gas & Power Private Ltd. and NEEPCO's AGBP, in individual year is found to vary between 85.1% in 2021- 22 to 92.3% in 2020- 21. For all seven (7) NTPC stations, the annual PAF is more than 85% consistently for 5-year period. The overall average of annual PAF for the 10 central sector stations for during the 5 year period is 88.4%. *Based on performance observed, the target PAF for these stations, excluding NEEPCO's AGBP is proposed to be retained to 85%.*

iv) Based on observed performance, the target annual PAF for gas/ liquid fuel based stations is proposed to be kept at the same level as coal based generating stations

except for NEEPCO's AGBP for which target annual PAF is proposed to be reduced to 70%.

v) For a comparison, the weighted average annual PAF of all 09 state sector stations of RVUNL, TANGEDCO and GSECL has been in the range 47.3% (in 2021- 22) to 57.3% (in 2018- 19). The 5-year average of annual PAF for these stations is found to vary from 23.6% for TANGEDCO's Thirumakkottai (K) Gas to 85.6% for TANGEDCO's Valuthur Gas Phase-I station. The overall weighted average of annual PAF for all 09 stations for during the 5-year period is 52.6%.

2.2 Secondary Fuel Oil Consumption:

2.2.1 The data for secondary/ specific fuel oil consumption has been analysed for 5 year period from 2018- 19 to 2022- 23 as per plant operation data received for 113 coal/ lignite based generating stations/ station stages (henceforth referred as stations) comprising of 46 stations of NTPC including, 1 station of its JV NTECL (Vallur TPS), 10 stations of DVC including 1 station of its JV Maithon Power Ltd., 6 lignite based stations of NLCIL, 4 stations of APGENCO, 2 stations each of GSCECL & PSCPL, 3 stations of HPGCL, 6 stations each of RVUN and TSGENCO, 7 stations each of MAHAGENCO and UPRVUNL, 4 stations of WBPDCL and TANGEDCO and 6 IPP stations. The separate data furnished by the utilities for individual stages of a power station, as applicable, have been considered as separate stations. The normative value of specific fuel oil consumption (ml/kWh) for the central sector generating stations has been taken as 0.5 ml/kWh as per applicable norms with relaxed norms for some specifically identified stations of DVC and for lignite based stations of NLCIL. The annual average specific fuel oil consumption has been calculated as per data furnished by the utilities for annual fuel oil consumption and annual gross generation for individual stations.

2.2.2 The analysis of annual specific fuel oil consumption for all 113 coal/ lignite based generating stations for the five (5) year period from 2018- 19 to 2022- 23 is indicated in Annexure- 2. The high consumption of oil as star marked in specific years for Unchahar Stage- IV, Barauni Stage-II, Gadarwara STPS, Solapur STPS and NNTPS seem to be due to addition of new units (except Unchahar Stage-IV) and these high values have been omitted in the analysis. The average annual specific oil consumption for most of the stations is within the prescribed norm for the period 2019- 24.

Based on the analysis, seven (07) stations including five (05) NTPC stations and two (02) DVC stations have been provided with relaxed norms. Considering only NTPC and DVC stations, the 5 year average of specific fuel oil consumption for individual stations is found to vary in the range 0.14 ml/kWh for NTPC's Rihand Stage-III TPS to 1.59 ml/kWh for Barauni Stage-II TPS. The overall weighted average of specific fuel oil consumption for the 49 central sector coal based stations for 5 year period is 0.52 ml/kWh (excluding 7 stations with relaxed norms).

2.2.3 Specific fuel oil consumption (SFC) of NTPC stations:

iv) The analysis of annual average specific fuel oil consumption (SFC) for coal based generating stations of NTPC is indicated in Table- 2.7 below:

Table- 2.7: Analysis of specific oil consumption for NTPC stations

Sl. No.	Power Station	Capacity (MW)	SFC norm (ml/kWh)	Specific Fuel Oil Consumption (ml/ kWh)						
				2018-19	2019-20	2020-21	2021-22	2022-23	Average over 5 year period	Excess over normative SFC (ml/kWh)
1	Barh- I**	660	0.5					1.49	**1.50**	**1.00**
2	Barh- II	1320	0.5	0.33	0.26	0.30	0.43	0.42	**0.35**	**-0.15**
3	Bongaigaon	750	0.5	0.64	0.81	0.84	0.51	0.52	**0.67**	**0.17**
4	Dadri Thermal, Stage-I	840	0.5	0.50	1.17	3.11	1.93	0.43	**1.43**	**0.93**
5	Dadri Thermal, Stage-II	980	0.5	0.24	0.77	0.59	0.43	0.44	**0.49**	**-0.01**
6	Farakka, Stage-I & II**	1600	0.5	0.57	1.00	0.93	1.39	0.79	**0.94**	**0.44**
7	Farakka, Stage-III	500	0.5	0.37	0.96	0.46	0.99	0.58	**0.67**	**0.17**
8	Kahalgaon, Stage- I	840	0.5	0.43	0.29	0.40	0.66	0.39	**0.43**	**-0.07**
9	Kahalgaon, Stage- II	1500	0.5	0.36	0.30	0.45	0.22	0.39	**0.35**	**-0.15**
10	Korba, Stage-I & II	2100	0.5	0.18	0.19	0.19	0.15	0.19	**0.18**	**-0.32**
11	Korba, Stage-III	500	0.5	0.08	0.25	0.03	0.11	0.35	**0.16**	**-0.34**
12	Mouda, Stage- I	1000	0.5	0.67	0.59	0.76	1.01	0.33	**0.67**	**0.17**
13	Mouda, Stage- II	1320	0.5	0.66	0.75	0.95	0.80	0.38	**0.71**	**0.21**
14	Ramagundam-I & II	2100	0.5	0.34	0.33	0.33	0.34	0.58	**0.38**	**-0.12**
15	Ramagundam-III	500	0.5	0.32	0.10	0.33	0.02	0.42	**0.29**	**-0.21**
16	Rihand, Stage-I	1000	0.5	0.41	0.23	0.32	0.23	0.54	**0.35**	**-0.15**

17	Rihand, Stage-II	1000	0.5	0.27	0.28	0.18	0.38	0.06	**0.24**	**-0.26**
18	Rihand, Stage-III	1000	0.5	0.16	0.08	0.21	0.14	0.13	**0.14**	**-0.36**
19	Simhadri, Stage- I	1000	0.5	0.15	0.56	0.62	0.50	0.39	**0.45**	**-0.05**
20	Simhadri, Stage- II	1000	0.5	0.57	0.48	0.40	0.47	0.33	**0.45**	**-0.05**
21	Singrauli	2000	0.5	0.25	0.25	0.30	0.34	0.25	**0.28**	**-0.22**
22	Sipat, Stage-I	1980	0.5	0.21	0.23	0.29	0.26	0.30	**0.26**	**-0.24**
23	Sipat, Stage-II	1000	0.5	0.26	0.21	0.24	0.21	0.18	**0.22**	**-0.28**
24	Talcher, Stage-I	1000	0.5	0.59	1.25	0.65	0.69	0.46	**0.73**	**0.23**
25	Talcher, Stage-II	2000	0.5	0.38	0.37	0.48	0.30	0.27	**0.36**	**-0.14**
26	Tanda, Stage-I	440	0.5	0.68	0.55	0.81	0.97	1.53	**0.91**	**0.41**
27	Tanda, Stage-II #	1320	0.5		3.35	0.79	1.22	0.56	**1.48**	**0.98**
28	Unchahar, Stage- I	420	0.5	0.36	1.90	0.92	2.24	0.95	**1.27**	**0.77**
29	Unchahar, Stage- II	420	0.5	0.75	1.09	1.25	0.97	1.32	**1.08**	**0.58**
30	Unchahar, Stage- III	210	0.5	0.66	0.96	0.51	1.34	0.16	**0.73**	**0.23**
31	Unchahar, Stage- IV #	500	0.5	4.43*	1.20	0.69	0.43	0.36	**0.67**	**0.17**
32	Vindhyachal, Stage- I	1260	0.5	0.21	0.30	0.27	0.29	0.28	**0.27**	**-0.23**
33	Vindhyachal, Stage- II	1000	0.5	0.22	0.36	0.22	0.35	0.19	**0.27**	**-0.23**
34	Vindhyachal, Stage- III	1000	0.5	0.15	0.12	0.09	0.21	0.16	**0.14**	**-0.36**
35	Vindhyachal, Stage-IV	1000	0.5	0.12	0.19	0.23	0.14	0.06	**0.15**	**-0.35**
36	Vindhyachal, Stage- V	500	0.5	0.30	0.07	0.20	0.16	0.19	**0.19**	**-0.31**
37	Barauni Stage-II #	500	0.5		14.88*	2.52	1.09	1.16	**1.59**	**1.09**
38	Darlipali STPS #	1600	0.5		2.19	1.59	1.19	0.62	**1.40**	**0.90**
39	Gadarwara STPS #	1600	0.5		4.38*	0.80	1.30	0.81	**0.97**	**0.47**
40	Kanti-II/Muzaffpur	390	0.5	0.92	0.70	0.52	0.58	0.33	**0.61**	**0.11**
41	Khargone STPS #	1320	0.5		0.90	0.98	0.45	0.80	**0.78**	**0.28**
42	Kudgi STPS**	2400	0.5	1.04	2.07	1.43	1.31	0.75	**1.32**	**0.82**
43	Lara STPS**	1600	0.5		0.52	1.18	0.66	0.86	**0.80**	**0.30**
44	Nabinagar STPS #	1980	0.5		0.92	0.59	0.35	0.42	**0.57**	**0.07**
45	Solapur STPS**	1320	0.5	2.51	7.79*	1.07	0.96	1.00	**1.38**	**0.88**

46	Vallur	1500	0.5	0.76	1.18	1.33	0.52	0.55	**0.87**	**0.37**
Weighted Average SFC (Capacity considered as weight)				**0.36**	**0.57**	**0.63**	**0.52**	**0.43**	**0.53**	**--**

* Relatively very high values not considered in the analysis.

Newly commissioned stations.

** Relaxed norms specified for stations having front and rear fired boiler and therefore not considered in the Average SFC calculation

v) From the above table, it is seen that in case of NTPC stations, out of total 46 stations, 16 stations have specific oil consumption below the norm of 0.5 ml/kWh consistently for the indicated 5-year period. For another four (04) stations, specific oil consumption is below the norm of 0.5 ml/kWh in 4 years out of total 5-year period. For some stations, the specific oil consumption in some specific year is even less than 0.1 ml/kWh viz. 0.03 ml/kWh for Korba stage-III TPS in 2020- 21, 0.02 ml/kWh for Ramagundam stage-III TPS in 2021- 22, 0.08 ml/kWh for Rihand stage-III TPS in 2019- 20 and 0.09 ml/kWh for Vindhyachal Stage- III.

vi) The weighted average specific oil consumption for all stations, excluding front fired boilers, in individual year is found to vary between 0.36 ml/kWh in 2018- 19 to 0.63 ml/kWh in 2020- 21. The 5 year average of specific oil consumption for individual stations is found to vary from 0.14 ml/kWh for Rihand Stage-III TPS to 1.59 ml/kWh for Barauni Stage-II TPS. The 5-year average of specific oil consumption is below the existing norm of 0.5 ml/kWh for 22 stations. The overall weighted average of specific oil consumption for all NTPC stations for 5 year period is **0.53 ml/kWh**. In the year 2022- 23, the weighted average of specific oil consumption for these stations was 0.43 ml/kWh. *Based on observed performance, the existing norm of 0.5 ml/kWh is considered to be adequate for NTPC stations.*

vii) Barh-I, Farakka Stage- I & II, Tanda Stage-II, Kudgi STPS and Solapur STPS are indicated to be provided with front and rear fired boiler and require oil support during part load or mill change over for flame stability. As per the table 2.8 below, the annual specific oil consumption of these stations is more than the existing norm of 0.5 ml/kWh in all 5 years. Further, the overall 5 year weighted average of specific oil consumption for these stations is 1.15 ml/kWh. A*s per observed performance, stations with front and rear fired boilers are proposed to be provided with relaxed specific oil consumption norm of 1.0 ml/kWh.*

Table- 2.8: Analysis of specific oil consumption for NTPC stations with front and rear fired boilers

Sl. No	**Power station**	**Capacity (MW)**	**SFC norm (ml/kWh)**	**Specific Oil Consumption (ml/ kWh)**						
				2018-19	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**Average over**	**Excess over**

									5 year period	normative SFC
1	Barh- I	600	0.5					1.50	**1.50**	**1.0**
2	Farakka, Stage-I & II	1600	0.5	0.57	1.00	0.93	1.39	0.79	**0.94**	**0.44**
3	Kudgi STPS	2400	0.5	1.04	2.07	1.43	1.31	0.75	**1.32**	**0.82**
4	Solapur STPS	1320	0.5	2.51	7.79*	1.07	0.96	1.00	**1.38**	**0.88**
5	Lara STPS	1600	0.5		0.52	1.18	0.66	0.86	**0.80**	**0.3**
Weighted Average SFC (Capacity considered as weight)			**0.5**	**1.26**	**1.32**	**1.19**	**1.11**	**0.89**	**1.15**	**0.65**

* Relatively very high values not considered in the analysis.

2.2.4 Specific oil consumption of DVC stations:

i) The analysis of annual average specific oil consumption for DVC stations is indicated in Table- 2.9 below:

Table- 2.9: Analysis of specific oil consumption for DVC stations

Sl. No	Power station	Capacity (MW)	SFC norm (ml/kWh)	Specific Oil Consumption (ml/ kWh)						
				2018-19	2019-20	2020-21	2021-22	2022-23	Average over 5 year period	Excess over normative SFC
1	Bokaro A	500	1.5	0.53	0.39	0.29	0.52	0.30	**0.40**	**-1.10**
2	Chandrapura	500	1.5	0.38	0.38	0.20	0.45	0.48	**0.38**	**-1.12**
3	Durgapur Steel	1000	0.5	0.68	0.33	0.55	0.53	0.35	**0.49**	**-0.01**
4	Koderma	1000	0.5	0.27	0.28	0.22	0.25	0.11	**0.23**	**-0.27**
5	Maithon	1050	0.5	0.34	0.32	0.22	0.11	0.15	**0.23**	**-0.27**
6	Mejia Unit 1-3*	630	0.5	1.11	0.85	0.44	1.02	3.02	**1.29**	**0.79**
7	Mejia Unit 4*	210	0.5	0.79	0.90	0.52	0.50	1.78	**0.90**	**0.40**
8	Mejia Unit 5-6	500	0.5	0.50	0.40	0.25	0.80	1.26	**0.64**	**0.14**
9	Mejia Unit 7-8	1000	0.5	0.51	0.46	0.23	0.38	0.19	**0.35**	**-0.15**
10	Raghunathpur	1200	0.5	0.82	0.37	0.31	0.99	1.05	**0.71**	**0.21**
Weighted Average SFC (Capacity considered as weight)				**0.52**	**0.36**	**0.29**	**0.50**	**0.46**	**0.43**	**--**

* Relaxed norms have been specified for the stations and therefore not considered in the Average SFC calculation.

ii) The average specific oil consumption for all 8 stations of DVC in individual year is found to vary between 0.29 ml/kWh in 2020- 21 to 0.52 ml/kWh in 2018- 19. The 5 year average of specific oil consumption for individual stations is found to vary from 0.23 ml/kWh for Maithon TPS and Koderma TPS to 0.71 ml/kWh for Raghunathpur TPS. The overall average of specific oil consumption for all DVC stations for 5 year period, *excluding Mejia Unit 1-4,* is found as **0.43 ml/kWh**. *Based on observed performance, the existing norm of 0.5 ml/kWh is considered to be adequate for DVC stations.*

iii) In case of Bokaro TPS, capacity of the station at the beginning of tariff period FY2019- 24 was 710 MW (Unit-3 of 210 MW and Uni-4 of 500 MW). However, 210 MW Unit- 3 has been retired w.e.f. 01.04.2021. As such, the present capacity of the station is 500 MW (Unit-4). The average specific oil consumption of the station for 5-year period is found as 0.40 ml/kWh. Based on the performance observed, *the existing relaxed norm of 1.5 ml/kWh is proposed to be reduced to 0.5 ml/kWh for the station.*

iv) As regards Chandrapura TPS, the station had a capacity of 630 MW at the beginning of existing norm period (i.e. FY 2019-24), consisting of 130 MW + 2x250 MW units. The 130 MW unit- 3 has been retired w.e.f. 19.03.2020 . As such, present capacity of the station is 500 MW. The average specific oil consumption of the station for 5-year period is found as 0.38 ml/kWh. As per performance observed, *the existing relaxed norm of 1.5 ml/kWh is proposed to be reduced to 0.5 ml/kWh for the station.*

v) Durgapur TPS (Unit-4 of 210 MW) had been provided with relaxed norms of 2.4 ml/kWh for the tariff period 2019- 24. However, the Unit- 4 has been retired w.e.f. 19.12.2022. *As such, the station has not been considered for the tariff period 2024-29.*

vi) In case of Mejia Unit 1-3, the annual specific oil consumption of the station has been in the range of 0.44 ml/kWh (in 2020- 21) to 3.02 ml/kWh (in 2022- 23). Similarly for Mejia Unit-4, the annual specific oil consumption of the station has been in the range of 0.50 ml/kWh (in 2021- 22) to 1.78 ml/kWh (in 2022- 23).The overall average of specific oil consumption for 5-year period in case of Mejia Unit 1-3 and Mejia Unit 4 is 1.1 ml/kWh. *Based on observed performance of the stations, the existing norm of 0.5 ml/kWh for 210 MW size unit- I to IV is proposed to be relaxed to 1.0 ml/kWh.*

2.2.5 Specific oil consumption of lignite fired stations of NLCIL:

i) The analysis of annual average specific oil consumption for NLCIL's lignite based stations is indicated in Table- 2.10 below:

Table- 2.10: Analysis of specific oil consumption for NLCIL stations.

Sl. No	Power station	Capacity (MW)	SFC norm (ml/kWh)	Specific Oil Consumption (ml/ kWh)						
				2018-19	2019-20	2020-21	2021-22	2022-23	Average over 5 year period	Excess over normative SFC
1	Barsingsar (CFBC)	250	1.0	0.78	0.58	0.70	0.56	0.46	**0.62**	**-0.38**
2	TPS I Expansion	420	1.0	0.73	0.34	0.45	0.81	0.72	**0.61**	**-0.39**
3	TPS II Stage- I	630	1.0	0.93	0.70	1.09	0.88	1.43	**1.01**	**0.01**
4	TPS II Stage- II	840	1.0	0.79	0.65	1.35	1.02	1.01	**0.96**	**-0.04**
5	TPS-II Expansion (CFBC)	500	1.0	1.94	3.64	1.59	1.60	2.28	**2.21**	**1.21**
6	NNTPS #	1000	1.0		8.89*	2.25	1.37	0.66	**1.42**	**0.42**
Weighted Average SFC (Capacity considered as weight)				**1.03**	**1.17**	**1.44**	**1.12**	**1.09**	**1.20**	**--**

* Relatively very high values not considered in the analysis.
# COD of Unit-1 on 28.12.2019 & Unit-2 on 10.02.2021

ii) The average specific oil consumption for all six (06) lignite fired stations of NLCIL in individual year is found to vary between 1.03 ml/kWh in 2018- 19 to 1.44 ml/kWh in 2020- 21. The 5 year average of specific oil consumption for individual stations is found to vary from 0.61 ml/kWh for TPS- I Expansion to 2.21 ml/kWh for TPS- II Expansion (CFBC). The overall average of specific oil consumption for all NLCIL stations for 5 year period is **1.20 ml/kWh**. *Based on observed performance, the existing norm of 1.0 ml/kWh is considered to be adequate for NLCIL stations*

iii) For NLCIL's pulverised lignite based TPS- II Stage- I & stage- II stations, the specific oil consumption is close to the prevailing norms of 1 ml/kWh. For these stations, the annual average specific oil consumption varies in the range 0.65 ml/kWh (for TPS- II Stage-II in 2019- 20) to 1.43 ml/kWh (for TPS- II Stage- I in 2022- 23). Similarly, in case of TPS I Expansion, annual average specific oil consumption varies in the range 0.34 ml/kWh in 2019- 20 to 0.81 in 2021- 22. The 5 year average of annual specific oil consumption for TPS- I Expansion, TPS- II Stage- I & TPS- II stage- II is 0.61, 1.01 and 0.96 ml/kWh respectively. *Based on observed specific oil consumption values, the specific oil consumption norm for TPS- I Expansion, TPS- II Stage- I and TPS- II Stage- II is proposed to be appropriately retained to 1.0 ml/kWh.*

iv) NLCIL's Barsingsar and TPS- II Expansion are CFBC technology based lignite fired stations. The annual average specific oil consumption of TPS- II Expansion station has been in the range of 1.59 ml/kWh in 2020- 21 to 3.64 ml/kWh in 2019- 20 and for NLCIL's Barsingsar, it varies from 0.46 ml/kWh in 2022-23 to 0.78

ml/kWh in 2018-19. The 5-year average of specific oil consumption for both the stations is 1.42 ml/kWh. *Based on performance observed, the specific oil consumption norm for CFBC based lignite fired station is proposed to be retained as 1.0 ml/kWh.*

v) As regards NLCIL's TPS- I, consisting of 6x50 MW + 2x100 MW units, had been provided with relaxed norm of 1.5 ml/kWh. The 50 MW Unit- 1 & 100 MW Unit- 9 have been retired w.e.f. 31.03.2020. Unit- 2, Unit- 4 and Unit- 8 having combined capacity of 200 MW have been retired w.e.f. 08.07.2020. Unit- 3, unit- 5 and unit- 6 each 50 MW capacity have been retired w.e.f. 30.07.2020, 28.09.2020 and 30.09.2020 respectively. *Since all the units are retired*, *the station has not been considered for the tariff period 2024- 29.*

vi) The NNTPS comprises of 2x500 MW units installed in 2015. The annual average specific oil consumption of this station has gradually reduced from 8.89 ml/kWh in 2019- 20 to 0.66 ml/kWh in 2022- 23. Considering gradually improved performance observed in the 4-year period, the existing norm of 1.0 ml/kWh is considered to be adequate for NNTPS.

2.2.6 For generating stations based on coal rejects, *as operational data is not available, it is proposed to retain the existing norm of 2.0 ml/kWh.*

2.2.6 Specific fuel oil consumption (SFC) of coal based NTPC and DVC stations, excluding stations with relaxed norms:

i) The analysis of annual average specific oil consumption for coal based NTPC and DVC stations, excluding stations with relaxed norms, is indicated in Table- 2.11 below:

Table- 2.11: Analysis of specific oil consumption for coal based stations, excluding stations with relaxed norms

Sl. No	Power station	Capacity (MW)	SFC norm (ml/kWh)	Specific Oil Consumption (ml/ kWh)						
				2018-19	2019-20	2020-21	2021-22	2022-23	Average over 5 year period	Excess over normative SFC
1	Barh- II	1320	0.5	0.33	0.26	0.30	0.43	0.42	**0.35**	-0.15
2	Bongaigaon	750	0.5	0.64	0.81	0.84	0.51	0.52	**0.67**	0.17
3	Dadri Thermal, Stage-I	840	0.5	0.50	1.17	3.11	1.93	0.43	**1.43**	0.93
4	Dadri Thermal, Stage-II	980	0.5	0.24	0.77	0.59	0.43	0.44	**0.49**	-0.01

5	Farakka, Stage-III	500	0.5	0.37	0.96	0.46	0.99	0.58	**0.67**	0.17
6	Kahalgaon, Stage- I	840	0.5	0.43	0.29	0.40	0.66	0.39	**0.43**	-0.07
7	Kahalgaon, Stage- II	1500	0.5	0.36	0.30	0.45	0.22	0.39	**0.35**	-0.15
8	Korba, Stage-I & II	2100	0.5	0.18	0.19	0.19	0.15	0.19	**0.18**	-0.32
9	Korba, Stage-III	500	0.5	0.08	0.25	0.03	0.11	0.35	**0.16**	-0.34
10	Mouda, Stage- I	1000	0.5	0.67	0.59	0.76	1.01	0.33	**0.67**	0.17
11	Mouda, Stage- II	1320	0.5	0.66	0.75	0.95	0.80	0.38	**0.71**	0.21
12	Ramagundam-I & II	2100	0.5	0.34	0.33	0.33	0.34	0.58	**0.38**	-0.12
13	Ramagundam-III	500	0.5	0.32	0.10	0.33	0.023	0.42	**0.24**	-0.26
14	Rihand, Stage-I	1000	0.5	0.41	0.23	0.32	0.23	0.54	**0.35**	-0.15
15	Rihand, Stage-II	1000	0.5	0.27	0.28	0.18	0.38	0.06	**0.24**	-0.26
16	Rihand, Stage-III	1000	0.5	0.16	0.08	0.21	0.14	0.132	**0.14**	-0.36
17	Simhadri, Stage- I	1000	0.5	0.15	0.56	0.62	0.50	0.39	**0.45**	-0.05
18	Simhadri, Stage- II	1000	0.5	0.57	0.48	0.40	0.47	0.33	**0.45**	-0.05
19	Singrauli	2000	0.5	0.25	0.25	0.30	0.34	0.250	**0.28**	-0.22
20	Sipat, Stage-I	1980	0.5	0.21	0.23	0.29	0.26	0.30	**0.26**	-0.24
21	Sipat, Stage-II	1000	0.5	0.26	0.21	0.24	0.21	0.18	**0.22**	-0.28
22	Talcher, Stage-I	1000	0.5	0.59	1.25	0.65	0.69	0.46	**0.73**	0.23
23	Talcher, Stage-II	2000	0.5	0.38	0.37	0.48	0.30	0.27	**0.36**	-0.14
24	Tanda, Stage-I	440	0.5	0.68	0.55	0.81	0.97	1.53	**0.91**	0.41
25	Tanda, Stage-II	1320	0.5		3.35	0.79	1.22	0.56	**0.86**	0.36
26	Unchahar, Stage- I	420	0.5	0.36	1.90	0.92	2.24	0.95	**1.27**	0.77
27	Unchahar, Stage- II	420	0.5	0.75	1.09	1.25	0.97	1.32	**1.08**	0.58
28	Unchahar, Stage- III	210	0.5	0.66	0.96	0.51	1.34	0.16	**0.73**	0.23
29	Unchahar, Stage- IV	500	0.5	4.43*	1.20	0.69	0.43	0.36	**0.67**	0.17
30	Vindhyachal, Stage- I	1260	0.5	0.21	0.30	0.27	0.29	0.28	**0.27**	-0.23
31	Vindhyachal, Stage- II	1000	0.5	0.22	0.36	0.22	0.35	0.19	**0.27**	-0.23

32	Vindhyachal, Stage- III	1000	0.5	0.15	0.12	0.09	0.21	0.16	**0.14**	-0.36
33	Vindhyachal, Stage- IV	1000	0.5	0.12	0.19	0.23	0.14	0.06	**0.15**	-0.35
34	Vindhyachal, Stage- V	500	0.5	0.30	0.07	0.20	0.16	0.19	**0.19**	-0.31
35	Barauni Stage-II	500	0.5		14.88*	2.52	1.09	1.16	**1.59**	1.09
36	Darlipali STPS	1600	0.5		2.19	1.59	1.19	0.62	**1.40**	0.90
37	Gadarwara STPS	1600	0.5		4.38*	0.80	1.30	0.81	**0.97**	0.47
38	Kanti-II/Muzaffpur	390	0.5	0.92	0.70	0.52	0.58	0.33	**0.61**	0.11
39	Khargone STPS	1320	0.5		0.90	0.98	0.45	0.80	**0.78**	0.28
40	Nabinagar STPS	1980	0.5		0.92	0.59	0.35	0.42	**0.57**	0.07
41	Vallur	1500	0.5	0.76	1.18	1.33	0.52	0.55	**0.79**	0.29
42	Bokaro	500	1.5	0.53	0.39	0.29	0.52	0.30	**0.40**	-1.10
43	Chandrapura	500	1.5	0.38	0.38	0.20	0.45	0.48	**0.38**	-1.12
44	Durgapur Steel	1000	0.5	0.68	0.33	0.55	0.53	0.35	**0.49**	-0.01
45	Koderma	1000	0.5	0.27	0.28	0.22	0.25	0.11	**0.23**	-0.27
46	Maithon	1050	0.5	0.34	0.32	0.22	0.11	0.15	**0.23**	-0.27
47	Mejia Unit 5-6	500	0.5	0.50	0.40	0.25	0.80	1.26	**0.64**	0.14
48	Mejia Unit 7-8	1000	0.5	0.51	0.46	0.23	0.38	0.19	**0.35**	-0.15
49	Raghunathpur	1200	0.5	0.82	0.37	0.31	0.99	1.05	**0.71**	0.21
Weighted Average SFC (Capacity considered as weight)				**0.44**	**0.88**	**0.57**	**0.53**	**0.43**	**0.52**	**--**

* Relatively very high values not considered in the analysis.

ii) From the above table, it is seen that the weighted average specific oil consumption for 49 coal based NTPC and DVC stations, excluding stations provided with relaxed norms, in individual year is found to vary between 0.43 ml/kWh in 2022-23 to 0.88 ml/kWh in 2019- 20. Out of above 49 stations, 27 stations have specific oil consumption over 5 year period as less than 0.5 ml/kWh. The overall weighted average of specific oil consumption for all stations for 5 year period is 0.52 ml/kWh. *Based on observed performance, the existing norm of 0.5 ml/kWh is considered to be adequate for coal based NTPC and DVC stations.*

2.2.7 For comparison, the weighted average annual specific oil consumption of 45 state sector stations of PSPCL, APGENCO, GSECL, HPGCL, MAHAGENCO,

UPRVUNL, RVUN and TSGENCO has been in the range of 0.89 ml/kWh (in 2022-23) to 1.05 ml/kWh (in 2020- 21). The 5 year average of annual specific oil consumption for these stations is found to vary from 0.24 ml/kWh for UPRVUNL's Anpara BTPS to 2.66 ml/kWh for MAHAGENCO's Koradi TPS. The overall average of annual specific oil consumption for all 45 stations during the 5 year period is 1.07 ml/kWh.

2.2.8 In case of IPPs, the weighted average annual specific oil consumption of the six (06) stations has been in the range of 0.15 ml/kWh (in 2021- 22) to 0.18 ml/kWh (in 2018- 19). The 5 year average of annual specific oil consumption for these stations is found to vary from 0.08 ml/kWh for Sasan TPP to 0.32 ml/kWh for Mahadev Prasad STPP. The overall average of annual specific oil consumption for all 06 stations during the 5 year period is 0.17 ml/kWh.

2.3 Gross Station Heat Rate

2.3.1 The gross station heat rate has been analysed for 5 year period from 2018- 19 to 2022- 23 as per plant operation data received for 123 generating stations/ station stages (henceforth referred as stations), comprising of 112 coal/ lignite based stations and 11 gas/ liquid fuel based stations. The coal/ lignite based stations comprises of 46 stations of NTPC including 1 station of its JV NTECL, 10 stations of DVC including 1 station of its JV Maithon Power Ltd., 6 lignite based stations of NLCIL, 44 stations of state sector, 6 IPP stations. The gas/ liquid fuel based stations comprises of 6 stations of NTPC, 3 stations of NEEPCO, 1 station each of ONGC and PPCL (Pragati Power Corporation Ltd.). The separate data furnished by the utilities for individual stages of a power station, as applicable, have been considered as separate stations.

For coal/ lignite based generating stations, the annual station heat date has been calculated as per annual coal consumption & its weighted average GCV (As Received, total moisture basis) minus 85 kcal/kg except for 2018-19 where GCV(ARB) has been considered, annual secondary fuel oil consumption & its weighted average GCV and annual gross generation of the station. As per details furnished, the coal consumption, in general, comprises of domestic coal, imported coal and spot market/ e- auction coal with major component being that of domestic coal.

2.3.2 CERC, vide its notification dated 6.4.2016, has provided the following station heat rate degradation factors for coal / lignite based generating stations as compensation for part loading of the units:

Sl. No.		Increase in station heat rate (%)

	Unit loading as % of installed capacity of the unit	Sub- critical units	Super- critical units
1.	85- 100	Nil	Nil
2.	75 - 84.99	2.25	1.25
3.	65 - 74.99	4	2
4.	55 - 64.99	6	3

Further, the above increase in station heat rate (%) values have been reviewed and the same has been covered at para 3.1.1 in Section- 3 of this report. And, analysis in this section has been carried out considering presently recommended degradation factors as below:

Sl. No.	Unit loading as % of installed capacity of the unit	Unit Heat Rate Degradation (%)	
		Sub- critical units	Super- critical units
1	85-100	Nil	Nil
2	80-<85	2.1	1.8
3	75-<80	3.0	2.5
4	70-<75	4.0	3.3
5	65-<70	5.1	4.1
6	60-<65	6.1	4.9
7	55-<60	7.6	6.0
8	50-<55	9.2	7.1
9	45-<50	11.3	8.3
10	40-<45	13.8	9.9

The above factors as applicable on case to case basis based on actual unit/ plant loading have been considered for modification/ correction of respective actual/operating station heat rate.

2.3.3 The gross station heat rate of all 112 coal/ lignite fired generating stations for the five (5) year period from 2018- 19 to 2022- 23 is indicated in Annexure- 3. The weighted average of annual operating gross heat rate for all 112 coal/ lignite stations

is found to vary from 2391 kcal/kWh in 2020-21 to 2456 kcal/kWh in 2018-19 with overall weighted average over 5 year period as 2406 kcal/kWh. For 62 central sector stations, the average of annual operating gross heat rate is found to vary in the range of 2366 kcal/kWh (in 2022-23) to 2404 kcal/kWh (in 2018-19) with overall weighted average over 5 year period as 2374 kcal/kWh.

The lowest annual station heat rate is 1977 kcal/kWh TSGENCO's Kothagudem Stage- VII TPS in 2020-21. In central sector, the lowest annual station heat rate is 2082 kcal/kWh NTPC's Kudgi TPS in 2020-21. The highest annual station heat rate for coal based stations had been 3853 kcal/kWh for RVUN's Suratgarh TPS in 2020-21.

Five year average of station heat rate for individual stations vary in the range 2085 kcal/kWh for TSGENCO's Kothagudem Stage- VII TPS to 3158 kcal/kWh for WBPDCL's Kolaghat TPS. In central sector, lowest station heat rate on 5 year average basis is 2134 kcal/kWh for NTPC's Kudgi STPS and the highest is 2920 kcal/kWh for NLC's TPS-II stage-I. The weighted average of five year average heat rate of all the stations amounts to 2406 kcal/kWh and for only coal based stations to 2400 kcal/kWh. For central sector stations, the weighted average of five year average heat rate of all stations amount to 2374 kcal/kWh and for only coal based stations to 2351 kcal/kWh.

2.3.4 The annual plant loading, applicable compensation factor for heat rate degradation due to part loading for individual stations and corrected actual/operating heat rate for individual year of 5 year period is indicated in Annexure- 4.

The weighted average of annual plant loading for all 112 stations in individual year is found to vary in the range 81.7% in 2019-20 to 85.5% in 2022-23. The weighted average of applicable correction in heat rate on annual basis for all 112 stations is found to vary in the range 1.32% in 2018-19 to 2.17% in 2019-20. The weighted average of corrected actual/operating heat rate on annual basis for all 112 stations is found to vary in the range 2289 in 2019-20 to 2371 in 2022-23. The average of annual plant loading for 5 year period for individual station is found to vary in the range 59% (for HPGCL's Deen Bandhu Chhota Ram TPS) to 101% (for Sasan TPS). The overall weighted average of annual plant loading ,applicable correction in heat rate and corrected actual/operating heat rate over 5 year period for all stations is found as 84.1%,1.6% and 2346 respectively.

2.3.5 Analysis of gross station heat rate for coal based stations having COD before 1.4.2009 (except for stations provided with higher relaxed heat rate norms):

In the existing norms, the coal based generating stations having COD before 1.4.2009 are provided with fixed heat norm of 2430 kcal/kWh for 200/210/250 MW sets and 2390 for 500 MW sets (sub-critical) (excluding for specific stations provided with higher relaxed heat rate norms). As per operation data received, there are 22 central sector stations (19 NTPC's stations and 3 DVC's stations) excluding stations

provided with higher relaxed heat rate norms, for which COD of last unit has taken place before 1.4.2009. The analysis of actual/operating heat rate and corrected actual/operating heat rate for individual stations (having COD before 01.04.2009) for individual year is indicated in Annexure- 5.

It is seen that out of 22 stations, there are 9 stations having only 200 MW series units, 9 stations having only 500 MW size units and the rest 4 stations having units of capacity 200 MW and 500 MW both.

Stations having only 500 MW size units

There are 9 stations having only 500 MW size units with existing normative heat rate as 2390 kcal/kWh (8 stations provided with TDBFP) except for Rihand Stage- I TPS with normative heat rate of 2350 kcal/kWh as this station is provided with MDBFP.

The average of operating heat rate for the one station with MDBFP is found to vary in the range 2304 kcal/kWh (for 2020-21) and 2370 kcal/kWh (for 2021-22). The corrected operating heat rate of the station is same as operating heat rate as no correction is applicable due to loading of the station being above 85% in all the years between 2018-23. *The overall average of corrected operating heat rate for this station with MDBFP over five year period is found as 2340 kcal/kWh which is 10 kcal/kWh less than the existing norm of 2350 kcal/kWh.*

The weighted average of operating heat rate for all stations with TDBFP for individual year is found to vary in the range 2373 kcal/kWh (for 2021-22) and 2394 kcal/kWh (for 2019-20). However, the weighted average of corrected operating heat rate for all stations with TDBFP for individual year is found to vary in the range 2363 kcal/kWh (for 2019-20) and 2379 kcal/kWh (for 2020-21).

The average operating heat rate for individual stations for five year period under consideration is found to vary in the range 2326 kcal/kWh (for Ramagundam- Stage-III TPS) to 2434 kcal/kWh (Simhadri, Stage- I TPS). The overall weighted average operating heat rate for all 8 stations with TDBFP over five year period is found as 2385 kcal/kWh. The average corrected operating heat rate for individual stations for five year period under consideration is found to vary in the range 2316 kcal/kWh (for Ramagundam- Stage- III TPS) to 2386 kcal/kWh (Talcher, Stage-ITPS). The overall weighted average of corrected operating heat rate for all 8 stations with TDBFP over five year period is found as 2371 kcal/kWh which is 19 kcal/kWh less than the existing norm of 2390 kcal/kWh. *Based on observed performance as above, the existing norm of 2390 kcal/kWh for gross station heat rate of 500 MW sets (sub-critical) for stations having achieved COD before 1.4.2009 is proposed to be reasonably decreased by 15 kcal/kWh to 2375 kcal/kWh.*

Stations having only 200/ 210/ 250MW size units

In this category, there are 9 stations (all provided with MDBFP) with existing normative heat rate as 2430 kcal/kWh. The analysis of operating gross station heat

rate and corrected actual/operating heat rate for these stations is indicated in Annexure- 5.

The weighted average of operating heat rate for all stations for individual year is found to vary in the range 2455 kcal/kWh (for 2021-22 & 2022-23) and 2467 kcal/kWh (for 2019-20). However, the weighted average of corrected operating heat rate for all stations for individual year is found to vary in the range 2377 kcal/kWh (for 2020-21) and 2417 kcal/kWh (for 2022-23).

The average operating heat rate for individual stations for five year period under consideration is found to vary in the range 2422 kcal/kWh (for Mejia Unit 4) to 2540 kcal/kWh (Unchahar, Stage- ITPS). The overall weighted average operating heat rate for all 9 stations over five year period is found as 2462 kcal/kWh. The average corrected operating heat rate for individual stations for five year period under consideration is found to vary in the range 2304 kcal/kWh (for Mejia Unit 4) to 2442 kcal/kWh (Unchahar, Stage- I TPS). The overall weighted average of corrected operating heat rate for all 9 stations over five year period is found as 2397 kcal/kWh which is 33 kcal/kWh less than the existing norm of 2430 kcal/kWh. *Based on observed performance as above, the existing norm of 2430 kcal/kWh for gross station heat rate of 200/210/250 MW sets (sub-critical) for stations having achieved COD before 1.4.2009 is proposed to be reasonably decreased by 30 kcal/kWh to 2400 kcal/kWh.*

However, after furnishing the recommendation to CERC, DVC has submitted revised data (via. email dated 15.03.2024) of Plant Loading for Mejia Unit 1-3, Mejia Unit 4 and Mejia Unit 5-6. The revised data submitted by DVC has been further analysed. The revised analysis of operating gross station heat rate and corrected actual/operating heat rate for stations having only 200/ 210/ 250MW size units (COD before 2009) is indicated in Annexure- 5(a). As per the analysis, it has been found the average Corrected Actual Heat Rate of Central Sector stations (NTPC & DVC) in respect of 200-300 MW commissioned before 2009 is 2419 kcal/kWh instead of 2397 kcal/kWh as calculated earlier. In view of this, *gross station heat rate of 200/210/250 MW sets (sub-critical) for stations having achieved COD before 1.4.2009 is proposed to be reasonably revised to 2415 kcal/kWh.*

2.3.6 The analysis of gross station heat rate of NTPC stations provided with relaxed heat rate norms:

M/s NTPC's Talcher TPS and Tanda TPS are presently provided with relaxed relaxed heat rate norm of 2830 and 2750 kcal/kWh respectively. In case of Talcher TPS, the heat rate norm of 2830 pertains to the capacity of 460 MW (4x60 + 2x110) existed at the beginning of the current tariff period. All the 6 units of Talcher TPS stage-I have been retired w.e.f. 01.04.2021. As such, this plant has not been

considered further for any norm. The analysis of operating gross station heat rate and corrected actual/operating heat rate for remaining one station (i.e. Tanda-440 MW) and one more station (i.e. Kanti-II – 390 MW) is indicated in Table- 2.12 below.

Table- 2.12: Analysis of gross station heat rate (SHR) of NTPC stations provided with relaxed heat rate norms.

Power Station	**Existing Normative HR (kcal/kWh)**	**2018-19**		**2019-20**		**2020-21**		**2021-22**		**2022-23**		**5 year avg. of Actual SHR (kcal/kWh)**	**5 year avg. of Corrected Actual SHR (kcal/kWh)**
		Actual SHR (kcal/kWh)	**Corrected Actual SHR (kcal/kWh)**	**Actual SHR (kcal/kWh)**	**Corrected Actual SHR (kcal/kWh)**	**Actual SHR (kcal/kWh)**	**Corrected Actual SHR (kcal/kWh)**	**Actual SHR (kcal/kWh)**	**Corrected Actual SHR (kcal/kWh)**	**Actual SHR (kcal/kWh**	**Corrected Actual SHR (kcal/kWh)**		
Tanda (440 MW)	2750	2844	2761	2837	2728	2873	2733	2865	2726	2963	2849	**2876**	**2759**
Kanti-II (390 MW)	2387	2631	2504	2610	2484	2557	2433	2579	2504	2527	2527	**2581**	**2491**

In case of Tanda TPS, the relaxed heat rate norm of 2750 kcal/kWh is applicable to its 4x110 MW units. The average heat rate of the station for five year period is found to vary in the range 2837 kcal/kWh (for 2020-21) to 2963 kcal/kWh (for 2022-23) with average heat rate for five year period being 2876 kcal/kWh. However, the average corrected actual heat rate of the station for five year period is found to vary in the range 2726 kcal/kWh (for 2021-22) to 2849 kcal/kWh (for 2022-23) with average corrected heat rate for five year period being 2759 kcal/kWh. *Considering existing operational performance, the relaxed heat rate norm of 2750 kcal/kWh for the station is proposed to be retained for 110 MW units of the station.*

In case of Kanti-II TPS, the average heat rate of the station for five year period is found to vary in the range 2527 kcal/kWh (for 2022-23) to 2631 kcal/kWh (for 2018-19) with average heat rate for five year period being 2581 kcal/kWh. However, the average corrected actual heat rate of the station for five year period is found to vary in the range 2433 kcal/kWh (for 2020-21) to 2527 kcal/kWh (for 2022-23) with average corrected heat rate for five year period being 2491 kcal/kWh. *Considering existing operational performance, the heat rate norm for Kanti-II TPS is proposed to be 2500 kcal/kWh.*

2.3.7 The analysis of gross station heat rate of DVC stations provided with relaxed heat rate norms:

M/s DVC's Bokaro TPS, Chandrapura TPS (Unit 3) and Durgapur TPS are presently provided with relaxed heat rate norm of 2700, 3000 and 2750 kcal/kWh respectively.

In case of Bokaro TPS, the heat rate norm of 2700 kcal/kWh pertains to 210 MW (1x210) MW existing at the beginning of the current tariff period. During existing norm period, 210MW (Unit-3) has been retired w.e.f 01.04.2021. As such, this plant also has not been considered further for any norm.

In case of Chandrapur TPS, the heat rate norm of 3000 kcal/kWh pertains to the capacity of 130 MW (unit-3) existing at the beginning of the current tariff period. The 130 MW unit- 3 has been retired w.e.f. 19.03.2020. As such, this plant also has not been considered further for any norm.

In case of Durgapur TPS 2750 kcal/kWh pertains to Unit-4 (1x210 MW) existing at the beginning of the current tariff period. During existing norm period, 210MW (Unit-4) has been retired w.e.f 19.12.2022. As such, this plant also has not been considered further for any norm.

2.3.8 The analysis of gross station heat rate of lignite fired stations of NLCIL provided with relaxed heat rate norms:

M/s NLCIL's TPS- I, TPS- I Expansion and TPS- II (Stage- I & II) are presently provided with relaxed heat rate norm of 4000, 2720 and 2890 kcal/kWh respectively. In case of TPS- I, the heat rate norm of 4000 pertains to 500 MW (6x50+2x100) existing at the beginning of the current tariff period. During existing norm period, Units-1&9 150MW (1x50+1x100), Units-2,4&8 200 MW (2x50+1x100), Unit-3 (50MW), Unit-5(50MW) and Unit-6(50MW), have been retired w.e.f. 31.03.2020, 08.07.2020, 30.07.2020, 28.09.2020 and 30.09.2020 respectively. As such, this plant has not been considered further for any norm.

The analysis operating gross station heat rate and corrected actual/operating heat rate for remaining stations and one more station (i.e. Barsingsar – 250 MW) is indicated in Table- 2.13 below.

Table- 2.13: Analysis of gross station heat rate (SHR) of NLCIL stations provided with relaxed heat rate norms.

Power Station	**Existing N**	**2018-19**		**2019-20**		**2020-21**		**2021-22**		**2022-23**		**5 year avg.**	**5 year avg.**
		Actual	**Correct**	**Actual**	**Correct**	**Actual**	**Correct**	**Actual**	**Correct**	**Actual**	**Correct**		

	ormative HR (kcal/kWh)	**SHR (kcal/kWh)**	**ed Actual SHR (kcal/kWh)**	**SHR (kcal/kWh)**	**ed Actual SHR (kcal/kWh)**	**SHR (kcal/kWh)**	**ed Actual SHR (kcal/kWh)**	**SHR (kcal/kWh)**	**ed Actual SHR (kcal/kWh)**	**SHR (kcal/kWh**	**ed Actual SHR (kcal/kWh)**	**of Actual SHR (kcal/kWh)**	**of Corrected Actual SHR (kcal/kWh)**
Barsingsar (250 MW)	2625	2546	2546	2548	2548	2513	2513	2530	2530	2540	2540	**2536**	**2536**
TPS I Exp. (420 MW)	2720	2715	2715	2713	2713	2712	2712	2719	2719	2714	2714	**2714**	**2714**
TPS II Stg- I (630 MW)	2890	2893	2893	2887	2887	2885	2885	2888	2888	3047	2984	**2920**	**2908**
TPS II Stg- II (840 MW)	2890	2893	2893	2888	2888	2886	2886	2890	2890	3038	2976	**2919**	**2907**

It is to mention that as per level of plant loading being consistently above 85%, no degradation of heat rate is involved in individual years in case of TPS- I Expansion and Barsingsar TPS over the 5 year period, TPS- II Stage- I for 4 year (2018-19 to 2021-22) and TPS- II Stage- II also for 4 year (2018-19 to 2021-22) indicating corrected actual heat rate values same as actual heat rate values for these respective years.

i) In case of Barsingsar TPS (COD after 2009), as per level of plant loading being consistently above 85%, no degradation of heat rate is involved in individual years the 5 year period. The operating heat rate of varies in the range 2513 kcal/kWh in 2020-21 to 2548 kcal/kWh in 2019-20. The average SHR over 5 year period amounts to 2536 kcal/kWh. *Based on observed performance, the relaxed normative SHR of 2525 kcal/kWh for* Barsingsar TPS *is proposed.*

ii) In case of TPS- I Expansion, the operating heat rate of varies in the range 2712 kcal/kWh in 2020-21 to 2719 kcal/kWh in 2021-22. The average SHR over 5 year period amounts to 2714 kcal/kWh which is 6 kcal/kWh less than normative SHR of 2720 kcal/kWh. *Based on observed performance, the relaxed normative SHR of 2720 kcal/kWh for TPS- I expansion is proposed to be reasonably decreased by 10 kcal/kWh. (i.e. 2710 kcal/kWh.)*

iii) In case of TPS- II Stage- I and TPS- II Stage- II, the corrected actual is same as actual heat rate for 4 years from 2018-19 to 2021-22 as level of plant loading being consistently above 85% and no applicable degradation of heat rate is involved in these years. The year on year performance of both the stations are similar in terms of heat rate values. The corrected actual/operating heat rate of TPS- II Stage- I varies in the range 2885 kcal/kWh in 2020-21 to 2984 kcal/kWh in 2022-23 and that of TPS- II Stage- II varies in the range 2886 kcal/kWh in 2020-21 to 2976 kcal/kWh in 2022-23. The average corrected actual/operating heat rate over 5 year period of TPS- II Stage- I amounts to 2908 kcal/kWh and that of TPS- II Stage- II amounts to 2907 kcal/kWh which is 17-18 kcal/kWh more than existing normative SHR of 2890 kcal/kWh. However, the operating heat rate is lower or equal than the normative heat rate in first 4 years and exceptionally high heat rate in 2022-23. Excluding the heat rate values of 2022-23, the average corrected actual/operating heat rate over first 4 year period of TPS- II Stage- I amounts to 2888 kcal/kWh and that of TPS- II Stage- II amounts to 2889 kcal/kWh which is 1-2 kcal/kWh less than normative SHR of 2890 kcal/kWh. *Based on observed performance, the relaxed normative SHR of 2890 kcal/kWh for TPS- II Stage- I and TPS- II Stage- II is proposed to be reasonably decreased by 10 kcal/kWh. (i.e. 2880)*

2.3.9 Analysis of gross station heat rate for coal based stations having COD on or after 1.4.2009:

i) As per operation data received, there are total 31 central utility coal based stations excluding stations provided with relaxed norms having COD of last unit on or after 1.4.2009. The stations considered comprise of 24 NTPC stations, 7 DVC stations.

ii) In the existing norms, the thermal generating stations having COD on or after 1.4.2009 are provided with normative heat rate of 1.05 times the design heat rate. For these stations, the conditionality of design heat rate admissible as per prescribed minimum boiler efficiency (86% for indigenous coal and 89% for imported coal), & maximum unit heat rate as per turbine inlet steam parameters is also applicable. The design station heat rate of the individual stations considered in the analysis as per data on turbine cycle heat rate at design condenser pressure & design boiler efficiency furnished by the utilities and limiting turbine heat rate values and boiler efficiency values as per applicable CERC regulations are indicated in Annexure- 6.

iii) The analysis of deviation of actual/operating heat rate and corrected actual/operating heat rate both w.r.t design heat rate of individual stations for all 31 stations in individual years is indicated in Annexure-7. Further, three specific cases of 5 year average deviation of corrected actual heat rate w.r.t design heat rate values found relatively very high (6.81% for NTPC's Farakka Stage-III TPS, 8.08% for NTPC's Barh Stage-I TPS and 6.19% for NTPC's Tanda Stage-II TPS) and two specific cases of 5 year average deviation of corrected actual heat rate w.r.t design

heat rate values found relatively very low(-0.99% for DVC's Ragunathpur TPS, -3.12% for NTPC's Kudgi TPS) and have been observed, thus these five stations have been ignored in the analysis. In case of two stations i.e Nabinagar STPS and Solapur STPS, it has been observed that the deviation of corrected actual heat rate w.r.t design heat rate values in initial one or two year of Commissioning is high while it improved in the subsequent years, thus the there high values if deviation (7.69 % in 2019-20 for Nabinagar STPS and 7.47% in 2018-19, 8.2% in 2019-20 for Solapur STPS) have also been ignored in the analysis.

iv) Referring to Annexure- 7, it is seen that out of 31 stations, there are 3 stations having only 200 MW series units, 16 stations having only 500-600 MW size units and 12 stations having only 660-800 MW size supercritical units.

Stations having only 200 MW series units

The weighted average of deviation of corrected actual heat rate from the design heat rate for the 3 stations under this category is found as 4.89%. *As such, existing applicable 5.0% operating margin in gross station heat rate for 200 MW series units having achieved COD on or after 1.4.2009 is found to be reasonable.*

Stations having 500 MW and above size units

There are 28 stations in this category comprising of 16 stations having only 500-600 MW size units and 12 stations having only 660-800 MW size supercritical units.
The deviation of corrected operating heat rate from the design heat rate is found to vary over a wide range from (-)0.81% for Vallur TPS in 2021-22 to 7.71% for Maithon TPS in 2021-22. The weighted average of operating heat rate deviation from the design heat rate for all 28 stations in individual years is found to vary in the range 5.11% (in 2021-22) to 6.78% (in 2018-19) and consistently decreased over the 4 year period (from 2018-19 to 2021-22). The weighted average of corrected operating heat rate deviation from the design heat rate for all 28 stations in individual years is found to vary in the range 3.13 % (in 2019-20) to 4.73% (in 2018-19). The average of corrected operating heat rate deviation from the design heat rate for individual station over 5 year period is found to vary in the range 1.63% for Lara STPS to 5.5% for Mejia Unit 7-8 (ignoring 5 stations with exceptionally high or low values) with weighted average for all station over five year period as 3.65%(4.04% for 500-600MW sets stations, 3.30% for 660-800MW sets super-critical stations). *Based on the above performance, 4.0% operating margin in gross station heat rate for 500 MW and above size units having achieved COD on or after 1.4.2009 is proposed.*

2.3.10 Analysis of gross station heat rate for lignite based stations having COD on or after 1.4.2009:

As per operation data received, there are only 2 central utility lignite based stations, i.e NLC's TPS-II Expansion (CFBC) and NNTPS, excluding stations provided with relaxed norms having COD of last unit on or after 1.4.2009.

In the existing norms, it is provided that in case of lignite-fired generating stations having COD on or after 1.4.2009 (including stations based on CFBC technology), maximum design heat rates shall be increased using factor for moisture content as given below:

(a) For lignite having 50% moisture: 1.10
(b) For lignite having 40% moisture: 1.07
(c) For lignite having 30% moisture: 1.04

As per the existing norm, for calculating design heat rate the min boiler efficiency to be considered, i.e. 86% in respect of the stations in this category, is same as that applicable to coal based stations. The design boiler efficiency of TPS-II Expansion is 78.62 % and that of NNTPS is 75.32% as per the provided data which is lower than the design boiler efficiency of coal based stations under same pressure and temperature category. One of the major contributor in this is the high moisture content in lignite compared to coal.

For analysis of operational data of the two stations 2 cases are considered in respect of Design Heat Rate calculation:

Case-1: As per the existing norms, min. boiler efficiency of 86%, multiplying factor of 1.1 applicable for 50% moisture content has been considered.

Case-2: For min. boiler efficiency 76% (for pulverized) for NNTPS and 80 %(for CFBC) for TPS-II expansion has been considered without applying multiplying factor for moisture content.

Table- 2.14: The analysis of deviation of actual/operating heat rate and corrected actual/operating heat rate both w.r.t design heat rate (case-1 and case-2) for these stations in individual years is indicated in below table.

Power Station	**Design Heat Rate**	**2018-19**		**2019-20**		**2020-21**		**2021-22**		**2022-23**		**5 year avg. Dev. Of Actual w.r.t DHR**	**5 year avg. Dev. Of Corrected Actu**
		Dev. Of Actual w.r.t DHR	**Dev. Of Corrected Actual w.r.**	**Dev. Of Actual w.r.t DHR**	**Dev. Of Corrected Actual w.r.**	**Dev. Of Actual w.r.t**	**Dev. Of Corrected Actual w.r.t**	**Dev. Of Actual w.r.t**	**Dev. Of Corrected Actual w.r.**	**Dev. Of Actual w.r.t DHR**	**Dev. Of Corrected Actual w.r.**		

			t DHR		t DHR	DHR	DHR	DHR	t DHR		t DHR		al w.r.t DHR
TPS II Exp. CFBC(2x250 MW)	2494 (Case-I)	3.82%	3.82%	3.73%	1.60%	2.86%	-0.14%	2.81%	-0.18%	2.97%	0.85%	**3.24%**	**1.19%**
	2438(Case-II)	6.23%	6.23%	6.14%	3.96%	5.25%	2.18%	5.20%	2.14%	5.36%	3.20%	**5.64%**	**3.54%**
NNTPS (2x500 MW)	2468 (Case-I)			5.36%	1.31%	5.79%	3.62%	7.09%	7.09%	6.78%	6.78%	**6.25%**	**4.70%**
	2539 (Case-II)			2.42%	-1.52%	2.84%	0.72%	4.10%	4.10%	3.80%	3.80%	**3.29%**	**1.77%**

In case of TPS- II Exp (CFBC) , in case-I as per existing norm, the 5 year average deviation of actual Heat Rate and corrected actual Heat Rate is 3.24% and 1.19% respectively which is 1.76 % point and 3.81 % point lower than the applicable 5% norm. However, in case-II with 80% as min boiler efficiency without applying multiplying factor for moisture, the 5 year average deviation of actual Heat Rate and corrected actual Heat Rate is 5.64% and 3.54% respectively which is 0.64% point higher and 1.46% point lower than the applicable 5% norm. *Based on observed performance, it is proposed that minimum boiler efficiency of 80% may be introduced and the multiplying factor for moisture content may be removed for TPS-II expansion. The operational margin of 5 % applicable as per the existing norm may be retained.*

In case of NNTPS, in case-I as per existing norm, the 5 year average deviation of actual Heat Rate and corrected actual Heat Rate is 6.25% and 4.7% respectively which is 1.25 % point higher and 0.3 % point lower than the existing 5% norm. However, in case-II with 76% as min boiler efficiency without applying multiplying factor for moisture, the 5 year average deviation of actual Heat Rate and corrected actual Heat Rate is 3.29% and 1.77% respectively which is 1.77% point lower and 3.23% point lower than the applicable 5% norm. However, it is evident from above table there is year on year variation in operation margin, by excluding the first two years after COD of the station i.e excluding FY 2019-20 and FY 2020-21, the 2 year (2021-22 and 2022-23) in case-II, average deviation of actual Heat Rate same as corrected actual Heat Rate w.r.t design is 3.95% which is 0.05% point lower than the recommended norm of 4% operation margin for coal based station with 500 MW units. *Based on observed performance, it is proposed that minimum boiler efficiency*

of 76% and 4% operation margin may be introduced and the multiplying factor for moisture content may be removed for NNTPS.

2.3.11 Design Heat Rate of Thermal Generating Stations (coal & lignite) having COD achieved on or after 1.4.2009:

Following changes (highlighted in RED) in the Regulation 49 (C) (b) (i) of CERC Tariff Regulation, 2019 are proposed.

The normative gross station heat rate[#] of coal-based and lignite-fired thermal generating stations other than those provided with relaxed norms:

For 200/210/250 MW sets= 1.05 X Design Heat Rate (kcal/kWh)

For 500 MW sets & above= 1.04 X Design Heat Rate (kcal/kWh)

Where the Design Heat Rate of a generating unit means the unit heat rate guaranteed by the supplier at conditions of 100% MCR, zero percent make up, design coal and design cooling water temperature/back pressure.

Provided that depending upon the pressure and temperature ratings of the units, the maximum design turbine cycle heat rate and minimum design boiler efficiency shall be as per the table below.

In case designed turbine cycle heat rate and boiler efficiency are better than these values, the same shall be considered for calculation of unit heat rate.

Pressure Rating (kg/ cm^2)	150	170	170
SHT / RHT (^{0} C)	535/535	537/537	537/565
Type of BFP	Electrical Driven	Turbine Driven	Turbine Driven
Max Turbine Heat Rate (kcal/kWh)	1955	1950	1935

Minimum Boiler Efficiency*(Percentage)			
Sub-Bituminous Indian Coal (%)	86	86	86
Bituminous imported coal (%)	89	89	89

Pressure Rating (kg/ cm^2)	247	247	260	270	270
SHT / RHT (^{0} C)	537/ 565	565/ 593	593/ 593	593/ 593	600/ 600
Type of BFP	Turbine Driven	Turbine Driven	Turbine Driven	Turbine Driven	Turbine Driven
Max Turbine Heat Rate(kcal/kWh)	1900	1850	1814	1810	1790
Minimum Boiler Efficiency*(Percentage)					
Sub-Bituminous Indian coal (%)	86	86	86	86.5	86.5
Bituminous imported coal (%)	89	89	89	89.5	89.5

* For lignite fired thermal generating station, the minimum boiler efficiency shall be 76% (for pulverised) and 80 %(for Fluidised bed) based boilers.

In case pressure and temperature parameters of a unit are different from ratings given in the above table, the maximum design turbine cycle heat rate & minimum boiler efficiency of the nearest class shall be taken.

For units based on dry cooling system, the maximum turbine cycle heat rate shall be considered as per the actual design or 6% higher than the values given in the table above, whichever is lower.

In the CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022, for units with pressure rating as 270 kg/ cm^2 and SHT / RHT (0 C) as 600/600, the Max Turbine Heat Rate(kcal/kWh) is specified as 1790 kcal/kWh. In consideration of the CEA regulation and in order to maintain uniformity in different regulations it is proposed that the existing value of Max Turbine Heat Rate in this category may be revised to 1790 kcal/kWh from 1800 kcal/kWh.

It has been requested by a utility having unit/station with pressure rating as 260 kg/ cm^2 and SHT / RHT (0 C) as 593/593 to include the parameters of this specification in the above table. In consideration of the request, data has been collected from OEM and accordingly Max Turbine Heat Rate (kcal/kWh), boiler efficiency has been included in this category. In consideration of above, it is proposed to include the column of pressure rating as 260 kg/ cm^2 and SHT / RHT (0 C) as 593/593.

i) The impact of change of BFP drive from steam turbine driven to electric motor driven on unit heat rate shall be mentioned as below:

> "In respect of generating units where the boiler feed pumps are electrically operated, the maximum design unit heat rate shall be 40 kcal/kWh lower than the maximum design unit gross heat rate with turbine driven BFP."

The normative heat rate values are arrived after applying the degradation factors given in table at F(1)(i) for coal/lignite based generating stations. In case degradation factors given in table at F(1)(i) are modified, the normative heat rate values need to be corrected accordingly and vice-versa.

2.3.12 Analysis of gross station heat rate for gas/ liquid fuel based thermal generating stations:

i) The gross station heat rate data has been analysed for 5 year period from 2018-19 to 2022- 23 for 11 gas/ liquid fuel based generating stations comprising of 3 NEEPCO, 6 NTPC stations and 1 station each of ONGC (OTPCL Tripura gas) and RGPPL. NTPC Kayakulam has not been considered in the analysis as there was no generation from the station during the entire period from 2018-19 to 2022-23. Plant loading data was not available for Pragati gas (PPCL) due to which it has not been considered in the analysis below.

ii) It is understood that stations operate at part load due to which heat rate of the station increases. In case of gas based stations, there are two modes of operation i.e. CCGT (closed cycle) and open cycle and both the modes of operation have different impacts on increase in heat rate of the gas stations. However, in the operation data provided by the utilities, separate data regarding different mode of operation has not been furnished. Therefore in the analysis, station heat rate degradation factors for gas/ liquid fuel based generating stations as compensation for part loading is considered only in closed cycle mode of operation. The correction factors for expected heat rate degradation of the gas/ liquid fuel based stations at part loading under CCGT mode as proposed under para 3.2.1 is reproduced below.

Sl. No.	**Module/ plant loading as % of installed capacity**	**Increase in station heat rate in CCGT mode(%)**
1.	85 - 100	Nil
2.	80 - < 85	2.5
3.	70 - < 80	5
4.	60 - < 70	8
5.	50 - < 60	12

The above factors as applicable on case to case basis based on actual unit/ plant loading have been considered for modification/ correction of respective station heat rate.

iii) The details of plant loading and expected station heat rate degradation due to part load operation for all 11 stations for 5 year period from 2018- 19 to 2022- 23 are indicated in Table- 2.15 below.

Table- 2.15: Annual plant loading factor and station heat rate (SHR) degradation factor of 11 gas/ liquid fuel based thermal generating stations for which operational data was furnished to CEA for the 5 year period 2018- 19 to 2022- 23.

Sl. No.	Power Station	2018- 19		2019- 20		2020- 21		2021- 22		2022- 23		5 year average of plant loading (%)	5 year avg. of SHR degradation (%)
		Plant loading (%)	Applicable SHR degradation (%)	Plant loading (%)	Applicable SHR degradation (%)	Plant loading (%)	Applicable SHR degradation (%)	Plant loading (%)	Applicable SHR degradation (%)	Plant loading (%)	Applicable SHR degradation (%)		
1	AGBP, Gas	67.25	8	70.49	5	66.71	8	73.78	5	68.57	8	69.36	6.8
2	AGTCCP, Gas	65.36	8	76.94	5	77.72	5	82.09	2.5	72.97	5	75.016	5.1
3	TGBP, Gas	85.28	0	84.24	2.5	70.32	5	90.65	0	91.31	0	84.36	1.5
4	Anta, Gas	64.07	8	57.92	12	62.78	8	56.67	12	60.79	8	60.446	9.6
5	Faridabad, Gas	61.45	8	61.7	8	67	8	60.03	8	34.24	12	56.884	8.8
6	Auraiya, Gas	60.12	8	59.79	12	62.25	8	59.76	12	66.57	8	61.698	9.6
7	Dadri, Gas	58.18	12	58.7	12	59.12	12	60.17	8	59.55	12	59.144	11.2
8	Gandhar, Gas	53.48	12	57	12	51.08	12	50.55	12	63.66	8	55.154	11.2
9	Kawas, Gas	72.83	5	72.67	5	67.8	8	62.61	8	66.79	8	68.54	6.8
10	Ratnagiri, Gas	70.76	5	71.38	5	60.86	8	63.01	8	57.96	12	64.794	7.6
11	Tripura, Gas (OTPC)	78.2	5	89.61	0	85.65	0	79.94	5	85.47	0	83.774	2.0
	Average of all stations	**66.51**	**7.3**	**68.24**	**7.2**	**64.35**	**7.9**	**63.58**	**8.3**	**63.19**	**8.9**	**65.17**	**7.9**

In the above table, the average annual plant/ station loading has been calculated as per consideration of annual gross generation, station capacity and operating hours. The annual operating hours of the station has been worked out as per average of operating hours for each GT/ ST of the CCGT station.

It is seen that average of annual plant loading for heat rate consideration all 11 stations vary in the range 63.6% (in 2021- 22) and 68.2% (in 2019- 20). As per factors considered, the average of SHR degradation for all stations varies in the range 7.24% (for 2019-20) to 8.86% (for 2022- 23). The average of SHR

degradation for individual station averaged over 5 year period is in the range 1.5% (for TGBP station) to 11.2% (for Dadri & Gandhar stations) with overall average for all 11 stations over 5 year period being 7.9%.

iv) Analysis of gross station heat rate for gas/ liquid fuel based stations having COD before 1.4.2009:

These stations are provided with fixed station heat rate by CERC for operation in both CCGT mode and open cycle mode.

The operating SHR and its deviation from the applicable norm for above 09 stations for the five (5) year period from 2018- 19 to 2022- 23 is indicated in Table-2.16 below.

Table- 2.16: Actual station heat rate (SHR) of 09 gas/ liquid fuel based thermal generating stations provided with fixed normative heat rate in closed cycle mode (COD before 1.4.2009)

Sl No.	**Power Station**	**Normative SHR (kcal/kWh)**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**5 year average of actual SHR (kcal/kWh)**	**5 yr. avg. dev. of actual SHR from normative SHR (kcal/kWh)**
			Actual SHR (kcal/kWh)	**Actual SHR (kcal/kWh)**	**Actual SHR (kcal/kWh)**	**Actual SHR (kcal/kWh)**	**Actual SHR (kcal/kWh)**		
1.	NEEPCO, AGBP (291 MW)	2600	2467	2616	2671	2671	2682	2621.6	**131.2**
2.	NEEPCO, Agartala GBP (135 MW)	2600	2580	2607	2624	2589	2681	2616.0	**257.6**
3.	NTPC, Anta (419.33 MW)	2075	2204	2349	2233	2891	3285	2592.6	**22.5**
4.	NTPC, Faridabad (431.586 MW)	1975	2021	2035	2013	2085	2560	2142.9	**-9.2**
5.	NTPC, Auriya (663.36 MW)	2100	2288	2367	2290	2405	3000	2470.1	**41.5**
6.	NTPC, Dadri (829.78 MW)	2000	2119	2152	2105	2163	2435	2194.9	**31.6**
7.	NTPC, Gandhar (657.39 MW)	2040	2332	2371	2134	2337	2919	2418.8	**50.9**

8.	NTPC, Kawas (656.2 MW)	2050	2074	2096	2081	2397	2947	2319.1	**-2.7**
9.	RGPPL, Ratnagiri (1967.08 MW)	1820	1833	1840	1855	1883	1895	1861.2	**8.9**
Weighted Average of all stations			**2088.7**	**2129.8**	**2085.8**	**2221.8**	**2514.7**	**2208.2**	**200.3**

Based on the actual SHR and station loading data (available for each year in the table 2.11), the corrected actual SHR of the above 09 stations is determined. The corrected actual SHR and its deviation from the applicable norm for above 09 stations for the five (5) year period from 2018- 19 to 2022- 23 is indicated in Table-2.17 below.

Table- 2.17: Analysis of corrected actual station heat rate (SHR) of 09 gas/ liquid fuel based thermal generating stations provided with fixed normative heat rate in closed cycle mode (COD before 1.4.2009)

Sl No.	**Power Station**	**Normative SHR (kcal/kWh)**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**5 year average of corrected actual SHR**	**5 yr. avg. dev. of corrected actual SHR from normative SHR (kcal/kWh)**
			Corrected Actual SHR (kcal/kWh)	**Corrected Actual SHR (kcal/kWh)**	**Corrected Actual SHR (kcal/kWh)**	**Corrected Actual SHR (kcal/kWh)**	**Corrected Actual SHR (kcal/kWh)**		
1.	NEEPCO, AGBP (291 MW)	2600	2285	2491	2473	2544	2483	**2455.4**	**-144.6**
2.	NEEPCO, Agartala GBP (135 MW)	2600	2389	2483	2499	2525	2553	**2489.8**	**-110.2**
3.	NTPC, Anta (419.33 MW)	2075	2041	2097	2068	2581	3042	**2365.9**	**290.9**
4.	NTPC, Faridabad (431.586 MW)	1975	1871	1885	1864	1930	2286	**1967.2**	**-7.8**
5.	NTPC, Auriya (663.36 MW)	2100	2119	2114	2121	2147	2777	**2255.5**	**155.5**
6.	NTPC, Dadri (829.78 MW)	2000	1892	1921	1879	2003	2175	**1974.1**	**-25.9**
7.	NTPC, Gandhar (657.39 MW)	2040	2082	2117	1906	2087	2703	**2179.0**	**139.0**

8.	NTPC, Kawas (656.2 MW)	2050	1975	1997	1927	2220	2729	**2169.4**	**119.4**
9.	RGPPL, Ratnagiri (1967.08 MW)	1820	1746	1753	1717	1744	1692	**1730.2**	**-89.8**
Weighted Average of all stations			**1937.7**	**1966.5**	**1915.6**	**2039.8**	**2292.6**	**2030.4**	**22.5**

61.2 8

From above table, it is seen that average of annual corrected SHR for all 09 stations in individual years is found to vary in the range 1916 kcal/kWh in 2020- 21 to 2293 kcal/kWh in 2022- 23.

The deviation of corrected actual SHR from normative SHR averaged over 5 year period is found to vary in the range (-)144.6 kcal/kWh for NEEPCO's Assam GBP station to 290.9 kcal/kWh for NTPC's Anta station, with overall deviation for all 09 stations being 22.5 kcal/kWh. The corrected actual SHR is more than normative SHR for NTPC Anta, Auraiya, Gandhar and Kawas gas stations and less than normative SHR for both the NEEPCO's stations, NTPC Faridabad, Dadri and Ratnagiri. It is seen that corrected actual SHR of all 09 stations averaged over 5 year period is 22.5 kcal/kWh, which is 1.02% more than the average normative SHR.

Based on observed performance, the existing fixed station heat rate norms for gas/ liquid based stations having COD before 1.4.2009 is proposed to be continued.

vi) Analysis of gross station heat rate for gas/ liquid fuel based stations having COD on or after 1.4.2009:

Out of 13 stations for which operation has been received, 03 stations (NEEPCO's TGBP, ONGC's Tripura and PPCL's Pragati stations) are considered as provided with norm based on design SHR. However, due to above mentioned reasons PPCL's Pragati station has not been considered in the analysis.

The actual SHR and its deviation from the design SHR for these stations for the five (5) year period from 2018- 19 to 2022- 23 is indicated in Table- 2.18 below.

Table- 2.18: Analysis of actual (SHR) of 02 gas/ liquid fuel based thermal generating stations provided with operation margin on design heat rate (COD on or after 1.4.2009)

Sl. No.	**Power Station**	**Design SHR**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**5 yr. avg. of**	**Deviation of 5 yr. avg. of**

		(kcal/kWh)	Actual SHR (kcal/kWh)	Actual SHR (kcal/kWh)	Actual SHR (kcal/kWh)	Actual SHR (kcal/kWh)	Actual SHR (kcal/kWh)	actual SHR (%)	actual SHR from design SHR (%)
1.	NEEPCO, TGBP (101 MW)	1876.4	1970	1975	2167	2025	2032	**2034**	**8.4**
2.	ONGC, Tripura, ONGC (726.6 MW)	1739.4	1791	1757	1764	1802	1798	**1782**	**2.5**

Based on the actual SHR and station loading data (available for each year in the table 2.19), the corrected actual SHR of the above 02 stations is determined. The corrected actual SHR and its deviation (in percentage) from the design SHR for these stations for the five (5) year period from 2018- 19 to 2022- 23 is indicated in Table- 2.15 below.

Table- 2.19: Analysis of corrected actual (SHR) of 02 gas/ liquid fuel based thermal generating stations provided with operation margin on design heat rate (COD on or after 1.4.2009)

Sl. No.	Power Station	Design SHR (kcal/kWh)	2018-19	2019-20	2020-21	2021-22	2022-23	5 yr. avg. of corrected actual SHR (%)	Deviation of 5 yr. avg. of corrected actual SHR from design SHR (%)
			Corrected Actual SHR (kcal/kWh)	Corrected Actual SHR (kcal/kWh)	Corrected Actual SHR (kcal/kWh)	Corrected Actual SHR (kcal/kWh)	Corrected Actual SHR (kcal/kWh)		
1.	NEEPCO, TGBP (101 MW)	1876.4	**1970**	**1927**	**2063**	**2025**	**2032**	**2004**	**6.8**
2.	ONGC, Tripura, ONGC (726.6 MW)	1739.4	**1705**	**1757**	**1764**	**1716**	**1798**	**1748**	**0.5**

As regards design heat rate of NEEPCO's TGBP, the plant operation data furnished to CEA indicates gross SHR in GT mode as 2734 kcal/kWh on LHV basis. As per this, the gross SHR of the station in CCGT mode works out to 1770.9 kcal/kWh on LHV basis. However, as per HBD furnished, the gross SHR on LHV basis is 1688.7 kcal/kWh. The analysis has been carried out considering HBD value which amounts to gross SHR of 1876.4 kcal/kWh on HCV basis.

It is seen that the deviation of actual SHR from design SHR for NEEPCO's TGBP is 8.4% and ONGC's Tripura is 2.5%. The deviation of average corrected actual

SHR from design SHR for NEEPCO's TGBP is 6.8% and ONGC's Tripura is 0.5%. Since, separate data for open cycle and closed cycle operation is not provided In case of NEEPCO's TGBP, therefore, based on observed performance, the existing norm of 5% operation margin *for gas based stations having COD on or after 1.4.2009 is proposed to be continued.*

2.4 Auxiliary Energy Consumption (AEC):

2.4.1 The auxiliary energy consumption data has been analysed for 5 year period from 2018- 19 to 2022-23 for 110 coal/ lignite based generating stations/ station stages (henceforth referred as stations) and 11 gas/ liquid fuel based generating stations. The coal/ lignite based stations comprises of 46 stations of NTPC,10 stations of DVC, 6 lignite based stations of NLCIL, 42 stations of state utilities and 6 IPP stations. The gas/ liquid fuel based stations comprises of 6 stations of NTPC, 3 stations of NEEPCO, 1 OTPC CCGT station and 1 private sector stations. The separate data furnished by the utilities for individual stages of a power station, as applicable, have been considered as separate stations.

2.4.2 CERC, vide its notification dated 6.4.2016, has provided the following auxiliary energy degradation factors for coal/ lignite based generating stations as compensation for part loading of the units:

Sl. No.	**Unit loading as % of installed capacity of the unit**	**% degradation in auxiliary energy consumption admissible**
1.	85- 100	Nil
2.	75 - 84.99	0.35
3.	65 - 74.99	0.65
4.	55 - 64.99	1.00

Further, the above additional auxiliary energy consumption values have been reviewed so as to have application steps similar to that proposed for application of station heat rate correction. The same has been covered at para 3.1.2 in Section-3 of this report. And, analysis in this section has been carried out considering presently recommended degradation factors as below:

Sl. No.	Module/ plant loading as % of installed capacity	Admissible % degradation in auxiliary energy consumption

		(% point)
1.	85 -100	Nil
2.	80 - < 85	0.5
3.	70 - < 80	1.1
4.	60 - < 70	1.8
5.	50 - < 60	2.5
6.	40 - < 50	3.2

The above factors as applicable on case to case basis based on actual unit/ plant loading have been considered for modification/ correction of respective actual/operating auxiliary energy consumption.

2.4.3 The details of plant loading and admissible additional auxiliary energy consumption due to part load operation for all 110 coal/ lignite based stations including 62 central sector stations, 42 state sector and 6 private sector stations for 5 year period from 2018-19 to 2022-23 are indicated in Annexure- 8. The 5 Year average Plant Loading and 5 year average Admissible degradation in AEC (% point) in respect of individual stations is also indicated. The values for state sector and private sector stations have been considered as per applicability for central sector stations.

From Annexure- 8, it is seen that average of admissible additional AEC on annual basis for all 110 coal/ lignite based stations is found to vary in the range 0.44% point in 2022-23 to 0.7% point in 2019-20. On 5 year average basis, no admissible degradation in AEC is involved in respect of 30 stations as per plant loading in these being consistently above 85% in all individual years of 5 year period. The maximum average additional AEC involved is 2.24% point in respect of HPGCL's Deen Bandhu Chhotu Ram TPP. The overall weighted average of admissible degradation in AEC for all 110 stations over 5 year period is found as 0.54% point. The overall weighted average of plant loading for all 110 stations over 5 year period is found as 84%.

2.4.4 The actual auxiliary energy consumption and 5 year average corrected actual AEC for all 110 coal/ lignite fired generating stations for the five (5) year period from 2018-19 to 2022-23 is indicated in Annexure- 9.

The weighted average annual auxiliary energy consumption (AEC) for all 110 stations in individual year vary in the range of 7.25% for year 2022-23 to 7.56% for 2019-20. The lowest annual AEC for individual station is 3.01% for NTPC's Nabinagar TPS in 2021-22. The five year average of auxiliary energy consumption

for individual station vary in the range 4.68% for NTPC's Nabinagar TPS to 15.74% for NLC's TPS-II Expansion. In case of coal based stations, the maximum auxiliary energy consumption on five year average basis is 13.82% for NTPC's Tanda Stage-I TPS. The overall weighted average of auxiliary energy consumption for all the 110 stations over 5 year period is found as 7.35%.

The 5 year average corrected auxiliary energy consumption is found to vary in a wide range of 4.29% APGENCO's Dr. N Tatarao TPS Stg-IV to 15.10 % for NLC's TPS-II Expansion, with overall weighted average for all stations as 6.82 %.

2.4.5 The analysis of auxiliary energy consumption for NTPC stations provided with relaxed auxiliary energy consumption norms:

M/s NTPC's Talcher TPS and Tanda TPS are presently provided with relaxed auxiliary energy consumption norm of 10.5% and 11.5% respectively. In case of Talcher TPS, the auxiliary energy consumption norm of 10.5% pertains to the capacity of 460 MW (4x60 + 2x110) existed at the beginning of the current tariff period. All the 6 units of Talcher TPS have been retired w.e.f. 01.04.2021. As such, this plant has not been considered further for any norm. The analysis of auxiliary energy consumption for the remaining one station is indicated in Table- 2.20 below.

Table- 2.20: Analysis of auxiliary energy consumption of NTPC stations provided with relaxed auxiliary energy consumption norms.

Power Station	**Normative AEC (%)**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**5 year average of actual AEC (%)**	**5 Year Avg. Admissible degradation in AEC (% point)**	**5 Year Avg. Corrected Actual AEC (%)**
		Actual AEC (%)	**Actual AEC (%)**	**Actual AEC (%)**	**Actual AEC (%)**	**Actual AEC (%)**			
Tanda Stage-I (440 MW)	11.5	12.86	13.44	14.02	14.51	14.3	**13.82**	**1.38**	**12.44**

In case of Tanda TPS, the auxiliary energy consumption norm of 11.5% pertains to 4x110 MW Tanda TPS Stage-I units existing at the beginning of the current tariff period. The auxiliary energy consumption in individual years of 5 year period has been in the range 12.86% (in 2018-19) to 14.51% (in 2021-22) and is consistently above the norm of 11.5% in all years. The 5 year average of annual corrected auxiliary energy consumption is found as 12.44% which is 0.94% point greater than the normative APC of 11.5%

Based on observed performance as above, the auxiliary energy consumption norm of Tanda TPS Stage-I(440MW) is proposed to be appropriately increased by 0.5% to 12% which still provides a margin of 0.44% point over corrected actual average AEC over 5 year period.

2.4.6 The analysis of auxiliary energy consumption for DVC stations provided with relaxed auxiliary energy consumption norms:

M/s DVC's Bokaro TPS, Chandrapur TPS and Durgapur TPS are presently provided with relaxed auxiliary energy consumption norm of 10.25%, 9.5% and 10.5% respectively.

In case of Durgapur TPS, the auxiliary energy consumption norm of 10.5% pertains to the capacity of 210 MW (1x210) existing at the beginning of current tariff period. The 210 MW (Unit- 4) has been retired w.e.f. 19.12.2022. As such, this plant has not been considered further for any norm.

In case of Bokaro TPS, the auxiliary energy consumption norm of 10.25% pertains to 210 MW (1x210) MW existing at the beginning of the current tariff period. During existing norm period, 210MW(Unit-3) has been retired w.e.f 01.04.2021. As such, this plant also has not been considered further for any norm.

The analysis of auxiliary energy consumption for the remaining one station is indicated in Table- 2.21 below.

Table- 2.21: Analysis of auxiliary energy consumption of DVC stations provided with relaxed auxiliary energy consumption norms.

Power Station	**Normative AEC (%)**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**5 year average of actual AEC (%)**	**5 Year Avg. Admissible degradation in AEC (% point)**	**5 Year Avg. Corrected Actual AEC (%)**
		Actual AEC (%)	**Actual AEC (%)**	**Actual AEC (%)**	**Actual AEC (%)**	**Actual AEC (%)**			
Chandrapur (500MW)	9.5	9.20	9.79	9.74	9.59	9.85	**9.63**	**0.1**	**9.53**

In case of Chandrapur TPS, the auxiliary energy consumption norm of 9.5% pertains to the capacity of 630 MW (1x130+ 2x250) existing at the beginning of the current tariff period. The 130 MW unit- 3 has been retired w.e.f. 19.03.2020. *As per observed performance of the station, the relaxed AEC norm of 9.5% is proposed to be continued for Chandrapur TPS, now having capacity of 500 MW.*

2.4.7 The analysis of auxiliary energy consumption for NLCIL's pulverised lignite fired stations provided with relaxed auxiliary energy consumption norms:

M/s NLCIL's TPS- I, TPS- I Expansion, TPS- II Stage I & II are presently provided with relaxed auxiliary energy consumption norm of 12.0%, 8.5% & 10.0% respectively. In case of TPS- I, the auxiliary energy consumption norm of 12% pertains to 600 MW (6x50+3x100) existing at the beginning of the current tariff period. During existing norm period, Units-1&9 150MW (1x50+1x100), Units-2,4&8 200 MW (2x50+1x100), Unit-3 (50MW), Unit-5(50MW) and Unit-6(50MW), has been retired w.e.f. 31.03.2020, 08.07.2020, 30.07.2020, 28.09.2020 and 30.09.2020 respectively. As such, this plant has not been considered further for any norm.

The analysis of auxiliary energy consumption for remaining three stations is indicated in Table- 2.22 below.

Table- 2.23: Analysis of auxiliary energy consumption of NLCIL stations provided with relaxed auxiliary energy consumption norms.

Power Station	**Existing Normative AEC (%)**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**5 year average of actual AEC (%)**	**5 Year Avg. Admissible degradation in AEC (% point)**	**5 Year Avg. Corrected Actual AEC (%)**
		Actual AEC (%)	**Actual AEC (%)**	**Actual AEC (%)**	**Actual AEC (%)**	**Actual AEC (%)**			
TPS I Expansion (420 MW)	8.5	8.21	8.44	9.09	8.65	9.05	**8.69**	**0.00**	**8.69**
TPS II Stg-I (630 MW)	10.0	9.87	9.89	9.68	9.70	11.50	**10.13**	**0.1**	**10.03**
TPS II Stg-II (840 MW)	10.0	9.75	9.93	10.06	9.56	10.22	**9.90**	**0.1**	**9.8**

Referring to Annexure-9, it is to mention that as per level of plant loading being consistently above 85% over the 5 year period, there is no Admissible degradation in AEC in individual years in case of TPS- I Expansion.

In case of TPS-I Expansion, the auxiliary energy consumption in individual years of 5 year period has been in the range 8.21% (in 2018-19) to 9.09% (in 2020-21) with 5 year average being 8.69 which is 0.19 higher than the normative APC of 8.5%. *Considering APC norm applicable for lignite fired stations, the TPS- I Expansion is proposed to be removed from the list of relaxed norm category stations.*

In case of TPS-II Stage- I, the auxiliary energy consumption in individual years of 5 year period has been in the range 9.68% (in 2020-21) to 11.50%(in 2022-23). The 5 year average of annual corrected auxiliary energy consumption is found as 10.03% which is 0.03% higher than the normative APC of 10.0%.

In case of TPS-II Stage- II, the auxiliary energy consumption in individual years of 5 year period has been in the range 9.56% (in 2021-22) to 10.22%(in 2022-23). The 5 year average of annual corrected auxiliary energy consumption is found as 9.8% which is 0.2% point less than the normative APC of 10.0%.
Based on observed performance of these stations, the relaxed AEC norm of 10% is proposed to be continued for TPS- II Stage- I & TPS- II Stage- II.

2.4.8 The analysis of auxiliary energy consumption for NLCIL's CFBC technology based lignite fired stations:

M/s NLCIL's 2x125 MW Barsingsar TPS is presently provided with relaxed auxiliary energy consumption norm of 12.5%. The TPS- II Expansion comprising of 2x250 MW auxiliary energy consumption norm amounts to 10%. The analysis of auxiliary energy consumption for these stations is indicated in Table- 2.24 below.

Table- 2.24: Analysis of auxiliary energy consumption of NLCIL's CFBC technology based lignite fired stations.

Power Station	**Existing Normative AEC (%)**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**5 year average of actual AEC (%)**	**5 Year Avg. Admissible degradation in AEC (% point)**	**5 Year Avg. Corrected Actual AEC (%)**
		Actual AEC (%)	**Actual AEC (%)**	**Actual AEC (%)**	**Actual AEC (%)**	**Actual AEC (%)**			
Barsingsar TPS (2x125 MW)	12.5	13.12	12.75	13.11	12.39	12.57	**12.79**	**0.00**	**12.79**

TPS- II Expansion (2x250 MW)	10.0	15.18	16.77	15.64	15.46	15.65	**15.74**	**0.64**	**15.10**

It is seen from the above Table- 2.14, that auxiliary energy consumption in case of both Barsingsar TPS and TPS- II Expansion is consistently higher than the applicable norms except of one year in Barsingser viz. 12.39% in 2021-22. In case of Barsingsar TPS, the average corrected AEC of 12.79% over 5 year period is 0.29% point higher than the normative AEC of 12.5%. In case of TPS- II Expansion having 250 MW units which are largest size CFBC units installed in the country, the average corrected AEC of 15.10% over 5 year period is 5.10% point higher than the normative AEC of 10%. *Based on observed performance as above, the auxiliary energy consumption norm for CFBC technology based lignite fired both Barsingsar TPS and TPS- II Expansion is proposed to be appropriately set at 12.5%.*

2.4.9 The analysis of auxiliary energy consumption for central utility coal based stations provided with 200 MW series units excluding stations provided with relaxed norms:

In the stations for which operation data has been furnished to CEA, there are 12 central utility stations (excluding stations with relaxed norms) which are provided with 200 MW series size units only. These comprise of 9 NTPC stations and 3 DVC stations. NTPC stations include 1 station (Unchahar, Stage- II TPS) having tube & ball mill. The analysis of auxiliary energy consumption for these 12 stations is indicated in Table- 2.25 below.

Table- 2.25: Analysis of auxiliary energy consumption for stations provided with 200 MW series units (excluding stations with relaxed norms).

Sr. No.	**Power Station**	**Existing Normative AEC (%)**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**5 Year Avg. Admissible degradation in AEC (% point)**	**5 year average of actual AEC (%)**	**5 Year Avg. Corrected Actual AEC (%)**
			Actual AEC (%)	**Actual AEC (%)**	**Actual AEC (%)**	**Actual AEC (%)**	**Actual AEC (%)**			
	NTPC									
1	Barauni Stage-II (2x250 MW)*	9.4		9.10	10.35	9.27	9.3	**0.40**	**9.50**	**9.10**
2	Bongaigaon (3x250 MW)*	9	9.04	9.13	9.70	9.10	8.64	**1.26**	**9.12**	**7.86**

3	Dadri Thermal, Stage- I (4x210 MW)**	8.5	8.36	9.32	14.06	10.55	8.48	**1.52**	**10.15**	**8.63**
4	Kahalgaon, Stage- I (4x210 MW)*	9	9.24	9.48	9.62	9.21	9.7	**0.10**	**9.44**	**9.34**
5	Kanti-II/Muzaffpur (2x195 MW)*	9	10.60	10.22	10.37	9.98	9.43	**0.76**	**10.12**	**9.36**
6	Unchahar, Stage- I (2x210 MW)	8.75	9.44	10.31	11.40	11.15	10.34	**1.38**	**10.53**	**9.15**
7	Unchahar, Stage- II (2x210 MW)*#	9.8	9.36	10.04	10.88	10.73	10.08	**1.52**	**10.22**	**8.70**
8	Unchahar, Stage- III (1x210 MW)*	9	9.36	9.73	10.47	9.97	9.45	**1.52**	**9.80**	**8.28**
9	Vindhyachal, Stage- I (6x210 MW)*	9	8.64	8.66	8.82	8.82	8.74	**0.00**	**8.73**	**8.73**
	DVC									
10	Mejia Unit 1-3 (3x210 MW)*	9	11.45	11.05	10.76	11.06	11.36	**1.68**	**11.13**	**9.45**
11	Mejia Unit 4 (1x210 MW)*	9	10.35	11.01	10.86	10.88	11.0	**1.54**	**10.81**	**9.27**
12	Mejia Unit 5-6 (2x250 MW)*	9	9.13	9.60	9.71	10.11	10.2	**0.54**	**9.74**	**9.20**
	Weighted Avg. (IDCT stations)	**9.0**	**9.49**	**9.57**	**9.73**	**9.60**	**9.56**	**0.69**	**9.59**	**8.90**
	Weighted Avg. (NDCT stations)	**8.5**	**8.36**	**9.32**	**14.06**	**10.55**	**8.48**	**1.52**	**10.15**	**8.63**
	Weighted Avg. (station with ball & tube type mill)	**9.8**	**9.36**	**10.04**	**10.88**	**10.73**	**10.08**	**1.52**	**10.22**	**8.70**

* Stations with IDCT **Stations with NDCT # Stations with ball and tube type mill

In case of Barauni Stage-II TPS (2x250 MW), one unit (U#8) has been provided with Bowl type mill, however another unit (U#9) has been provided with ball and tube type mill, therefore this station has not been included in the weighted average calculation.

It is seen from the above Table- 2.15, that there is only one station with NDCT i.e Dadri Thermal, Stage- I (4x210 MW) and the average corrected AEC of this station is 8.63% over 5 year period, which is 0.13 % point higher than the existing Normative AEC of 8.5%.

Further, there is only one station in 200 MW series in which all units are provided with ball and tube type mill i.e Unchahar, Stage- II (2x210 MW) and the weighted

average corrected AEC of this station is 8.7% over 5 year period, which is 1.1 % point lesser than the existing Normative AEC of 9.8%.

In case of stations with IDCT, the weighted average of actual AEC and corrected AEC over 5 year period is 9.59% and 8.9% respectively implying applicability of average admissible degradation in AEC of 0.69% point on account of part loading of the stations. The weighted average of corrected AEC over 5 year period of these stations is 8.9%, which is 0.1% point lesser than the existing Normative AEC of 9%.

Based on observed performance as above, existing AEC norm of 8.5% (9% with IDCT) for 200 MW series (200/ 210/ 250 MW) thermal generating units is found to be reasonable.

2.4.10 The analysis of auxiliary energy consumption for central utility coal based stations provided with 500 MW sets only excluding stations provided with relaxed norms:

In the stations for which operation data has been furnished to CEA, there are 26 central utility stations (excluding stations with relaxed norms) which are provided with 500 MW sets size units only. These comprise of 20 NTPC stations and 6 DVC stations. NTPC stations include two stations (Vindhyachal, Stage- II TPS & Talcher, Stage- I TPS) which are provided with tube and ball mills, involving relatively higher auxiliary power consumption. The analysis of auxiliary energy consumption for these 26 stations is indicated in Table- 2.26 below.

Table- 2.26: Analysis of auxiliary energy consumption for stations provided with 500 MW sets units

Sr. No.	Power Station	Existing Normative AEC (%)	2018-19 Actual AEC (%)	2019-20 Actual AEC (%)	2020-21 Actual AEC (%)	2021-22 Actual AEC (%)	2022-23 Actual AEC (%)	5 Year Avg. Admissible degradation in AEC (% point)	5 year average of actual AEC (%)	5 Year Avg. Corrected Actual AEC (%)
	NTPC									
1	Dadri Thermal, Stage- II (2x490 MW)**	5.75	5.02	6.23	6.29	6.02	6.07	1.38	5.93	4.55
2	Simhadri, Stage-I (2x500 MW)**	5.75	5.93	6.40	6.87	5.96	5.8	1.26	6.20	4.94
3	Simhadri, Stage-II (2x500 MW)**	5.75	5.95	6.49	6.47	5.97	5.9	0.98	6.15	5.17
4	Rihand, Stage-I (2x500 MW)**	8	7.80	8.06	7.63	7.82	8.1	0.00	7.88	7.88

5	Farakka, Stage-III (1x500 MW)*	6.25	6.25	6.17	6.44	6.51	6.3	0.54	6.33	5.79
6	Kahalgaon, Stage- II (3x500 MW)*	6.25	5.85	6.08	6.42	5.73	5.8	0.10	5.98	5.88
7	Korba, Stage-III (1x500 MW)*	6.25	5.84	5.63	5.37	5.40	5.2	0.00	5.49	5.49
8	Mouda, Stage- I (2x500 MW)*	6.25	6.06	6.42	7.04	6.14	5.7	1.24	6.27	5.03
9	Ramagundam-III (1x500 MW)*	6.25	5.25	6.09	5.98	6.29	6.7	0.10	6.06	5.96
10	Rihand, Stage-II (2x500 MW)*	6.25	5.62	5.58	5.88	6.07	5.7	0.00	5.77	5.77
11	Rihand, Stage-III (2x500 MW)*	6.25	5.30	4.67	5.21	5.25	5.3	0.00	5.14	5.14
12	Sipat, Stage-II (2x500 MW)*	6.25	5.61	5.84	5.80	5.73	6.0	0.00	5.79	5.79
13	Talcher STPS, Stage-I (2x500 MW)*#	7.05	7.89	8.21	7.49	7.50	7.2	0.10	7.65	7.55
14	Talcher STPS, Stage-II (4x500 MW)*	6.25	5.80	6.24	6.09	5.90	5.7	0.10	5.94	5.84
15	Unchahar, Stage- IV (1x500 MW)*	6.25	7.77	6.37	6.71	6.24	6.77	1.26	6.77	5.51
16	Vindhyachal, Stage- II (2x500 MW)*#	7.05	5.83	6.44	6.31	6.32	6.18	0.00	6.22	6.22
17	Vindhyachal, Stage- III (2x500 MW)*	6.25	5.25	5.47	5.37	5.62	5.55	0.00	5.45	5.45
18	Vindhyachal, Stage- IV (2x500 MW)*	6.25	5.56	5.67	5.45	5.56	5.45	0.00	5.54	5.54
19	Vindhyachal, Stage- V (1x500 MW)*	6.25	5.67	5.67	6.13	6.35	6.40	0.00	6.04	6.04
20	Vallur (3x500 MW)*	6.25	7.7	9.0	9.5	7.7	7.0	1.44	8.20	6.76
	DVC									
21	Bokaro (3x210+1x500 MW)**	5.75	5.84	5.86	5.40	5.96	5.65	0.52	5.74	5.22
22	Durgapur Steel (2x500 MW)**	5.75	4.96	5.61	5.86	5.20	5.24	0.88	5.37	4.49
23	Koderma (2x500 MW)**	5.75	4.83	5.62	5.22	5.39	5.19	0.20	5.25	5.05
24	Mejia Unit 7-8 (2x500 MW)**	5.75	5.08	5.42	5.37	5.61	5.5	0.88	5.39	4.51
25	Raghunathpur (2x600 MW)**	5.75	6.80	6.22	6.23	6.29	6.38	1.80	6.38	4.58
26	Maithon (2x525 MW)*	5.75	5.64	5.92	6.10	5.74	5.6	0.32	5.81	5.49

	Weighted Avg. (stations with TDBFP & NDCT)	**5.75**	**5.57**	**5.99**	**6.01**	**5.80**	**5.73**	**1.04**	**5.82**	**4.78**
	Weighted Avg. (stations with TDBFP & IDCT)	**6.25**	**5.95**	**6.19**	**6.36**	**6.03**	**5.90**	**0.35**	**6.09**	**5.74**
	Weighted Avg. (stations with MDBFP)	**8.00**	**7.80**	**8.06**	**7.63**	**7.82**	**8.12**	**0.00**	**7.88**	**7.88**
	Weighted Avg. (stations with ball & tube type mill)	**7.05**	**6.86**	**7.32**	**6.90**	**6.91**	**6.68**	**0.05**	**6.93**	**6.88**

* Stations with IDCT **Stations with NDCT or Once through Cooling System # Stations with ball and tube type mill

As per the above table, the 5 year average of annual AEC for individual station is found to vary in the range 5.14% (for Rihand, Stage-III TPS, normative AEC 6.25%) to 8.20% (for Vallur TPS, normative AEC 6.25%).

Out of the 26 stations indicated in the above table, there is only station i.e Rihand, Stage-I (2x500 MW) provided with MDBFP and all other 25 stations have type of BFP as TDBFP. The Rihand, Stage-I TPS has once through cooling system and thus the existing AEC norm of this station is 8%. The plant loading of this station is more than 85% consistently for 5 year period implying no admissible degradation in AEC. The annual AEC of the station is found to vary in the range of 7.63% in 2020-21 to 8.12% in 2022-23 with average AEC over 5 year period as 7.88 which is 0.12% point lesser than the existing Normative AEC of 8%.

In case of stations with TDBFP and NDCT, the weighted average of annual AEC of the stations is found to vary in the range of 5.57% in 2018-19 to 6.01% in 2020-21. The weighted average of actual AEC and corrected AEC over 5 year period is 5.82 % and 4.78 % respectively implying applicability of average admissible degradation in AEC of 1.04 % point on account of part loading of the stations. The weighted average of corrected AEC over 5 year period of these stations is 4.78%, which is 0.97% point lesser than the existing Normative AEC of 5.75%.

In case of stations with TDBFP and IDCT, the weighted average of annual AEC of the stations is found to vary in the range of 5.90% in 2022-23 to 6.36% in 2020-21. The weighted average of actual AEC and corrected AEC over 5 year period is 6.09% and 5.74% respectively implying applicability of average admissible degradation in AEC of 0.35% point on account of part loading of the stations. The weighted average of corrected AEC over 5 year period of these stations is 5.74%, which is 0.51% point lesser than the existing Normative AEC of 6.25%.

Further, there is two stations in 500 MW sets in which are provided with ball and tube type mill i.e Vindhyachal, Stage- II TPS & Talcher, Stage- I TPS. Both of these stations have type of BFP as TDBFP and type of Cooling tower as IDCT implying existing Normative AEC of 7.05%. The weighted average corrected AEC of these stations is 6.88% over 5 year period, which is 0.17 % point lesser than the existing Normative AEC of 7.05%.

Based on observed performance as above, the existing AEC norm of 5.75% (6.25% with IDCT) for 500 MW size thermal generating units is proposed to be appropriately decreased by 0.50% point.

2.4.11 The analysis of auxiliary energy consumption for central utility coal based stations provided with 660-800 MW Super-critical units with TDBFP:

In the stations for which operation data has been furnished to CEA, there are 12 central utility stations all of NTPC which are provided with 660-800 MW Super-critical units. All these stations are provided with TDBFP. The analysis of auxiliary energy consumption for these 12 stations is indicated in Table- 2.27 below.

Table- 2.27: Analysis of auxiliary energy consumption for stations provided with 660-800 MW Super-critical units with TDBFP

Sr. No.	Power Station	Existing Normative AEC (%)	2018-19	2019-20	2020-21	2021-22	2022-23	5 Year Avg. Admissible degradation in AEC (% point)	5 year average of actual AEC (%)	5 Year Avg. Corrected Actual AEC (%)
			Actual AEC (%)	Actual AEC (%)	Actual AEC (%)	Actual AEC (%)	Actual AEC (%)			
	NTPC									
1	Barh- I (2x660 MW)*	6.25	-	-	-	-	6.80	0.00	6.80	6.80
2	Barh- II (2x660 MW)*	6.25	5.15	5.84	5.96	6.10	5.47	0.54	5.71	5.17
3	Mouda, Stage- II (2x660 MW)*	6.25	5.65	5.92	6.59	5.85	5.3	1.38	5.85	4.47
4	Sipat, Stage-I (3x660 MW)*	6.25	5.19	5.41	5.39	5.66	5.6	0.00	5.45	5.45
5	Tanda, Stage-II (2x660 MW)**	5.75	-	5.95	6.09	5.87	5.8	0.38	5.93	5.56
6	Darlipali STPS (2x800 MW)*	6.25	-	7.95	6.58	6.24	6.20	0.45	6.74	6.29
7	Gadarwara STPS (2x800 MW)*	6.25	-	9.25	6.89	6.87	6.28	0.70	7.32	6.62

8	Khargone STPS (2x660 MW)*	6.25	-	5.62	6.77	6.19	7.11	1.10	6.42	5.32
9	Kudgi STPS (3x800 MW)*	6.25	6.89	8.00	7.06	6.59	6.05	1.66	6.92	5.26
10	Lara STPS (2x800 MW)*	6.25	-	5.83	5.93	5.72	5.96	0.13	5.86	5.73
11	Nabinagar STPS (3x660 MW)*	6.25	-	5.14	5.26	3.01	5.33	0.00	4.68	4.68
12	Solapur STPS (2x660 MW)*	6.25	9.87	13.03	6.97	6.65	6.47	1.24	8.60	7.36
	Weighted Avg. (IDCT stations)	**6.25**	**6.49**	**7.12**	**6.31**	**5.83**	**6.01**	**0.66**	**6.34**	**5.68**
	Weighted Avg. (NDCT stations)	**5.75**	**-**	**5.95**	**6.09**	**5.87**	**5.8**	**0.38**	**5.93**	**5.56**

* Stations with IDCT **Stations with NDCT

As per the above table, the 5 year average of annual AEC for individual station is found to vary in the range 4.68% (for Nabinagar STPS, normative AEC 6.25%) to 8.60% (for Solapur STPS, normative AEC 6.25%).

It is seen from the above Table- 2.23, that there is only one station with NDCT i.e Tanda, Stage-II TPS and average of actual AEC and corrected AEC over 5 year period for this station is 5.93% and 5.56% respectively implying applicability of average admissible degradation in AEC of 0.38% point on account of part loading of the stations and corrected AEC being 0.19% point lesser than the existing Normative AEC of 5.75%.

In case of stations with IDCT, the weighted average of annual AEC of the stations is found to vary in the range of 5.83% in 2021-22 to 7.12% in 2019-20. The weighted average of actual AEC and corrected AEC over 5 year period is 6.34% and 5.68% respectively implying applicability of average admissible degradation in AEC of 0.66% point on account of part loading of the stations. The weighted average of corrected AEC over 5 year period of these stations is 5.68%, which is 0.57% point lesser than the existing Normative AEC of 6.25%.

Based on observed performance as above, the existing AEC norm of 5.75% (6.25% with IDCT) for 660-800 MW size thermal generating units is proposed to be appropriately decreased by 0.50% point.

2.4.12 The analysis of auxiliary energy consumption for central utility pulverised lignite based stations excluding stations provided with relaxed norms:

In the stations for which operation data has been furnished to CEA, there is only 1 pulverised lignite based stations excluding stations provided with relaxed norms i.e NLS's NNTPS station with two 500 MW i.e Unit-1 (COD 28.12.19) and Unit-2

(COD 10.02.21). The analysis of auxiliary energy consumption for this station is indicated in Table- 2.28 below.

Table- 2.28: Analysis of auxiliary energy consumption of pulverised lignite based stations excluding stations provided with relaxed norms.

Power Station	2018-19	2019-20	2020-21	2021-22	2022-23	5 year average of actual AEC (%)	5 Year Avg. Admissible degradation in AEC (% point)	5 Year Avg. Corrected Actual AEC (%)
	Actual AEC (%)	Actual AEC (%)	Actual AEC (%)	Actual AEC (%)	Actual AEC (%)			
NNTPPS (2x500MW)		9.53	7.84	6.80	6.10	**7.57**	**0.40**	**7.17**

It is seen from the above Table- 2.24, in case of NNTPS the average corrected AEC of 7.17% over 5 year period is 0.92 % point higher than the normative AEC of 6.25%. The actual auxiliary energy consumption is consistently higher than the applicable norms of 6.25 except of one year viz. 6.1% in 2021-22. However the actual AEC has consistently improved in the 4 year period from 2019-20 to 2022-23 and improved to 6.1% which is 0.15% point below the existing applicable norm of 6.25%. *Based on observed performance as above, the auxiliary energy consumption norm for pulverised lignite fired i.e 0.5% point more than the AEC norm of coal based stations is proposed to be retained.*

2.4.13 The analysis of auxiliary energy consumption for state and private sector coal based stations:

In the stations for which operation data has been furnished to CEA, there are 42 state utility stations and 6 private sector stations comprising of 26 stations with 200 MW series units, 1 station with 300MW units, 13 stations with 500-600MW sets and 8 stations with 660-800 MW Super-critical units. The analysis of auxiliary energy consumption for these 48 stations is indicated in Table- 2.29 below.

Table- 2.29: Analysis of auxiliary energy consumption for state and private sector coal based stations

Sr. No.	Power Station	Existing Normative AE	2018-19	2019-20	2020-21	2021-22	2022-23	5 year average of actual AEC (%)	5 Year Avg. Corrected Actual	Deviation of Corrected Actual
			Actual AEC (%)	Actual AEC (%)	Actual AEC (%)	Actual AEC (%)	Actual AEC (%)			

		C (%)							AEC (%)	APC w.r.t Normative
1	Dr N Tatarao TPS Stage-I (2x210 MW)**	8.5	9.20	9.83	6.23	10.56	9.80	9.12	8.14	-0.36
2	Dr N Tatarao TPS Stage-II (2x210 MW)**	8.5	11.03	10.86	8.15	11.09	9.71	10.17	9.65	1.15
3	Dr N Tatarao TPS Stage-III (2x210 MW)**	8.5	10.16	10.12	9.87	9.70	9.92	9.96	9.76	1.26
4	Gandhinagar TPP (3x210 MW)**	8.5	10.30	11.88	11.16	10.49	11.37	11.04	10.50	2.00
5	Sikka TPP (2x250 MW)*	9	9.49	9.47	9.99	10.53	10.79	10.05	9.43	0.43
6	Panipat TPS (210+2*250 MW)**#	9.3	8.99	9.62	10.65	9.54	9.56	9.67	9.67	0.37
7	Deen Bandhu Chhotu Ram TPP (2*300 MW)**	8	8.49	8.57	8.32	8.63	8.50	8.50	6.26	-1.74
8	Koradi (1*210 MW)*	9	9.70	13.47	12.69	12.20	11.29	11.87	10.61	1.61
9	Nasik (3*210 MW)*	9	10.64	11.59	12.87	11.75	12.61	11.89	10.63	1.63
10	GHTP Stage-I (2x210 MW)**	8.5	10.54	12.31	14.10	10.52	10.03	11.50	11.50	3.00
11	GHTP Stage-II (2x250 MW)**	8.5	9.08	11.41	10.41	9.00	8.14	9.61	9.51	1.01
12	Kota STPS (2x110+3x210+ 2x195 MW)*#	9.65	11.00	11.88	11.75	11.53	11.50	11.53	11.43	1.78
13	Suratgarh TPS (6X250 MW)*#	9.8	9.79	10.00	10.66	10.27	9.83	10.11	9.59	-0.21
14	Chhabra TPP (4x250 MW)*#	9.8	9.35	9.62	9.41	10.12	10.33	9.76	9.66	-0.14
15	Kothagudem TPS Stg-V (2X250 MW)**	8.5	9.99	10.70	11.08	10.33	10.37	10.49	10.49	1.99
16	Anpara ATPS (3x210 MW)**	8.5	9.13	9.58	10.55	10.46	10.19	9.98	9.24	0.74
17	Harduaganj TPS Stage-I (2x250 MW)*	9	8.52	8.68	8.31	10.08	9.25	8.97	7.87	-1.13
18	Obra BTPS (5x200 MW)**	8.5	8.96	9.54	9.36	9.76	9.54	9.43	8.67	0.17
19	Paricha BTPS (2x210 MW)*	9	9.82	9.57	10.62	10.19	10.03	10.05	8.67	-0.33

20	Paricha CTPS (2x250 MW)**	8.5	8.23	9.15	9.13	9.45	9.45	9.08	7.84	-0.66
21	Kolaghat TPS (6x210 MW)*	9	11.58	12.43	14.13	11.67	11.48	12.26	11.28	2.28
22	Bakreswar TPS (5x210 MW)*	9	9.23	9.10	8.78	8.72	9.01	8.97	8.97	-0.03
23	Santaldih TPS (2x250 MW)*	9	8.84	8.22	8.37	8.33	8.52	8.46	8.46	-0.54
24	Mettur TPS-I (4 X 210 MW)*	9	8.49	8.51	8.53	8.58	8.79	8.58	8.58	-0.42
25	Tuticorin TPS (5 X 210 MW)**	8.5	7.90	8.28	8.61	8.79	9.20	8.56	8.56	0.06
26	North Chennai-I (3x210 MW)**	8.5	9.15	9.78	10.40	10.61	9.77	9.94	9.18	0.68
27	Mahadev Prasad STPP (2 x 270 MW)*	9	8.37	8.37	7.80	8.61	8.48	8.33	8.01	-0.99
	Weighted Avg. (200MW series)	**8.94**	**9.53**	**10.05**	**10.18**	**10.05**	**9.96**	**9.95**	**9.43**	**0.49**
28	Dr N Tatarao TPS Stage-IV (1x500 MW)**	5.75	5.02	5.13	5.19	5.00	4.83	5.03	4.29	-1.46
29	Rajiv Gandhi TPP (2x600 MW)**	5.75	6.12	6.72	6.82	5.96	5.90	6.30	5.54	-0.21
30	Bhusawal Stage-III (2*500 MW)**	5.75	6.28	6.28	5.99	6.45	6.36	6.27	5.53	-0.22
31	Khaperkheda (1*500 MW)**	5.75	5.89	5.86	5.99	5.75	5.85	5.87	5.37	-0.38
32	Kalisindh TPP (2x600 MW)**	5.75	6.19	6.39	6.10	6.47	6.94	6.42	5.78	0.03
33	Kakatiya TPP,Stg-I (1X500 MW)**	5.75	5.38	5.74	6.42	5.43	5.86	5.77	5.77	0.02
34	Kakatiya TPP,Stg-II (1X600 MW)**	5.75	5.10	4.94	5.48	5.35	5.39	5.25	5.05	-0.70
35	Kothagudem TPS Stg-VI (1 X 500 MW)**	5.75	5.26	5.03	5.16	5.23	5.20	5.17	5.07	-0.68
36	Anpara BTPS (2x500 MW)**#	6.55	7.63	7.94	7.65	7.78	8.17	7.84	7.84	1.29
37	Anpara DTPS (2x500 MW)*	6.25	5.61	6.00	6.00	5.95	5.55	5.82	5.82	-0.43
38	Mettur TPS-II (1x600 MW)**	5.75	6.93	7.05	7.19	7.60	7.68	7.29	6.05	0.30
39	IL&FS (2* 600 MW)*	6.25	7.86	6.90	7.63	8.19	8.69	7.85	6.97	0.72
40	Singareni TPP (2 X 600 MW)*	6.25	5.64	5.99	6.10	5.81	6.03	5.91	5.91	-0.34
	Weighted Avg. (500-600 MW sets)	**5.98**	**6.23**	**6.32**	**6.42**	**6.40**	**6.53**	**6.38**	**5.92**	**-0.05**

41	Koradi (3*660 MW)**	5.75	8.45	8.11	8.10	7.53	7.34	7.91	6.25	0.50
42	Chhabra Super Critical TPP (2x660 MW)**	5.75	6.80	6.58	6.06	6.47	6.11	6.40	5.16	-0.59
43	Suratgarh STPS (2 X 660 MW)**	5.75			6.51	7.10	6.93	6.85	6.31	0.56
44	Kothagudem TPS Stg-VII (1X800 MW MW)**	5.75	4.52	5.25	4.49	4.58	4.64	4.70	4.70	-1.05
45	Harduaganj TPS Stage-II (1x660 MW)*	6.25				10.71	7.39	9.05	7.60	1.35
46	Rajpura TPP (2 X 700 MW)**	5.75	5.10	5.06	4.90	4.82	4.63	4.90	4.80	-0.95
47	Sasan TPP (6x660 MW)*	6.25	5.99	5.94	5.97	5.98	6.02	5.98	5.98	-0.27
48	Mahatma Gandhi TPP,Jhajjar (2x660 MW)**	5.75	6.69	7.20	6.67	6.61	6.25	6.68	5.80	0.05
	Weighted Avg. (660-800 MW sets)	**5.93**	**6.40**	**6.41**	**6.24**	**6.48**	**6.18**	**6.45**	**5.83**	**-0.10**

* Stations with IDCT ball and tube type mill **Stations with NDCT or Once through Cooling System # Stations with

It is seen from the above Table- 2.25, that in the state and private sector stations for which operation data has been furnished to CEA, there are 27 stations with 200 MW series units, 13 stations with 500-600 MW sets units and 8 stations with 660-800 MW sets units.

In case of stations with 200 MW series units, the weighted average of annual AEC of the stations is found to vary in the range of 9.53% in 2018-19 to 10.18% in 2020-21. The weighted average of actual AEC and corrected AEC over 5 year period is 9.95% and 9.43% respectively implying applicability of average admissible degradation in AEC of 0.52% point on account of part loading of the stations. The deviation of average corrected AEC over 5 year period w.r.t existing Normative AEC for individual stations is found to vary in the range in the range -1.74% point (for Deen Bandhu Chhotu Ram TPP , normative AEC 8%) to 3% point (for GHTP Stage-I, normative AEC 8.5%) with overall weighted average of deviation of all stations as 0.49.

In case of stations with 500-600 MW sets units, the weighted average of annual AEC of the stations is found to vary in the range of 6.23% in 2018-19 to 6.53% in 2022-23. The weighted average of actual AEC and corrected AEC over 5 year period is 6.38% and 5.92% respectively implying applicability of average admissible degradation in AEC of 0.46% point on account of part loading of the stations. The

deviation of average corrected AEC over 5 year period w.r.t existing Normative AEC for individual stations is found to vary in the range in the range (-1.46)% point (for Dr N Tatarao TPS Stage-IV , normative AEC 5.75%) to 1.29% point (for Anpara BTPS, normative AEC 6.55%) with overall weighted average of deviation of all stations as (-0.05)% point.

2.4.14 Auxiliary energy consumption of gas/ liquid fuel based stations:

i) The auxiliary energy consumption data has been analysed for 5 year period from 2018- 19 to 2022- 23 for 11 gas/ liquid fuel based generating stations comprising of 3 NEEPCO, 6 NTPC stations and 1 station each of OTPCL (ONGC Palatana) and RGPPL Ratnagiri.

ii) For analysis of auxiliary energy consumption of gas/ liquid fuel based generating stations in this report, the following factors have been considered as per degradation in auxiliary energy consumption proposed at para 3.2.3, which is reproduced below:

Sl. No.	**Module/ plant loading as % of installed capacity**	**Admissible % degradation in auxiliary energy consumption (% point)**
1.	85 - < 100	Nil
2.	80 - < 85	0.25
3.	70 - < 80	0.50
4.	60 - < 70	0.80
5.	50 - < 60	1.20

The above factors as applicable on case-to-case basis based on actual unit/ plant loading have been considered for modification/ correction of respective admissible auxiliary energy consumption.

iii) The analysis has not been carried out for NTPC Kayakulam, as there was no generation from the station during the entire period from 2018-19 to 2022-23. Pragati gas (PPCL) did not provide the plant loading data due to which it has not been considered in the analysis. Further, relatively very high annual auxiliary energy consumption values observed for NTPC Faridabad station (due to very low gross output) in the period 2022- 23 has not been considered and omitted in the analysis.

iv) The details of plant loading and admissible additional auxiliary energy consumption due to part load operation for all 11 gas/ liquid fuel based stations is indicated in Annexure- 10. The normative auxiliary energy consumption in respect of individual stations is also indicated.

From Annexure- 10, it is seen that average of annual plant loading for all 11 stations varies in the range 63.2% (in 2022- 23) and 68.2% (in 2019- 20). As per the considered factor the average of admissible additional AEC on annual basis for all 11 stations is in the range 0.72% (for 2019- 20) to 0.84% (for 2022- 23). The overall weighted average of additional AEC for all 11 stations over 5 year period is found as 0.79%. Further, the overall weighted average of additional AEC for the 09 stations, excluding stations provided with relaxation, over 5 year period is found as 0.87%.

v) The auxiliary energy consumption and corrected actual AEC for all 11 stations for the five (5) year period from 2018- 19 to 2022- 23 is indicated in Annexure- 10. It is seen that average of corrected actual AEC for these stations in individual years is found to vary in the range 2.55% in 2018- 19 to 3.91% in 2022- 23. The 5 year average of actual AEC provided by the stations for individual station is found to vary in the range 2.42% (for NEEPCO's AGBP station) to 4.74% (for NTPC Anta station). The 5 year average of corrected actual AEC for individual station is found to vary in the range 1.74% (for NEEPCO's AGBP station) to 3.94% (for NTPC Anta station). The overall weighted average of actual AEC for 09 stations, excluding stations provided with relaxation, over 5 year period is found as 3.09%.

Based on above analysis, *the existing auxiliary energy consumption norm of 2.75% for gas/ liquid fuel based CCGT plants is proposed to be retained except for below mentioned two stations, which are proposed to be provided with relaxed AEC norm.*

vi) In this respect, it is to mention that the following 02 stations have indicated their design AEC as more than the AEC norm of 2.75%. The design AEC values, corrected actual average AEC over 5-year period (as calculated in Annexure- 10) and deviation from the norm in respect of these 02 stations are indicated as below:

Sl. No.	**Power Station**	**Design AEC indicate by the utility (%)**	**Normative AEC (%)**	**5 year average of actual AEC (%)**	**5 year average of corrected actual AEC (%)**	**Excess AEC over normative AEC (% point)**
1.	NEEPCO, TGBP (101 MW)	5.54	2.95	**3.71**	**3.56**	**0.61**

2.	ONGC, Palatana (726.6 MW)	3.3	2.75	**3.99**	**3.74**	**0.99**

Regarding increased auxiliary energy consumption of TGBP station, it was mentioned in the previous explanatory memorandum for the tariff period 2019 -24, that the same is due to power required for gas booster station.

Based on overall considerations of relevant aspects involved, the relaxed AEC norm for above two stations is proposed to be as below:

NEEPCO, Tripura GBPP (101 MW) : 3.5%

ONGC- TPCL, Palatana CCPP (726.6 MW): 3.5%

Further, the existing auxiliary energy consumption norm of 1% for gas turbine operation in open cycle mode is proposed to be retained.

2.5 Annual Plant Load Factor (PLF)

2.5.1 The data for annual plant load factor (PLF) has been analysed for 5 year period from 2018- 19 to 2022- 23 as per plant operation data received for 133 generating stations/ station stages (henceforth referred as stations), comprising of 111 coal/ lignite based stations and 22 gas/ liquid fuel based stations. The separate data furnished by the utilities for individual stages of a power station, as applicable, have been considered as separate stations. The annual PLF has been calculated as per data furnished by the utility for gross generation (MU) of the station and maximum possible generation of the station as per weighted average installed in the particular year.

2.5.2 The details of annual PLF for all 111 coal/ lignite based generating stations for the five (5) year period from 2018- 19 to 2022- 23 is indicated in Annexure- 12. The average of annual PLF for all 111 stations is found to vary between 68.1% for year 2020- 21 to 73.6% for 2022- 23. The five year average of annual PLF for individual stations is found to vary in the range 44.1% for NLCIL's TPS-II Expansion (CFBC) TPS to 93.4% for Reliance's Sasan TPP with overall average of annual PLF for all the 111 stations for 5 year period as 70.0%.

NTPC Stations

The average of annual PLF of all 46 NTPC stations is found to vary in the range 72.4% (in 2020- 21) and 77.4% (in 2018- 19). The five year average of annual PLF for individual stations is found to vary in the range 47.0% for Khargone STPS to 91.3% for Korba Stage-III TPS with overall average of annual PLF for all the 46 stations for 5 year period being 72.6% which is about 2.6% more than average PLF of 70.0% for all 111 coal based stations. Out of 46 stations, 15 stations have

5 year average PLF as more than 80%, another 13 stations have 5 year average PLF between 80% and 70% and 18 stations have 5 year average PLF less than 70%.

DVC Stations

The average of annual PLF of all 10 DVC stations is found to vary in the range 64.6% (in 2019- 20) and 76.0% (in 2022- 23). The five year average of annual PLF for individual stations is found to vary in the range 52.3% for Raghunathpur TPS to 80.2% for Chandrapura CTPS with overall average of annual PLF for all the 10 stations for 5 year period being 69.3%.

NLCIL Stations

The average of annual PLF of all 06 NLCIL stations is found to vary in the range 60.2% (in 2020- 21) and 73.4% (in 2018- 19). The five year average of annual PLF for individual stations is found to vary in the range 44.1% for TPS- II Expansion (CFBC) to 83.9% for TPS- I Expansion with overall average of annual PLF for all the 06 stations for 5 year period being 67.8% (71.5% excluding TPS- II Expansion).

State sector stations

The average of annual PLF of 43 state sector stations is found to vary in the range 60.7% (in 2020- 21) and 67.6% (in 2018- 19). The five year average of annual PLF for individual stations is found to vary in the range 47.0% for MAHAGENCO's Nasik TPS to 84.9% for WBPDCL's Santaldih TPS with overall average of annual PLF for all the 43 stations for 5 year period being 63.6%.

IPPs

The average of annual PLF of 06 IPPs is found to vary in the range 72.9% (in 2020- 21) and 85.6% (in 2021- 22). The five year average of annual PLF for individual stations is found to vary in the range 55.8% for IL&FS Tamil Nadu Power Company Ltd to 93.4% for Reliance's Sasan TPP with overall average of annual PLF for all the 06 stations for 5 year period being 78.5%.

2.5.3 The details of annual PLF for 22 gas/ liquid fuel based thermal generating stations for the five (5) year period from 2018- 19 to 2022- 23 is indicated in Annexure- 13. NTPC Kayakulam has not been considered in the analysis as there is no generation from the station for the entire 5 year period of 2018- 23. The average of annual PLF of gas based stations is distinctly lower than that for coal/ lignite based stations due to non-availability of the gas. The average of annual PLF for all 22 stations is found to vary between 18.3% for year 2022- 23 to 32.2% for 2018- 19. The five year average of annual PLF for individual stations is found to vary in the range 7.8% for NTPC's Auraiya station to 76.7% for NEEPCO's TGBP with overall average of annual PLF for all the 22 stations for 5 year period as 26.7%. Out of 22 stations, only 6 stations have 5 year average PLF more than 50%.

Section- 3: Other Aspects

3.1 Impact of Part Load Operation in Coal/ Lignite Based Thermal Generating Stations:

3.1.1 Impact on station heat rate:

A thermal unit is designed for optimum heat rate at rated full load i.e. 100% MCR. At part load, performance deteriorates and heat rate increases depending upon deviation from design condition and plant operating practices. Because of increasing impact of renewables and for other considerations, thermal power plants often are required to operate at reduced loading. In order to account for increased station heat rate due to part loading, CERC, vide its notification dated 6.4.2016, has provided the following station heat rate degradation factors for coal/ lignite based generating stations as compensation for part loading of the units:

Sl. No.	Unit loading as % of installed capacity of the unit	Increase in station heat rate (%)	
		Sub- critical units	Super- critical units
1.	85- 100	Nil	Nil
2.	75 - 84.99	2.25	1.25
3.	65 - 74.99	4	2
4.	55 - 64.99	6	3

As per above table, no degradation is admissible up to 85% loading and first admissible step for sub- critical units is of 2.25% which is equal to half of admissible operation margin of 4.5%. This appears to be too steep and appreciable degradation in the load range above 85% is not addressed.

The turbine cycle heat rate degradation at part load as per OEM's HBDs for some sub- critical and super- critical thermal units as available at specific unit loading (viz. 100%, 80%, 60%, 50%, 40%) has been analysed. The values at intermediate loading have been taken as per appropriate curve fitting. The expected trend of heat rate degradation at part load is indicated below:

<u>Sub- critical units:</u>

	Turbine Cycle Heat Rate Degradation	Average Heat Rate

Unit loading					degradation (%)
	500MW (Vindhyachal TPS)*		250MW (Bongaigaon TPS)*		
	Heat rate (Kcal/kWh)	Heat rate degradation (%)	Heat rate (Kcal/kWh)	Heat rate degradation (%)	
100%	1931.6	Base	1943.7	Base	Base
95%	1942.4	0.56	1956.4	0.65	0.6
90%	1953.1	1.11	1969.0	1.30	1.2
85%	1963.9	1.67	1981.7	1.95	1.8
80%	1974.6	2.23	1994.3	2.60	2.4
75%	1993.8	3.22	2015.7	3.70	3.5
70%	2013.0	4.21	2037.0	4.80	4.5
65%	2032.2	5.21	2058.4	5.90	5.6
60%	2051.4	6.20	2079.7	7.00	6.6
55%	2087.2	8.06	2123.4	9.24	8.6
50%	2123.0	9.91	2167.0	11.49	10.7
45%	2158.8	11.76	2210.7	13.73	12.7
40%	2194.6	13.62	2254.3	15.98	14.8

* HBDs available for 100%, 80%, 60% & 50%.

Super- critical units:

Unit loading (%)	Turbine Cycle Heat Rate Degradation						Average Heat Rate increase (%)
	660 MW (Khargone)*		660 MW (Mauda)*		800 MW (Telangana TPS)*		
	Heat rate (Kcal/kWh)	Heat rate degradation (%)	Heat rate (Kcal/kWh)	Heat rate degradation (%)	Heat rate (Kcal/kWh)	Heat rate degradation (%)	
100	1780.8	Base	1832.7	Base	1776.0	Base	Base
95	1791.2	0.59	1840.4	0.42	1785.1	0.51	0.5
90	1801.6	1.17	1848.1	0.84	1794.2	1.02	1.0

85	1812.0	1.76	1855.8	1.26	1803.2	1.53	1.5
80	1822.5	2.34	1863.5	1.68	1812.3	2.05	2.0
75	1839.9	3.32	1876.9	2.41	1826.1	2.82	2.9
70	1857.4	4.30	1890.2	3.14	1839.8	3.60	3.7
65	1874.9	5.29	1903.6	3.86	1853.6	4.37	4.5
60	1892.4	6.27	1916.9	4.59	1867.3	5.14	5.3
55	1919.3	7.78	1936.5	5.66	1890.4	6.44	6.6
50	1946.2	9.29	1956.1	6.73	1913.5	7.74	7.9
45	1973.1	10.80	1975.7	7.80	1936.6	9.04	9.2
40	2000.1	12.31	1995.3	8.87	1959.7	10.34	10.5

* HBDs available for 100%, 80%, 60% & 50%.

There is no significant change in boiler efficiency at part loading. As such, turbine cycle heat rate degradation in % can be taken as applicable for degradation of the unit heat rate also.

In respect of recommendation of degradation in heat rate below 55% unit loading, no operational data is available. Therefore, heat rate degradation in percentage for loading below 55% is calculated using data provided by BHEL, Net heat rate degradation values by TPRM Division-CEA and heat balance diagram. The details of the heat rate degradation values obtained from these three sources are as follows:

a. The gross heat rate degradation provided by BHEL below 55% loading are as follows:

Unit HR degradation (%)			
Sl No	**Unit loading (%)**	**Sub-critical units**	**Super-critical units**
1	50 - <55	8.7	5.6
2	45 - <50	11.1	7.9
3	40 - <45	13.9	11.7

b. TPR&M division had published Net heat rate degradation percentage in the report- "Flexibilisation of coal-fired power plant" in February 2023. Gross heat rate degradation percentage derived from the Net heat rate degradation percentage given in the aforementioned TPR&M Division's report for loading below 55% is given below.

Unit HR degradation (%)

Sl No	Unit loading (%)	Sub-critical units	Super-critical units
1	50 - <55	7.4	5.8
2	45 - <50	9.4	8.2
3	40 - <45	12.0	10.9

c. Based on the Heat Balance Diagrams of TPPs, Gross heat rate degradation percentage below 55% loading are as follows:

Unit HR degradation (%)			
Sl No	Unit loading (%)	Sub-critical units	Super-critical units
1	50 - <55	9.7	7.3
2	45 - <50	11.7	8.6
3	40 - <45	13.8	9.9

On the basis of comparison of the above values, trend analysis and considering HBD values as the upper limit, the heat rate degradation for loading below 55% is suitably considered as below.

Unit HR degradation (%)			
Sl No	Unit loading (%)	Sub-critical units	Super-critical units
1	50 - <55	9.2	7.1
2	45 - <50	11.3	8.3
3	40 - <45	13.8	9.9

Based on expected degradation as per the above analysis, the increase of unit heat rate for coal/ lignite based sub- critical & super- critical units is proposed to be appropriately considered as per the following:

Unit HR degradation (%)			
Sl No	Unit loading (%)	Sub-critical units	Super-critical units
1	85-100	Nil	Nil
2	80 - <85	2.1	1.8
3	75 - <80	3.0	2.5

4	70 - <75	4.0	3.3
5	65 - <70	5.1	4.1
6	60 - <65	6.1	4.9
7	55 - <60	7.6	6.0
8	50 - <55	9.2	7.1
9	45 - <50	11.3	8.3
10	40 - <45	13.8	9.9

3.1.2 **Impact on auxiliary energy consumption**:

CERC, vide its notification dated 6.4.2016, has provided the following auxiliary energy degradation factors for coal/ lignite based generating stations as compensation for part loading of the units:

Sl. No.	**Unit loading as % of installed capacity of the unit**	**% degradation in auxiliary energy consumption admissible**
1.	85- 100	Nil
2.	75 - 84.99	0.35
3.	65 - 74.99	0.65
4.	55 - 64.99	1.00

The above additional auxiliary energy consumption values have been reviewed In this respect, typical characteristic curve was received from BHEL for 660 MW/800 MW TPP (considering BFP as TDBFP and Cooling Tower as IDCT).On the basis of the received curve the degradation in AEC at various loadings has been tabulated below:

Load (%)		
	AEC as per OEM curve (%)	Additional AEC (% point)
100	6.00	Base
95	6.25	0.25
90	6.4	0.4
85	6.6	0.6
80	6.9	0.9

75	7.1	1.1
70	7.4	1.4
65	7.8	1.8
60	8	2
55	8.5	2.5

Based on the above table and appropriate curve fitting for lower load values, the suggested AEC correction values are indicated as below:

Sl. No.	Module/ plant loading as % of installed capacity	Admissible % degradation in auxiliary energy consumption **(% point**)
1.	85 -100	Nil
2.	80 - < 85	0.5
3.	70 - < 80	1.1
4.	60 - < 70	1.8
5.	50 - < 60	2.5
6.	40 - < 50	3.2

3.2 Impact of Part Load Operation in Gas/ Liquid Fuel Based Thermal Generating Stations:

3.2.1 Impact on station heat rate for Combined Cycle Gas Power Plant:

In case of gas/ liquid fuel based units, there are, in general, more than one mode of plant operation depending upon level of operating load and availability of machines of the module. For example, for a CCGT module of (2GT+ST) module, there are three (3) possible modes of operation i.e. (2GT+ ST) mode, (1GT+ST) mode and GT in open cycle mode. All these three modes have distinctly different operating heat rates. As such, evaluation of heat rate degradation factor for CCGT modules need to have consideration of individual operation in different modes. Reference OEM data for such evaluation is not available.

The degradation of station heat rate in case of gas/ liquid fuel based generating stations has been analysed based on BHEL curve furnished by M/s PPCL for Bawana CCPP, data furnished by NTPC for their CCGTs and observed actual degradation as per plant operation data analysis for 5 year period. It is also to mention that all the gas/ liquid fuel based stations for which data has been furnished

are of combined cycle configuration. The reference input data considered for analysis of heat rate degradation at part load operation of gas/ liquid fuel based stations in CCGT mode is indicted below:

Unit loading (%)	Module Heat Rate Degradation in CCGT Mode						Average Heat Rate increase (%)
	685.6 MW (2x216 MW GT +253.6MW ST) Bawana CCGT		419.33 MW (3x88.71MW GT +153.2MW ST) Anta CCGT		359.8 MW (2x115.2MW GT +129.18MW ST) Kayamkulam CCGT		
	CCGT Heat rate (Kcal/kWh)	CCGT Heat rate degradation (%)	CCGT Heat rate (Kcal/kWh)	CCGT Heat rate degradation (%)	CCGT Heat rate (Kcal/kWh)	CCGT Heat rate degradation (%)	
100	1796	Base	1951	Base	1896	Base	Base
95	1802	0.37	--	--	--	--	0.37
90	1827	1.74	--	--	--	--	1.74
85	1852	3.12	1995	2.26	1962	3.48	**2.95**
80	1877	4.50	2006	2.82	1978	4.32	**3.88**
75	1914	6.56	2034	4.25	2006	5.80	**5.54**
70	1957	8.98	2070	6.10	2026	6.86	**7.31**
65	2012	12.03	2107	8.00	2064	8.86	**9.63**
60	2073	15.41	2153	10.35	2093	10.39	**12.05**
55	2136	18.92	2193	12.40	2125	12.08	**14.47**
50	2199	22.46	--	--	--	--	--

Based on expected degradation as per above, observed actual part load performance, the increase of unit heat rate for gas/ liquid fuel based stations in CCGT mode is proposed to be appropriately considered as per the following:

Sl. No.	Module/ plant loading as % of installed capacity	Increase in module/ plant heat rate (%)
1.	85 -100	Nil
2.	80 - < 85	2.5
3.	70 - < 80	5
4.	60 - < 70	8

5.	50 - < 60	12

3.2.2 **Impact on station heat rate for Open Cycle Gas Power Plant:**

The degradation of module/ plant heat rate for gas/ liquid fuel based thermal generating stations in Open cycle mode of operation are proposed to be considered as below based on the characteristic curve received from M/s Siemens for degradation in efficiency of Gas plant in open cycle for various different loadings of plant operation:

Sl. No.	Module/ plant loading as % of installed capacity	Increase in module/ plant heat rate (%)
1.	85 -100	Nil
2.	80 - < 85	3
3.	70 - < 80	7
4.	60 - < 70	11
5.	50 - < 60	16

3.2.3 **Impact on auxiliary energy consumption:**

It is understood that presently there is no specific norm for auxiliary energy degradation factors/ additional admissible auxiliary energy consumption for gas/ liquid fuel based generating stations. The degradation of AEC in case of gas/ liquid fuel based generating stations has been analysed based on BHEL curve furnished by M/s PPCL for Bawana CCPP, data furnished by NTPC for their CCGTs. The reference input data considered for analysis of AEC degradation at part load operation of gas/ liquid fuel based stations in CCGT mode is indicated below. The NTPC data, furnished for load range 85% to 55%, has been adjusted for correction of base to 100% load in line with trend observed for Bawana CCPP.

Unit loading (%)	**Module AEC (%) & Additional AEC at Part load in CCGT Mode (% point)**								Average Additional AEC (% point)
	685.6 MW (2x216 MW GT +253.6MW ST) Bawana CCGT		431.586 MW (2x137.758MW GT +156.07MW ST) Faridabad CCGT			328.1 MW (2x106MW GT +116.1MW ST) Kawas CCGT			
	AEC as per	Additional AEC (% point)	AEC as per	Additional AEC (% point)	*Adjusted additional	AEC as per	Additional AEC (% point)	*Adjusted additional	

	OEM curve (%)		NTPC data (%)		AEC (% point)	NTPC data (%)		AEC (% point)	
100	2.55	Base	--	--	Base	--	--	Base	Base
95	2.63	0.08	--	--	0.10	--	--	0.10	**0.10**
90	2.71	0.16	--	--	0.21	--	--	0.21	**0.19**
85	2.80	0.25	2.35	Base	0.33	2.2	Base	0.33	**0.30**
80	2.90	0.35	2.48	0.13	0.46	2.33	0.13	0.46	**0.42**
75	3.05	0.50	2.62	0.27	0.60	2.55	0.35	0.67	**0.59**
70	3.20	0.65	2.73	0.38	0.71	2.83	0.63	0.96	**0.77**
65	3.35	0.80	2.86	0.51	0.84	3.17	0.97	1.30	**0.98**
60	3.55	1.00	2.97	0.62	0.95	3.48	1.28	1.61	**1.18**
55	3.75	1.20	3.11	0.76	1.09	3.77	1.57	1.90	**1.39**
50	4.00	1.45	--	--	--	--	--	--	**1.45**

* Adjustment for base correction done in line with Bawana CCGT data.

Based on expected degradation as per above, observed actual part load performance over 5 year period, and application of part load correction in better loading steps, the increase in AEC for gas/ liquid fuel based stations in CCGT mode is proposed to be appropriately considered as per the following:

Sl. No.	Plant/ module loading as % of installed capacity	Admissible % additional auxiliary energy consumption (% point)
1.	85 -100	Nil
2.	80 - < 85	0.25
3.	70 - < 80	0.50
4.	60 - < 70	0.80
5.	50 - < 60	1.20

3.3 **Additional Auxiliary Energy Consumption on Account of Ball & Tube Mills:**

NTPC's Talcher Stage- I, Unchahar Stage- II and Vindhyachal Stage- II stations are provided with tube and ball mills. These are indicated to be high energy intensive milling system. Presently, no specific norm is provided for impact of tube & ball mills on auxiliary energy consumption of the station vis- a vis conventional bowl mills.

The details of power consumption as per design data of tube & ball mills installed in above stations and additionally for Barauni TPS are indicated below:

Description	Vindhyachal, Stage- II TPS	Talcher, Stage- I TPS	Unchahar, Stage- II TPS	Barauni TPS*
Unit gross capacity, MW	500	500	210	250
Coal flow under TMCR condition (design coal), tph	301	356.6	144.3	172.5
Type of tube & ball mill	BHEL BBD 4772	GE BBD 4772 SI	BBD 4760	BBD 4772
Motor rating, kW	2570	2400	1500	--
No. of mills in operation at TMCR	4	4	2	2
Power consumption of one mill, kW	1770	1900	1385	1692**
Power consumption for all operating mills, kW	7080	7600	2770	3384
Power consumption as % of gross unit output	1.42%	1.52%	1.32%	1.35%
Average power consumption of tube & ball mills at MCR as % of gross unit output	**1.40%**			

* Data furnished by BHEL.
** As per total power consumption of 3384 kW for the unit at MCR with design coal.

The corresponding details of design power consumption of conventional bowl mills installed in some stations and typical data for BHEL mills are indicated below:

Description	Vindhyachal, Stage- IV TPS	Bongaigaon TPS	BHEL typical data	
Unit gross capacity, MW	500	250	500	210
Coal flow under TMCR condition (design coal), tph	318	133	--	--
Type of bowl mill	XRP 1003	XRP 883	XRP 1003	XRP 803
Motor rating, kW	525	425	525	340
No. of mills in operation at TMCR	7	4	6	4
Power consumption of one mill, kW	393.75*	286.4**	500	300

Power consumption for all operating mills, kW	2756.25	1145.6	3000	1200
Power consumption as % of gross unit output	0.55%	0.46%	0.60%	0.57%
Average power consumption of bowl mills at MCR as % of gross unit output	**0.55%**			

* Assumed as 75% of motor rating.

** Pro- rata as per total power consumption of 1249 kW for BMCR coal flow of 145 tph for the unit.

From the above, it is seen that design auxiliary power consumption of tube & ball mills is significantly higher than that for bowl type mills with typical values being as 1.45% and 0.55% of gross output of the unit respectively. As such, AEC of the station is expected to increase by typically 0.85% point (of gross unit output) for change milling system from bowl mill type to tube & ball mill type.

The analysis of auxiliary energy consumption for Talcher Stage- I, Unchahar Stage- II and Vindhyachal Stage- II stations as per the operation data received for 5 year period is indicated as below:

Name of station	Capacity (MW)	AEC norm (%)	Average actual AEC for 5 year period (%)	Average Corrected actual AEC for 5 year period (%)	Excess of corrected actual AEC over the normative AEC (% point)
Unchahar, Stage- II TPS	2x210	9.80	10.22	8.70	**(-) 1.10**
Talcher, Stage- I TPS	2x500	6.55	7.65	7.55	**0.75**
Vindhyachal, Stage- II TPS	2x500	6.55	6.22	6.22	**(-) 0.83**
				Weighted Average	**(-) 0.33%**

As indicated above, the corrected actual average AEC for Talcher Stage- I station is 0.75% more than normative AEC. For Vindhyachal Stage- II station, actual average AEC is 0.02% less than the corrected normative AEC. The overall average of excess AEC over corrected normative AEC for 3 stations provided with tube & ball mills is 0.69% (0.84% over uncorrected normative AEC). Further, considering recommendation of increased normative AEC for 500 MW & higher size units as at para 2.4.12 of this report, the excess of actual AEC over normative/ corrected normative AEC shall reduce from the values indicated above.

Keeping in view the design data of two types of coal mills and actual auxiliary energy consumption of above three stations observed over 5 year period vis- a vis existing

norm, *additional auxiliary energy consumption of 0.8% is proposed to be considered for coal based thermal generating stations provided with tube & ball type mills.*

3.4 Transit losses.:

The data for transit loss has been analysed for 5 year period from 2018- 19 to 2022-23 as per plant operation data received for 45 NTPC generating stations/ station stages (henceforth referred as stations), comprising of 23 pithead stations and 22 non-pithead stations. The separate data furnished by the utility for individual stages of a power station, as applicable, have been considered as separate stations. The transit loss has been calculated only on the domestic coal consumption.

3.4.1 Transit loss for *pithead* and *non-pithead* NTPC generating stations.

i) The analysis of transit loss for pithead NTPC generating stations is indicated in table below:

Analysis of transit loss for pithead NTPC generating stations

Sl No.	Power Plant	Plant capacity (MW)	2018-19	2019-20	2020-21	2021-22	2022-23	Average transit loss % for 5 years
1	Darlipali STPS	1600		0.18	0.20	0.44	0.19	**0.25**
2	Farakka, Stage-I & II	1600	0.600	0.570	0.505	0.689	0.572	**0.59**
3	Farakka, Stage-III	500	0.600	0.570	0.505	0.689	0.572	**0.59**
4	Kahalgaon, Stage- I	840	0.197	0.249	0.240	0.294		**0.24**
5	Kahalgaon, Stage- II	1500	0.197	0.249	0.240	0.294		**0.24**
6	Korba, Stage-I & II	2100	0.14	0.14	0.16	0.17	0.20	**0.16**
7	Korba, Stage-III	500	0.140	0.140	0.160	0.170	0.200	**0.16**
8	Ramagundam-I & II	2100	0.026	0.045	0.096	0.024	0.138	**0.07**
9	Ramagundam-III	500	0.026	0.045	0.096	0.024	0.138	**0.07**
10	Rihand, Stage-I	1000	0.22	0.20	0.19	0.22	0.19	**0.20**
11	Rihand, Stage-II	1000	0.22	0.20	0.19	0.22	0.19	**0.20**
12	Rihand, Stage-III	1000	0.22	0.20	0.19	0.22	0.19	**0.20**
13	Singrauli	2000	0.19	0.19	0.20	0.20	0.20	**0.20**
14	Sipat, Stage-I	1980	0.116	0.171	0.155	0.180	0.191	**0.16**

15	Sipat, Stage-II	1000	0.116	0.171	0.155	0.180	0.191	**0.16**
16	Talcher, Stage-I	1000	0.27	0.54	0.54	0.51	0.50	**0.47**
17	Talcher, Stage-II	2000	0.27	0.54	0.54	0.51	0.50	**0.47**
18	Vindhyachal, Stage-I	1260	0.196	0.226	0.226	0.294	0.227	**0.23**
19	Vindhyachal, Stage-II	1000	0.196	0.226	0.226	0.294	0.227	**0.23**
20	Vindhyachal, Stage-III	1000	0.196	0.226	0.226	0.294	0.227	**0.23**
21	Vindhyachal, Stage-IV	1000	0.196	0.226	0.226	0.294	0.227	**0.23**
22	Vindhyachal, Stage-V	500	0.196	0.226	0.226	0.294	0.227	**0.23**
23	Lara STPS	1600		0.68	0.75	0.77	0.69	**0.72**
Weighted Average transit loss (%)			**0.21**	**0.27**	**0.28**	**0.32**	**0.29**	**0.28**

ii) From the above table, it is seen that the average of transit loss for all stations in individual year is found to vary between 0.21% in 2018- 19 to 0.32% in 2021- 22. The 5-year average of transit loss for individual stations is found to vary from 0.07% for Ramagundam TPS to 0.72% for Lara STPS. The overall weighted average of transit loss for all the 23 stations for 5-year period is 0.28%.

iii) The analysis of transit loss for non-pithead NTPC stations is indicated in the table below:

Analysis of transit loss for non-pithead NTPC generating stations

Sl No.	**Power Plant**	**Plant capacity (MW)**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**Average transit loss% for 5 years**
1	Barauni Stage-II	500		0.80	0.78	0.64	0.74	**0.74**
2	Barh- I	1320				0.78	0.78	**0.78**
3	Barh- II	1320	0.52	0.55	0.79	0.78	0.78	**0.68**
4	Bongaigaon	750	1.58	0.80	0.80	0.80	0.80	**0.95**
5	Dadri Thermal, Stage- I	840	0.62	0.56	0.67	0.62	0.59	**0.61**

6	Dadri Thermal, Stage- II	980	0.62	0.56	0.67	0.62	0.59	**0.61**
7	Mouda, Stage- I	1000	0.80	0.80	0.80	0.80	0.80	**0.80**
8	Mouda, Stage- II	1320	0.80	0.80	0.80	0.80	0.80	**0.80**
9	Simhadri, Stage- I	1000	1.77	0.80	0.80	0.78	0.80	**0.99**
10	Simhadri, Stage- II	1000	1.77	0.80	0.80	0.78	0.80	**0.99**
11	Tanda, Stage-I	440	0.80	0.79	0.78	0.79	0.79	**0.79**
12	Tanda, Stage-II	1320		0.79	0.78	0.79	0.79	**0.79**
13	Unchahar, Stage- I	420	0.79	0.79	0.75	0.74	0.58	**0.73**
14	Unchahar, Stage- II	420	0.79	0.79	0.75	0.74	0.58	**0.73**
15	Unchahar, Stage- III	210	0.79	0.79	0.75	0.74	0.58	**0.73**
16	Unchahar, Stage- IV	500	0.79	0.79	0.75	0.74	0.58	**0.73**
17	Gadarwara STPS	1600		0.74	0.77	0.74	0.77	**0.76**
18	Kanti-II/Muzaffpur	390	0.80	0.80	0.78	0.78	0.75	**0.78**
19	Khargone STPS	1320		0.28	1.12	0.87	0.80	**0.77**
20	Kudgi STPS	2400						
21	Nabinagar STPS	1980		0.89	0.78	0.79	0.79	**0.81**
22	Solapur STPS	1320	0.79	0.86	0.80	0.80	0.79	**0.81**
Weighted Average transit loss (%)			**0.95**	**0.73**	**0.80**	**0.77**	**0.75**	**0.79**

iv) From the above table, it is seen that the average of transit loss for all stations in individual year is found to vary between 0.73% in 2019- 20 to 0.95% in 2018- 19. The 5-year average of transit loss for individual stations is found to vary from 0.61% for Dadri TPS to 0.99% for Simhadri TPS. The overall weighted average of transit loss for all the 22 stations for 5-year period is 0.79%.

Based on the above performance, the transit and handling losses for coal/lignite based stations are proposed as follows:

Thermal Generating Station	**Transit and Handling losses (%)**

Pit-head [using Rail / Road]	0.20 %
Non-pit head [All Rail Route (ARR) – where loading into railway rakes is done by Coal company]	0.80 %
Non-pit head [Road Cum Rail (RCR) Route – where coal is lifted from mines, transported to good shed /other siding by road and then loading into railway rakes is done by generating company or other multi-modal transportation system involving multiple trans-shipments]	1.00 %

Provided that in the case of any combination of the above modes of transportation, the transit and handling losses shall be calculated on pro-rata basis using the formula given below:

Transit loss of coal/lignite based stations (%) = 0.2% x (percentage of coal transported through Pit-head source) + 0.8% x (percentage of coal transported through ARR) + 1.0% x (percentage of coal transported through RCR route or other multi-modal transportation system involving multiple trans-shipments).

4.1 Operation norm for implementation of new environmental emission control measures in thermal power stations

As per MoEF&CC notification dated 7.12.2015, thermal power stations are required to be provided with DeSOx systems for control of SO_2 emission and DeNOx system for control of NOx emission. The requirement of SOx and NOx to be complied is as below:

Sulphur Dioxide (SO_2)

Units installed upto 31.12. 2016 : 600 mg/Nm^3 for units < 500MW capacity
: 200 mg/Nm^3 for units ≥ 500MW capacity

Units installed from 1.1. 2017 : 100 mg/Nm^3

Oxides of Nitrogen (NOx)

Units installed upto 31.12. 2003 : 600 mg/Nm^3

Units installed after 1.1. 2004 up to 31.12. 2016 : 450* mg/Nm^3

Units installed from 1.1. 2017 : 100 mg/Nm^3

* Amended vide Gazette Notification G.S.R. 662(E) dated 22nd October, 2020

Presently, operational data on DeSOx system is available only for Jhajjar Power Ltd (M/s Apraava Energy) and no operational data is available on DeNOx system in the country. Some DeSOx systems are commissioned and some are under implementation in other units and pilot studies are underway for suitability of DeNOx systems for high ash Indian coals.

The following operation norms are worked out based on inputs received from utilities, OEMs and issues as analysed at our end.

4.1.1. DeSOx systems:

i) Limestone consumption of wet limestone based FGD system:
Wet limestone type FGD system is most widely used FGD system for removal of SO_2 from flue gases in thermal power plants. The consumption of limestone depends upon a number of factors including gross station heat rate (SHR), GCV & sulphur content of coal, SO_2 conversion factor, required SO_2 removal efficiency, stoichiometric ratio, purity of limestone etc. For estimating specific limestone consumption, the following assumptions have been made:

- Required SO2 removal efficiency for emission norm of 100 & 200 mg/Nm3 = 96%
- Required SO2 removal efficiency for emission norm of 600 mg/Nm3 = 73%
- SO2 conversion factor = 95%
- Stoichiometric molar ratio of reagent consumption= 1.05

- Typical purity of limestone = 85%
- Further, contribution or specific oil consumption in heat rate is neglected.

Based on above assumption, the limestone consumption of wet limestone FGD system has been estimated and same on gross generation basis can be taken as below:

Based on above assumption, the consumption of 85% purity limestone for wet limestone FGD system has been estimated and same on gross generation basis can be taken as below:

Specific consumption of limestone =

$$\frac{K \times \text{Normative heat rate (kcal/kWh)} \times \text{Sulphur content of coal (\%)}}{\text{GCV of coal (kcal/kg)}} \text{ g/kWh}$$

Where,

K= 35.2 for units to comply with SO_2 emission norm of 100/ 200 mg/Nm^3.

= 26.8 for units to comply with SO_2 emission norm of 600 mg/Nm^3.

The tables below indicate comparison of specific limestone consumption based on data furnished by the utilities/ OEM pertaining to wet limestone FGD plants under implementation and that estimated from above empirical formulae.

Parameters	Unit	Telengana, NTPC	Jhajjar, NTPC	Lara, NTPC	Harduaganj, TJPS	Typical, GE
Plant capacity	MW	2 x 800	3 x 500	2 x 800	1 x 660	2 x 500
Take normative gross heat rate	kcal/kWh	2250	2375	2250	2250	2375
GCV of coal	kcal/kg	3000	3200	3000	3200	3600
Sulphur content of coal	%	0.6	0.5	0.5	0.45	0.5
SO2 removal efficiency	%	97.1	95.1	96.6	95	92
Limestone consumption for one unit	kg/h	12245*	7290*	10000*	7200**	5100#
Specific limestone consumption	g/kWh	15.3	14.6	12.5	10.9	10.2
Specific limestone consumption worked out as per proposed formulation	g/kWh	15.8	13.1	13.2	11.1	11.6

*Limestone purity 79% for design & 89% for guarantee.

** Limestone purity 85%.
#Limestone purity 100%.

Parameters	Unit	Vindhyachal-V, NTPC	Dadri, NTPC	Unchahar-IV, NTPC	Jhajjhar Power Ltd, Apraava Energy
Plant capacity	MW	1 x 500 MW	2 x 490	1 X 500	2 x 660
Take normative gross heat rate	kcal/kWh	2337	2341	2337	2195
GCV of coal	kcal/kg	2900	3200	3000	3600
Sulphur content of coal	%	0.49	05	0.6	0.5
SO2 removal efficiency	%	90.6	95.1	95.1	90
Limestone consumption for one unit	kg/h	6250	7000	6909	8400*
Specific limestone consumption	g/kWh	12.5	14.3#	13.8	12.73
Specific limestone consumption worked out as per proposed formulation	g/kWh	13.9	9.8	16.5	10.7

* Limestone purity 90%
# NTPC Dadri has high specific limestone consumption of 14.3 g/kWh compared to 9.8 g/kWh as per the proposed formula because it is designed for 100 mg/Nm^3 guaranteed SO_2 level at outlet. However, calculation is made as per applicable emission norm of 600 mg/Nm^3 SO_2 level at outlet.

From above, good agreement is seen in the indicated limestone consumption and that worked out as per proposed formulae. As such, proposed empirical formulae can be used to calculate admissible limestone consumption of FGD system in thermal power stations.

As such, for units provided with wet limestone based FGD system for control of SO2 emission, the admissible specific consumption of limestone on gross generation basis is proposed to be taken as per following:

Specific limestone consumption =

$$\frac{\text{K x Normative heat rate (kcal/kWh) x Sulphur content of coal (\%)}}{\text{GCV of coal (kcal/kg)}} \text{ x [85/LP] g/kWh}$$

Where,
LP = Limestone Purity in percentage,
K= 35.2 x (Design SO2 Removal Efficiency/96%); for units to comply with SO_2 emission norm of 100/ 200 mg/Nm^3.
= 26.8 x (Design SO2 Removal Efficiency/73%) for units to comply with SO_2 emission norm of 600 mg/Nm^3.

ii) Lime consumption of lime spray dryer/ semi dry FGD system:

The lime spray dryer/ semi dry FGD system is generally used for small size units. The efficiency of reagent utilisation in semi dry system is less as compared to that in wet FGD system. The chemical reaction taking place in lime spray dryer/ semi dry FGD system is indicated as below:

$CaO + H_2O = Ca(OH)_2$
(1x56)
$Ca(OH)_2 + SO_2 + 1/2\ O_2 = CaSO_4 + H_2O$
(1x64)

As per the chemical reaction between lime and SO2, one mole of Ca is stoichiometrically required to neutralise one mole of SO2. For lime spray dryer system, the reagent feed ratio is generally expressed in terms of mole Ca/mole of SO2 in the inlet flue gas. The reagent feed ratio varies considerably with required efficiency of SO2 removal. It varies from the order of 0.9 mole Ca/mole of input SO2 for around 70% removal efficiency to the order of 1.6 mole Ca/mole of input SO2 for around 90% removal efficiency. These feed ratios are equivalent to 1.3 mole Ca/mole of SO2 removed for around 70% removal efficiency range and 1.8 mole Ca/mole of SO2 removal for 90% efficiency range.

For units to comply with SO2 emission limit of 600 mg/Nm3, typical required SO2 removal efficiency is expected to be of the order of 70%. For such cases, the lime spray dryer/ semi dry FGD system using lime provides a feasible option with reagent requirement appropriately taken as 1.35 mole of Ca per mole of SO2 removed. For a typical 210 MW series unit, the specific consumption of lime is estimated as below:

Take normative heat rate of the unit = 2450 kcal/kWh
Take GCV of coal= 3600 kcal/kg
Sulphur content = 0.5%
SO2 conversion factor = 95%
Expected SO2 level in flue gas = 1800 mg/Nm3
Considering SO2 level in exit flue gas as 550- 600 mg/Nm3, the required capture efficiency shall be of the order of 70%.
Take typical purity of lime = 90%

For above inputs, the requirement of lime
= (Heat Rate/GCV of coal) * (Sulphur content in %/100) * (SO2 conversion factor)* (Molecular wt of SO2/ Molecular wt of Sulphur) * (SO2 removal efficiency) * (Moles of Ca/mole of SO2 removed * Molecular wt of CaO/Molecular wt of SO2) * (1000 g/kg) / (Limestone purity)
= (2450/3600)*(0.5/100)*0.95*(64/32)*0.7*(1.35*56/64)*1000/0.90
= 5.94 g/kWh
Say 6 g/kWh

In the data furnished by OEM, the requirement of 100% lime for lime spray dryer/ semi dry FGD system in a typical 2x210 MW plant for SO2 removal efficiency of 70% has been indicated as 2300 kg/h. This amounts to specific consumption of 100% purity lime as 5.48 g/kWh and 90% purity lime as 6.08 g/kWh.

As such, for units to comply with SO2 emission norm of 600 mg/ Nm3 and provided with lime spray dryer/ semi dry FGD system, the admissible specific **consumption of 90% purity lime (CaO) on gross generation basis is proposed to be taken as 6 g/kWh**, to be adjusted as per purity of actual limestone used.

iii) Sodium bicarbonate consumption of dry sorbent injection system:

The dry sorbent injection system using sodium bicarbonate is generally used for small size units with low SO2 removal requirements. The efficiency of reagent utilisation in dry sorbent injection system is less as compared to that in wet FGD and semi dry FGD systems. The system has lower capital cost and smaller construction time but higher reagent cost.

The chemical reaction taking place in dry sorbent system is indicated as below:

$2\,NaHCO_3 + Heat = Na_2CO_3 + H_2O + CO_2$
(2x84)
$Na_2CO_3 + SO_2 = Na_2SO_4 + CO_2$
(1x64)

As per above, theoretically, 2 moles of NaHCO3 are required to remove 1 mole of SO2. In case of DSI, the requirement of reagent is expressed in terms of normalised stoichiometric ration (NSR) defined as moles of Na2 required per mole of inlet SO2 and depends considerably with required SO2 removal efficiency. It varies from the order of 0.5 for around 30% SO2 removal efficiency to the order of 2.0 for around 70% removal efficiency. The NSR value of 1.0 can be considered for SO2 removal efficiency of about 50%.

For units to comply with SO2 emission limit of 600 mg/Nm3 and coal having low sulphur content, the required SO2 removal efficiency is expected to be of the order of 50- 55%. For such cases, the dry sorbent injection system using sodium bicarbonate makes a feasible option and NRS of 1.0 can be taken as an appropriate value for the same. For a typical 210 MW series unit, the specific consumption of sodium bicarbonate is estimated as below:

Take normative heat rate of the unit = 2450 kcal/kWh
Take GCV of coal= 3600 kcal/kg
Sulphur content = 0.35%
SO2 conversion factor = 95%
Expected SO2 level in flue gas = 1200 mg/Nm3
Considering SO2 level in exit flue gas as 550- 600 mg/Nm3, the required capture efficiency shall be of the order of 50%.
For above inputs, the requirement of 100% pure sodium bi-carbonate
= (Heat Rate/GCV of coal) * (Sulphur content in %/100) * (SO2 conversion factor)* (Molecular wt of SO2/ Molecular wt of Sulphur) * (SO2 removal efficiency) * (2.0 * Molecular wt of NaHCO3/ Molecuar wt of SO2) * (1000 g/kg)
= (2450/3600)*(0.35/100)*0.95*(64/32)*(2.0*84/64)*1000
= 12 g/kWh

In the data furnished by NTPC, the requirement of 99% sodium bi- carbonate for DSI being considered for 210 MW unit at Dadri is indicated as 2180 kg/h. This amounts to specific consumption of 10.4 g/kWh.

As such, for units to comply with SO2 emission norm of 600 mg/ Nm3 and provided with dry sorbent injection system, the **admissible normative specific consumption of 100% purity sodium bi- carbonate on gross generation basis is proposed to be taken as 12 g/kWh.**

iv) Limestone consumption for furnace injection in CFBC power plant:

In CFBC power plants, limestone is in- situ injected into the boiler furnace along with fuel (lignite) for control of SO2. The efficiency of reagent utilisation in CFBC is less as compared to that in FGD system. The chemical reaction taking place in furnace injection of limestone for control of SO2 in CFBC boiler is indicated as below:

$CaCO_3$ + heat = $CaO + CO_2$
(1x100)
$CaO + SO_2 + 1/2\ O_2 = CaSO_4$
(1x64)

As per the chemical reaction between lime and SO_2, one mole of Ca is stoichiometrically required to neutralise one mole of SO2. For furnace injection of limestone, the reagent feed ratio is generally expressed in terms of mole Ca/mole of SO2 generated. The reagent feed ratio varies considerably with required efficiency of SO2 removal. Typically, CFBC can achieve a sulphur removal efficiency of the order of 90- 95% at a Ca/S molar ratio of around 2. Furnace injection of limestone is able to reduce SO2 level in exit flue gas upto the level of 200- 300 mg/Nm3.

For CFBC units to comply with SO2 emission limit of 600 mg/Nm3, typical required SO2 removal efficiency can be upto the level of 90% depending upon level of SOx generation in the boiler. For the purpose of norm, limestone consumption is considered to be calculated taking appropriate value of Ca/S molar ratio as 1.8.

Based on above assumption, the consumption of 85% purity limestone can be taken as below:

Specific consumption of limestone =

$$\frac{\textbf{62.9 x Normative heat rate (kcal/kWh) x Sulphur content of coal (\%)}}{\textbf{GCV of fuel (lignite) (kcal/kg)}} \textbf{ x [85/ LP] g/kWh}$$

For example:
For a lignite based CFBC unit having normative station heat rate of 2500 kcal/kWh, GCV of lignite as 2650 kcal/kg with sulphur content as 0.7 %, the admissible amount of limestone consumption for the unit on gross generation basis for compliance of SO2 emission norm of 600 mg/ Nm3 shall be:

= (62.9 x 2500 x 0.7)/2650 = 41.5 g/kWh (59.3 g/kWh for 1 % sulphur)

In the data furnished by NLCIL, consumption of 85% purity limestone for one 250 MW unit of TPS- II Exp. has been indicated as 15000 kg/h with GCV of lignite as 2650 kcal/kg and sulphur content as 0.7 % for best quality lignite and 1 % for worst quality lignite. The indicated consumption amounts to 60 g/kWh which compares well with the specific limestone consumption admissible as per proposed formulation.

It is also to mention that in the notification dated 24.2.2014 of Rajasthan Electricity Regulatory Commission (RERC), the regulation 45(5) indicates for normative limestone consumption of lignite based CFBC power plant to be computed in the following manner:

Limestone consumption = 0.056 x normative specific lignite consumption (kg/kWh) x S_{avg} (%) kg/kWh

Where, S_{avg} = weighted average inorganic sulphur content in lignite.

It is to mention that in the above formulation, the purity of limestone has not been indicated/ referred.

4.1.2. **Auxiliary energy consumption of FGD system:**

i) Wet limestone based FGD system:

The table below indicates auxiliary energy consumption (AEC) based on data furnished by the utilities pertaining to wet limestone FGD plants both under operation and also under implementation.

S No	Particulars	Unit	1	2	3	4	5
1	Name of Company		NTPC	NTPC	NTPC	NTPC	Jhajjhar Power Ltd. (Apraava Energy)
2	Name of Power Project/ Station		Vindhyachal-V	NCTPS DADRI in Unit -5	UNCHAHAR-IV	KHARGONE FGD in Unit -1	Jhajjhar Power Plant
3	Capacity (unit size) & Configuration	MW	1 X 500	2 X 490	1 X 500	2 X660	2 X660
4	Applicable SO2 emission norm (100/200/600 mg/Nm3)	mg/Nm^3	200	600	100	100	200
5	SO2 removal efficiency of FGD system	%	90.6	95.06	95.06	96.72	90.00
6	FGD system envisaged with GGH	Yes/ No	**Yes**	No	No	No	No
7	Auxiliary energy consumption per unit for FGD system	kW	5439*	4900-5629*	4060-4941*	5100-6900*	**Calculation based on actual Generation and FGD AEC data provided**
8	Auxiliary energy consumption (as per above data)	minimum (%)	1.09	1.00	0.81	0.77	
		maximum (%)	1.09	1.15	0.99	1.05	
9	**Average AEC**	**%**	**1.09**	**1.07**	**0.90**	**0.91**	**0.81**

Note:

1) * Auxiliary Power guarantee value is yet to be proved and is based on design data.
2) Design for NTPC Units is based upon maximum SOx loading
3) In Jhajjhar Power Ltd. (Apraava Energy), FGD is Operational data since February-2019

In the operation data furnished to CEA, actual operational data has been indicated on actual AEC of FGD system for Jhajjhar Power Ltd. (Apraava Energy).

In respect of all the NTPC units mentioned in the above table, design data of auxiliary energy consumption has been indicated in a range. Therefore, average

AEC has been determined in such cases. Further, Wet Limestone based FGD system with GGH provision at NTPC Vindhyachal Stage-V TPS (1x500MW) is operational since 2017; however, NTPC has provided design data for AEC.

It is observed that the auxiliary energy consumption for wet limestone FGD (without GGH) is found to vary in the range 0.81% for Apraava Energy's Jhajjhar Power Plant to 1.07% for NTPC's Dadri Unit-V. Based on the data furnished, it is proposed to retain the AEC as 1% of gross generation of the power plant.

ii) Sea water based FGD system:

Sea water based FGD is applicable for coastal locations. For power stations based on sea water once- through CW system, the auxiliary energy consumption of FGD system (without GGH) is proposed to be considered as 1% of gross output of the power plant.

iii) Lime spray dryer/ semi dry FGD system:

Based on data furnished by OEM for typical lime spray dryer/ semi dry FGD system and information available on internet, the auxiliary energy consumption of lime spray dryer/ semi dry FGD system is proposed to be considered as 1% of gross generation of the power plant.

iv) Additional auxiliary energy consumption for provision of GGH:

For FGD envisaged with GGH, additional auxiliary energy consumption is proposed to be taken as 0.2% of gross generation of the power plant.

4.2.1. DeNOx systems:

The NOx generation in pulverised coal power plant boilers is generally considered as 260 g/GJ of heat input in the boiler and this corresponds to the NOx level of about 750 mg/Nm^3 in the flue gas. Primary means of combustion modification are able to reduce NOx emission level upto 450 mg/Nm^3. As such, primary means of combustion modification are adequate for power plants to comply with NOx emission limit of 600 mg/Nm3. For emission reduction below about 450 mg/Nm^3 level, SCR/ SNCR system need to be adopted. SNCR is considered for plants to comply with NOx emission limit of 300 mg/Nm^3 and SCR for plants to comply with NOx emission limit of 100 mg/Nm^3. The NOx produced in the boiler comprises of about 95% as NO, however, it is reported in NO_2.
Generally, urea [$(NH_2)_2CO$] is used as reagent in SNCR and ammonia (NH_3) in SCR for control of NOx emission from the boiler.

The chemical reaction taking place with use of ammonia and urea are indicated as below:

$2\ NH_3 + 2\ NO + ½\ O_2 = 2\ N_2 + 3\ H_2O$
(2x17) (2x30)

$(NH_2)_2CO + 2\ NO + ½\ O_2 = 2\ N_2 + 2\ H_2O + CO_2$
(1x60) (2x30)

In the reactions taking place, the NO_x is represented as NO since it is the predominant form of NO_x within the boiler. Theoretically, 1 mole of ammonia (or ½ mole of urea) is required to remove 1 mole of NOx.
The NOx reduction reactions are most effective within a specified temperature range or window. Factors such as the temperature, residence time, reagent distribution in the flue gas etc. have impact on performance of NOx reduction.

i) Reagent consumption for plants using SNCR to comply with NOx emission limit of 300 mg/Nm^3

In case of SNCR, the actual requirement of reagent is expressed in terms of normalised stoichiometric ratio (NSR), defined as moles of ammonia required per mole of inlet NOx and varies considerably depending upon inlet NOx concentration and required NOx removal efficiency.
For plants with permissible emission limit of 300 mg/Nm^3, take NOx reduction to be achieved = 150- 175 mg/Nm^3 [considering a margin of 25 mg/Nm^3]
Required NOx reduction efficiency range = 30- 40%.

For 30- 40 % NOx reduction in SNCR, take appropriate value of NSR as 1.1.

Take normative unit heat rate of a typical 500 MW unit = 2375 kcal/kWh
NOx generation as per heat rate of the unit = 2.585 g/kWh
(This is considered to be corresponding to NOx concentration of 750 mg/Nm^3)
On pro- rata basis, NOx for concentration of 450 mg/Nm^3 = 1.551 g/kWh
Requirement of 100% urea= (0.5x60/46) x 1.1 x 1.551= 1.113 g/kWh
Say 1.2 g/kWh

In the data furnished by OEM, the requirement of 100% urea for SNCR in a typical 500 MW unit for NOx reduction from level of 450 to 175 mg/Nm^3 has been indicated as 500 kg/h. This amounts to specific consumption of 1.0 g/kWh and compares well with the norm worked out above.

As such, for units to comply with NOx emission norm of 300 mg/ Nm^3 and provided with SNCR system, the admissible **specific consumption of 100% pure urea on gross generation basis is proposed to be taken as 1.2 g/kWh**.

ii) Reagent consumption for plants using SCR to comply with NOx emission limit of 100 mg/Nm3

In case of SCR, the actual requirement of reagent is expressed in terms of stoichiometric ratio (SR), defined as moles of ammonia required per mole of NOx removed.

For plants with permissible emission limit of 100 mg/Nm^3, take NOx reduction to be achieved = 350- 375 mg/Nm^3 [considering a margin of 25 mg/Nm^3]

Required NOx reduction efficiency range = 75- 85%.

For estimating reagent consumption for 75- 85 % NOx reduction in SCR, take appropriate value of SR as 1.05.

Take normative unit heat rate of 660 MW unit = 2250 kcal/kWh

NOx generation as per heat rate of the unit = 2.449 g/kWh

(This is considered to be corresponding to concentration of 750 mg/Nm^3)

On pro- rata basis, NOx for concentration of 450 mg/Nm^3 = 1.469 g/kWh

Requirement of 100% ammonia = (17/46) x 1.05 x 1.469= 0.5702 g/kWh

Say 0.6 g/kWh

In the data furnished by OEM, the requirement of 100% ammonia for SCR in 1x660 MW Harduaganj TPS for NOx reduction from level of 406 to 81 mg/Nm3 has been indicated as 286 kg/h. This amounts to specific ammonia consumption of 0.433 g/kWh and compares well with the norm worked out above.

As such, for units to comply with NOx emission norm of 100 mg/ Nm^3 and provided with SCR system, the admissible **specific consumption of 100% ammonia on gross generation basis is proposed to be taken as 0.6 g/kWh**.

iii) Additional auxiliary energy consumption for plants using SCR to comply with NOx emission limit of 100 mg/Nm^3

The catalyst sections of SCR system are required to be installed in the flue gas path between economiser and air preheaters. The pressure drop on account of this results in requirement of additional auxiliary energy consumption by ID fans. As per data received from OEMs, the pressure drop of SCR system in a 660 MW unit amounts to about 150 mmwc and average additional power consumption is indicated about 1.3 MW. *For the purpose of the norm, the additional auxiliary energy consumption on account of SCR system is suggested to be taken as 0.2% of gross output.*

Section- 4: Recommendations

Reference: Regulation 49 under Chapter 12 in CERC (Terms and Conditions of Tariff) Regulations, 2019:

The recommendations of Central Electricity Authority on plant operation norms in respect of thermal generating stations for the tariff period 2024- 2029 are as below:

A. Normative Annual Plant Availability Factor (PAF)

i) All thermal(coal, lignite and gas based) generating stations, except those covered under clause ii), iii) & iv) : - 85 %

ii) Lignite fired generating stations using circulatory fluidized bed combustion (CFBC) technology and generating stations based on coal rejects:

a) First Three years from Commercial Operation Date (COD): 68.5%

b) For next year after completion of three years of COD : 75%

iii) For following Lignite-fired Thermal generating stations of NLC India Ltd:

a) TPS- II Stage- I & Stage- II : 80%

b) Barsingsar (CFBC) : 75%

c) TPS-II Expansion (CFBC) : 70%

iv) M/s NEEPCO's gas fired thermal generating station:

a) Assam Gas Based Plant : 70%

B. Normative Secondary Fuel Oil Consumption (SFOC)

i) Coal-based generating stations other than stations at (ii) & (iii) below: 0.50 ml/kWh

ii) For coal based generating stations with wall (front/rear/sides) fired boilers: 1.0 ml/kWh

iii) Coal-based generating station of DVC:

Mejia TPS 210 MW Unit- 1 to 4: 1.0 ml/kWh

iv) Lignite-fired generating stations (Pulverised and CFBC): 1.0 ml/kWh

v) Generating stations based on coal rejects : 2.0 ml/kWh

C. Gross Station Heat Rate:

1. Existing Thermal Generating Stations (COD achieved before 1.4.2009):

i) The normative gross station heat rate for coal based thermal generating units/ stations other than those relaxed norms covered under clause (ii) below shall be as under:

200-300 MW sets (sub-critical)	2415 kcal/kwh
500-600 MW sets (sub-critical) (TDBFP)	2375 kcal/kwh

Note:

In respect of 500 MW and above units where the boiler feed pumps are electrically operated, the gross station heat rate shall be 40 kcal/kWh lower than the gross station heat rate specified above.

ii) NTPC's coal based thermal generating stations:

Tanda TPS (4x110MW)	2750kcal/kWh

(Note for (i) & (ii) : Normative gross station heat rate has been arrived at considering storage loss of 85 kcal/kg in GCV i.e GCV as received basis (ARB)-85 kcal/kg for coal based stations)

iii) Lignite fired thermal generating stations:

The gross heat rate norms in respect of NLCIL lignite based thermal generating stations shall be as below:

NLC TPS-I (Expansion) (2x210MW)	2710 kcal/kWh
NLC TPS-II Stage I (3x210MW) and NLC TPS-II Stage II (4x210MW)	2880 kcal/kWh

iv) Open cycle gas turbine/ combine cycle thermal generating stations:

The operation norm for existing open cycle gas turbine/ combine cycle thermal generating stations given at CERC Regulation 49(C)(a)(vi) are proposed to be retained.

2. Thermal Generating Stations (coal & lignite) having COD achieved on or after 1.4.2009:

ii) The normative gross station heat rate[#] of coal-based and lignite-fired thermal generating stations other than those relaxed norms covered under clause (ii) & (iii):

For 200-300 MW sets= 1.05 X Design Heat Rate (kcal/kWh)

For 500 MW sets & above= 1.04 X Design Heat Rate (kcal/kWh)

(Note: Normative gross station heat rate has been arrived at considering storage loss of 85 kcal/kg in GCV i.e GCV as received basis (ARB)-85 kcal/kg for coal based stations)

Where the Design Heat Rate of a generating unit means the unit heat rate guaranteed by the supplier at conditions of 100% MCR, zero percent make up, design coal and design cooling water temperature/back pressure.

Provided that depending upon the pressure and temperature ratings of the units, the maximum design turbine cycle heat rate and minimum design boiler efficiency shall be as per the table below.

In case designed turbine cycle heat rate and boiler efficiency are better than these values, the same shall be considered for calculation of unit heat rate.

Pressure Rating (kg/ cm^2)	*150*	*170*	170
SHT / RHT (^{0} C)	535/535	537/537	537/565
Type of BFP	Electrical Driven	Turbine Driven	Turbine Driven
Max Turbine Heat Rate	1955	1950	1935

(kcal/kWh)			
Minimum Boiler Efficiency*(Percentage)			
Sub-Bituminous Indian Coal (%)	86	86	86
Bituminous imported coal (%)	89	89	89

Pressure Rating (kg/ cm^2)	247	247	260	270	270
SHT / RHT (^{0} C)	537/ 565	565/ 593	593/ 593	593/ 593	600/ 600
Type of BFP	Turbine Driven	Turbine Driven	Turbine Driven	Turbine Driven	Turbine Driven
Max Turbine Heat Rate(kcal/kWh)	1900	1850	1814	1810	1790
Minimum Boiler Efficiency*(Percentage)					
Sub-Bituminous Indian coal (%)	86	86	86	86.5	86.5
Bituminous imported coal (%)	89	89	89	89.5	89.5

* For lignite fired thermal generating station, the minimum boiler efficiency shall be 76% (for pulverised) and 80 %(for Fluidised bed) based boilers. Further, it may be noted that as the lignite fired thermal generating station has been provided with lower minimum boiler efficiency in consideration of higher moisture content, any

further moisture content factor is not applicable over and above the design heat rate.

In case pressure and temperature parameters of a unit are different from ratings given in the above table, the maximum design turbine cycle heat rate & minimum boiler efficiency of the nearest class shall be taken.

For units based on dry cooling system, the maximum turbine cycle heat rate shall be considered as per the actual design or 6% higher than the values given in the table above, whichever is lower.

iii) NTPC's coal based thermal generating stations:

Kanti TPS (2x195 MW)	2500 kcal/kWh

(Note: Normative gross station heat rate has been arrived at considering storage loss of 85 kcal/kg in GCV i.e GCV as received basis (ARB)-85 kcal/kg for coal based stations)

iv) The impact of change of BFP drive from steam turbine driven to electric motor driven on unit heat rate shall be mentioned as below:

"In respect of generating units where the boiler feed pumps are electrically operated, the maximum design unit heat rate shall be 40 kcal/kWh lower than the maximum design unit gross heat rate with turbine driven BFP."

The normative heat rate values are arrived after applying the degradation factors given in table at F(1)(i) for coal/lignite based generating stations. In case degradation factors given in table at F(1)(i) are modified, the normative heat rate values need to be corrected accordingly and vice-versa.

3. Gas-based/ Liquid-based thermal generating unit(s)/ block(s) having COD on or after 01.04.2009:

For Natural Gas and RLNG = 1.05 x Design Heat Rate of the unit / block (kCal/kWh),
For Liquid Fuel = 1.071 x Design Heat Rate of the unit / block (kCal/kWh),

Where, the Design Heat Rate of a unit shall mean the guaranteed heat rate for a unit at 100% MCR and at site ambient conditions; and the Design Heat Rate of a block shall mean the guaranteed heat rate for a block at 100% MCR, site ambient

conditions, zero percent make up, design cooling water temperature/back pressure.

4. **Applicability of Heat Rate Norms**

i) The Station Heat Rate (SHR) norms of the coal/lignite based units commissioned till 31.03.2024 (before 2009 and after 2009) is to be fixed based on the recommended operating norms for the control period 2024-29, for the lifetime of the respective units. ***However, this shall not be applicable for units with relaxed norms.***

ii) The units commissioned from 01.04.2024 till 31.03.2029 will adopt recommended operating norms for the control period 2024-29. However, the same will be reviewed and SHR norms will be fixed for the life time in the next control period i.e 2029-34 and so on based on the actual performance.

iii) The commission may review the SHR norms for the life time of the units in case it desires so, for situations like change in law, improvement in efficiency like R&M or any other valid reasons on case-to-case basis.

D. Auxiliary energy consumption

1. Coal Based Thermal Generating Stations:

i) Coal-based thermal generating stations except at (ii) & (iii) below:

	(Auxiliary energy consumption ## as % of gross generation) With NDCT/Once-through
200-300 MW sets	8.5%
500-600 MW sets with TDBFP (sub-critical)	5.25%
660-800 MW with TDBFP (Super-critical)	5.25%

In case of thermal units of 500 MW and above with electrically driven Boiler Feed Pumps, the auxiliary energy consumption allowed shall be 8.0%.

In case of thermal generating stations provided with Induced Draft Cooling Tower (IDCT), the additional auxiliary energy consumption allowed shall be 0.5%.

In addition, thermal generating stations provided with ball and tube mills, the additional auxiliary energy consumption allowed shall be 0.8%.

In case of thermal generating stations provided with Dry Cooling Systems, the additional auxiliary energy consumption allowed shall be as below:

Type of dry cooling system	(% of gross generation)
Direct cooling air cooled condensers with mechanical draft fans	1.0%
Indirect cooling system employing jet condensers with pressure recovery turbine and natural draft tower	0.5%

ii) NTPC's coal based thermal generating stations:

Tanda Thermal Power Station (440 MW)	12%

iii) DVC's coal based thermal generating stations:

Chandrapur Thermal Power Station *(*2x250 MW*)*	9.50%

2. Lignite Based Thermal Generating Stations:

i) For all pulverised lignite fired thermal generating stations with 200 MW sets and above, the auxiliary energy consumption norms shall be 0.5 percentage point more than the auxiliary energy consumption norms of coal-based generating stations except at (ii) below.

ii) M/s NLCIL's pulverised lignite fired generating stations:

TPS-II stage- I (630 MW)	10%
TPS- II stage- II (840 MW)	10%

iii) For lignite fired thermal generating stations using CFBC technology, the auxiliary energy consumption norms shall be 1.5 percentage point more than the auxiliary energy consumption norms of coal-based generating stations except at (iv) below.

iv) M/s NLCIL's CFBC technology based lignite fired generating stations:

Barsingsar TPS (2x125 MW)	12.5 %
TPS-II Expansion (2x250 MW)	12.5 %

The Auxiliary energy consumption values are arrived after applying the degradation factors given in table at F(1)(ii) for coal/lignite based generating stations. In case degradation factors given in table at F(1)(ii) are modified, the Auxiliary energy consumption values need to be corrected accordingly and vice-versa.

3. Gas Turbine/ Combined Cycle Generating Stations:

i) Gas turbine/ combined cycle generating stations, except those at (ii) below:

a) Combined cycle generating stations : 2.75%

b) Open cycle generating stations : 1.0%

In case of Combine Cycle Generating Stations using electric motor driven Gas Booster Compressor, the Auxiliary Energy Consumption shall be 3.30% (including impact of air-cooled condensers for Steam Turbine Generators).

Further additional Auxiliary Energy Consumption of 0.35% shall be allowed for stations having direct cooling air cooled condensers with mechanical draft fans.

ii) a) NEEPCO's Tripura gas based station (101 MW) : 3.5%

b) OTPC Palatana CCPP (726.6 MW) : 3.5%

E. Annual Plant Load Factor (PLF) for Incentive

The level of Annual Plant Load Factor (PLF) for Incentive is recommended **at the same level** of Normative Annual Plant Availability Factor (NAPAF) for the station for the year.

F. Impact of Part Load Operation on Performance of Thermal Generating Stations:

1. Coal/ lignite based thermal generating stations:

i) Impact on station heat rate:

The applicable factors for unit heat rate degradation at part loading for sub-critical and super- critical units are proposed as follows:

		Unit HR degradation (%)	
Sl No	**Unit loading (%)**	**Sub-critical units**	**Super-critical units**
1	85-100	Nil	Nil
2	80 - <85	2.1	1.8

3	75 - <80	3.0	2.5
4	70 - <75	4.0	3.3
5	65 - <70	5.1	4.1
6	60 - <65	6.1	4.9
7	55 - <60	7.6	6.0
8	50 - <55	9.2	7.1
9	45 - <50	11.3	8.3
10	40 - <45	13.8	9.9

ii) Impact on auxiliary energy consumption:

The admissible additional auxiliary energy consumption values at part loading of coal/ lignite based thermal generating stations are proposed as follows:

Sl. No.	Module/ plant loading as % of installed capacity	Admissible % degradation in auxiliary energy consumption **(% point)**
1.	85 -100	Nil
2.	80 - < 85	0.5
3.	70 - < 80	1.1
4.	60 - < 70	1.8
5.	50 - < 60	2.5
6.	40 - < 50	3.2

iii) Impact on SFOC:

Considering flexible operation requirement of coal based thermal stations in view of capacity addition from renewable sources, additional specific oil consumption of 0.2 ml/kWh is proposed to be provided for units operating in 40-55% average loading.

2. Gas/ liquid fuel based thermal generating stations:

i) Impact on station heat rate:

The degradation of module/ plant gross heat rate for gas/ liquid fuel based thermal generating stations in CCGT mode of operation are proposed to be considered as below:

Sl. No.	Module/ plant loading as % of installed capacity	Increase in module/ plant heat rate (%)
1.	85 -100	Nil
2.	80 - < 85	2.5
3.	70 - < 80	5
4.	60 - < 70	8
5.	50 - < 60	12

ii) The degradation of module/ plant heat rate for gas/ liquid fuel based thermal generating stations in Open cycle mode of operation are proposed to be considered as below:

Sl. No.	Module/ plant loading as % of installed capacity	Increase in module/ plant heat rate (%)
1.	85 -100	Nil
2.	80 - < 85	3
3.	70 - < 80	7
4.	60 - < 70	11
5.	50 - < 60	16

iii) Impact on auxiliary energy consumption:

The additional auxiliary energy consumption admissible at part loading of gas/ liquid fuel based thermal generating station is proposed to be considered as below:

Sl. No.	Plant/ module loading as % of installed capacity	Admissible % additional auxiliary energy consumption (% point)
1.	85 -100	Nil
2.	80 - < 85	0.25
3.	70 - < 80	0.50
4.	60 - < 70	0.80
5.	50 - < 60	1.20

G. Transit losses of coal:

For coal and lignite, the transit and handling losses shall be as per the following norms:-

Thermal Generating Station	**Transit and Handling losses (%)**
Pit-head [using Rail / Road]	0.20 %
Non-pit head [All Rail Route (ARR) – where loading into railway rakes is done by Coal company]	0.80 %
Non-pit head [Road Cum Rail (RCR) Route – where coal is lifted from mines, transported to good shed /other siding by road and then loading into railway rakes is done by generating company or other multi-modal transportation system involving multiple trans-shipments]	1.00 %

Provided that in the case of any combination of the above modes of transportation, the transit and handling losses shall be calculated on pro-rata basis using the formula given below:

"Transit loss of coal/lignite based stations (%) = 0.2% x (percentage of coal transported through Pit-head source) + 0.8% x (percentage of coal transported through ARR) + 1.0% x (percentage of coal transported through RCR route or other multi-modal transportation system involving multiple trans-shipments)*."*

Provided further that in case of imported coal, the transit and handling losses applicable for pit-head station shall apply.

H. Reagent and auxiliary energy consumption due to implementation of DeSOx system and DeNOx system:

The recommendations of CEA on admissibility of reagent consumption and auxiliary energy consumption on account of implementation of DeSOx system and DeNOx system towards compliance of new environmental emission norms are as below:

1. Reagent consumption:

i) Limestone consumption of wet limestone based FGD system:

Specific limestone consumption (g/kWh) on gross generation basis =

[K x SHR x S/CVPF] *x [85/ LP]*

Where,

S = Sulphur content in percentage,

LP = Limestone Purity in percentage,

SHR= Gross station heat rate, in kCal per kWh;

CVPF = (a) *Weighted Average Gross calorific value of coal considering GCV as per Regulation 60, in kCal per kg for coal based stations less 85 Kcal/Kg on account of variation during storage at generating station;*

(b) Weighted Average Gross calorific value of lignite as received, in kCal per kg, as applicable for lignite based thermal generating stations:

Provided that value of K shall be equivalent to (35.2 *x Design SO2 Removal Efficiency/96%)* for units to comply with SO2 emission norm of 100/200 mg/Nm3 or (26.8 *x Design SO2 Removal Efficiency/73%)* for units to comply with SO2 emission norm of 600 mg/Nm3;

Provided further that the limestone purity shall not be less than 85%.

ii) Lime consumption of lime spray dryer/ semi dry FGD system:

Specific consumption 90% purity lime (CaO) on gross generation basis = [6 x 90 / LP] g/kWh

iii) Sodium bicarbonate consumption of dry sorbent injection system:

Specific consumption of 100% sodium bicarbonate on gross generation basis = 12 g/kWh

iv) Limestone consumption of CFBC power plants (furnace injection):

Specific limestone consumption on gross generation basis =

[62.9 x S x SHR /CVPF] x [85/ LP]

Where,

S = Sulphur content in percentage,

LP = Limestone Purity in percentage,

SHR = Gross station heat rate, in kCal per kWh,

CVPF = Weighted Average Gross calorific value of lignite as received, in kCal per kg as applicable for lignite based thermal generating stations.

v) Urea consumption of SNCR system:

Specific consumption of 100% urea on gross generation basis = 1.2 g/kWh

vi) Ammonia consumption of SCR system:

Specific consumption of 100% ammonia on gross generation basis = 0.6 g/kWh

2. **Auxiliary energy consumption:**

i) Wet limestone based FGD system:

Normative auxiliary energy consumption for wet limestone FGD system= 1% of gross generation of the power plant.

ii) Sea water based FGD system:

Normative auxiliary energy consumption for sea water based FGD system= 1% of gross generation of the power plant.

iii) Lime spray dryer/ semi dry FGD system:

Normative auxiliary energy consumption for lime spray dryer/ semi dry FGD system= 1% of gross generation of the power plant.

iv) Additional auxiliary energy consumption for provision of Gas-Gas Heaters (GGH):

For FGD envisaged with GGH, additional auxiliary energy consumption= 0.2% of gross generation of the power plant/ unit.

v) Additional auxiliary energy consumption for provision of SCR:

Normative auxiliary energy consumption for installation of SCR system= 0.2% of gross generation of the power plant/ unit.

The above proposed norms for reagent consumption and auxiliary energy consumption in respect of DeSOx systems and DeNOx systems are suggested to be reviewed after sufficient operational data is available in due course of time.

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