



National Electric Power Regulatory Authority

Islamic Republic of Pakistan

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No. NEPRA/R/SA(Tech)/TRF-362/K-Electric-2016/26795-26797
September 2, 2020

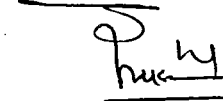
Subject: **Approval of Heat Rate for 248 MW KCCPP of K-Electric (KE)**
(Case No. NEPRA/TRF-362/K-Electric-2016)

Dear Sir,

Please find enclosed herewith subject Approval of the Authority (07 Pages) in the matter of approval of Heat Rate for 248 MW KCCPP of K-Electric (KE) in Case No. NEPRA/TRF-362/K-Electric-2016.

2. The subject approval/Decision of the Authority is being intimated to the Federal Government for the purpose of notification in the official Gazette pursuant to Section 31(7) of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

Enclosure: As above


02 09 20

(Syed Safer Hussain)

Secretary
Ministry of Energy (Power Division)
'A' Block, Pak Secretariat,
Islamabad

CC:

1. Secretary, Cabinet Division, Cabinet Secretariat, Islamabad.
2. Secretary, Ministry of Finance, 'Q' Block, Pak Secretariat, Islamabad.

ORDER

APPROVAL OF HEAT RATE FOR 248 MW KCCPP OF K-ELECTRIC (KE)

Background:

Korangi Combined Cycle Power Plant (KCCPP) of 248 MW is part of the overall fleet of generating facilities owned by K-Electric (KE) which was commissioned in the year 2008. A Steam Turbine was added in the complex in 2015. Under the current setup the plant comprises 4GTs, 2 STs, 2 HRSGs - in 02 combined cycle blocks each having 02 gas turbines, 01 HRSG and 01 steam turbine. The fuel used for plant operation is natural gas supplied by Sui Southern Gas Company Limited (SSGC) through a dedicated 24 inch pipeline. Plant is connected to the K-Electric transmission system.

Multi-Year Tariff (MYT) Determination of K-Electric Ltd:

2. The Authority in the matter of reconsideration request filed by the Federal Government regarding Multi-Year Tariff (MYT) petition of KE for the period commencing from July 1, 2016 to June 30, 2023 directed KE to conduct heat rate test of KCCPP, Site Gas Turbine Power Station (SGTPS) and Korangi Town Gas Turbine Power Station (KGTPS) and to submit report to the Authority for approval (Ref: Case # NEPRA/TRF-362/K-Electric-2016/10232-10234 dated July 5, 2018 - Paragraph 34 (viii), Page 49)

"In view of the addition of steam turbines at KCCP, SGTPS and KGTPS, the numbers in respect of efficiency and auxiliary consumption are worked on provisional basis, based on the given information and supporting documents. K-Electric is directed to conduct heat rate test of KCCP, SGTPS and KGTPS and submit the report to the Authority for approval. The adjustment in heat rates will be made based on the results of the performance (Heat Rate) test."

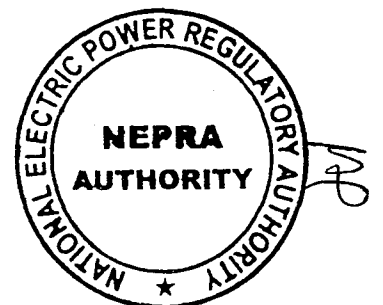
3. In order to test and evaluate the thermal performance of KCCPP, NEPRA directed KE to undertake a bidding process to procure the services of an Independent Engineer (IE) for conducting the performance test (Heat Rate and Capacity).

4. Pursuant to the above mentioned Authority's directions, KE procured the services of NESPAK-SGS for conducting the performance test (Heat Rate and Capacity) of KCCPP plant.

Objective of Performance (Capacity and Heat Rate) Test:

5. The main objective of this test as required by NEPRA was to evaluate the thermal performance (heat rate/thermal efficiency) and capacity of the KCCPP plant in the following plant configurations:

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- i. Base Load operation of Plant in Combined Cycle (CC) Mode (04 Gas Turbines, 02 Steam Turbines referred to as Primary Test # 1)
- ii. 85% Load operation of Plant in Combined Cycle (CC) Mode (04 Gas Turbines, 02 Steam Turbines referred to as Primary Test # 2)
- iii. Base Load operation of Block-1 in Combined Cycle (CC) Mode (02 Gas Turbines, 01 Steam Turbine referred to as Primary Test # 3)
- iv. Base Load operation of Block-2 in Combined Cycle (CC) Mode (02 Gas Turbines, 01 Steam Turbine referred to as Primary Test # 4)
- v. Gas Turbine Operation in Open Cycle Mode (All 04 Gas Turbines without Steam Turbines referred to as Primary Test # 5)

Miscellaneous Additional Scope:

6. Authority vide letter to KE dated June 21, 2017 sought additional recommendations and analysis from Independent Engineer (IE) in Heat Rate report.

Test Standards:

7. The guidelines of following applicable standards were followed while preparing test procedure, conducting and evaluating the Heat Rate and Capacity test:

- **ASME PTC 46-2015** Overall Plant Performance
- **ISO-2314 2015** Gas Turbines - Acceptance Tests
- **ASTM D1945** Standard Test method for Analysis of Natural Gas Chromatography
- **ASTM D3588-98** Standard Practice for calculating heat value, compressibility factor, and relative density of gaseous fuels

Performance (Capacity and Heat Rate) Tests (June 15, 16, 17 & July 09, 2019):

8. Pursuant to performance test procedures formulated and submitted by Independent Engineer (IE) and thereafter approved by KE and agreed upon by NEPRA, the performance tests in different plant configuration were conducted on June 15, 16 & 17, 2019. During the course of data recording for Primary Test-3 dated June 17, 2019, GT-2 tripped on some fault. Resultantly, test had to be aborted. Following rectification of fault the test was re-performed on July 09, 2019 in the presence of all the stakeholders.

Calculations of Calorific Values (LHV/HHV) of Gas fuel by IE:

9. All necessary arrangements for collection of Gas samples and their subsequent tests/analysis from an accredited laboratory for determination of composition including HHV/LHV were made. A fuel gas sampling point was jointly identified prior to the test (Upstream of GT-2 gas flow meter). Special care was taken to ensure that the fuel sampling location was as far



downstream of all filters as possible and closer to the Gas turbines, so that the samples were true representation of the fuel actually consumed by the Power Plant.

Test Results:

10. Following are the detailed results of the test regarding capacity and heat rate of KCCPP as prepared by the Independent Engineer (IE) and forwarded by KE to NEPRA vide dated September 23, 2019.

- i. Base Load Corrected (RSC) Net Heat rate (HHV) = 8178.259 Btu/kWh;
- ii. The Part load (85%) Corrected (RSC) Net Heat rate (HHV) = 8367.972 BTU/kWh i.e. increased by 2.320% from the base load Net Heat Rate.
- iii. The average degradation factor for Gross/Net Heat Rate (HHV basis) for remaining life (25 years) is 1.014;
- iv. Auxiliary consumption at Base load = 16.225 (7.148%);
- v. Auxiliary consumption at 85%-part load = 16.235 MW (8.337%);
- vi. Auxiliary consumption from Base load to part load (85%) is increased by 1.189%.

Request of K-Electric:

11. Through its letter dated September 23, 2019, KE requested following heat rates for approval:

Financial Year	Net HHV Heat Rate ¹ (Btu / kWh)
2017	8,514 ²
2018	8,538 ²
2019	8,368
2020	8,441
2021	8,504
2022	8,482
2023	8,518
Average for the control period (FY 17-23)	8,481

- 1. For further details and basis, please refer IE NESPAK's report.
- 2. FY 17 and 18, heat rates calculated based on Heat rate of FY 19 and degradation curve of the plant

Analysis:

12. Pursuant to the instructions of the Authority, the Independent Engineer (IE) has carried out the performance (capacity and heat rate) tests of KCCPP of KE successfully as per ASME PTC 46 standard and code which were also witnessed by the NEPRA representatives. It may be noted that under KE MYT FY 2016~23, NEPRA's earlier determined heat rates for KCCPP were provisionally approved therefore the same needs to be finalized by the Authority. Therefore, in



this regard adjustment needs to be made firstly for the period from year July 2016 to May 2019 and secondly from June 2019 till June 2023. Moreover, based on NEPRA's latest decision of MYT of KE the adjustment in heat rate will be made based on the results of the performance (Heat Rate) test.

13. There are usually two options for setting up heat rates. The heat rate could be based on the 100% loading conditions (calculated based on test results), whereas to account for partial load operations, the correction curves based on OEM data could be used every time to work out actual efficiency and corresponding fuel used. Or alternatively a level may be agreed upon on which the plant would be expected to operate during the period of interest. Thereafter corresponding to that level, a flat 'part-load' factor could be applied every month. In the current case, both the producer and purchaser are part of one entity. Therefore; it is in the interest of consumers and also for transparency, to use one number for plant loading for the overall control period. Further, in regards to efficiency and historical operational data it was observed that KCCPP would normally operate at higher levels and therefore it was agreed that 85% output level would be taken flat for Heat Rate purposes. Moreover, NEPRA's Review Decision dated Oct 9, 2017 supports using alternative approach as stated above.

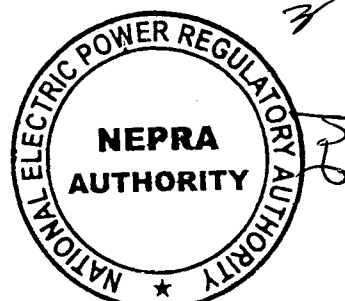
Effect of Part Load on the Heat Rate Results

14. As noted above an average flat loading level of 85% is considered for whole control period. It is further to state that in case of IPPs, the power purchase agreements contain Part load operation correction factors/curves which are based on OEM data and fixed at the time of commissioning, considering reference site conditions instead of actual operating scenarios of the power plants. In regards to KCCP plant it is noted that KE had provided unrealistic part load curve for overall plant operation. Therefore, in the absence of realistic part load curve specified by OEM and developed/integrated by EPC, it was recommended to consider part load adjustment factor i.e. (1.0232) at 85% loading as evaluated by IE in secondary test results.

Effect of degradation on the Heat Rate Results:

15. It is noted that the overall degradation correction curve as enunciated in the test report are prepared by ISTRO ENERGO INT'L and verified by NESPAK based on OEM curves /data and the same are found to be satisfactory as also comparable with regional and international benchmarks and therefore has been considered for the analysis.

Comparison of Guaranteed and EPC Performance Test and IE's Performance Results



16. As per information provided by KE, Plant was installed and commissioned in 2008-09. Initially GT-1 and 2 were commissioned in Open Cycle mode; while GT-3 and 4 were commissioned in Combined Cycle mode. In 2015, GT-1 and GT-2 were also converted in combined cycle with installation and commissioning of second HRSG and Steam Turbine. Necessary BOP equipment was also installed to support the new combined Cycle Block. EPC (METKA) carried out performance testing of individual Gas Turbine units and steam turbine separately in 2008-09 periods. Further as per KE there was no contractual requirement for performance testing of whole plant as per PTC-46 standard. Hence, performance figures of EPC (2008-2009 tests) cannot be compared with present performance test numbers and is not applicable as plant capacity had been modified and its configuration had been considerably changed in 2015. As per KE, the performance parameters established at COD (in different phases) and those of guaranteed parameters cannot be compared with performance parameters established by IE.

HEAT RATE Evaluation for July 2016- May 2019 and June 2019- June 2023

17. As pointed out earlier, under KE MYT FY 2016~23, NEPRA's earlier determined heat rates for KCCPP were provisionally approved therefore the same needs to be finalized. In this regard adjustment needs to be made firstly for the period from year July 2016 to May 2019 and secondly from June 2019 till June 2023.

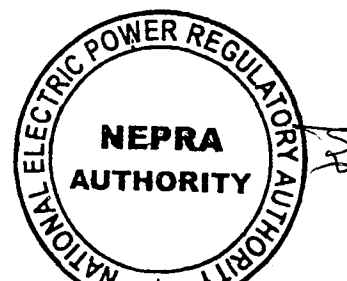
18. For the period between July 2016 (start of control period) to June 2019 (the month, test was conducted) KE had requested a heat rate which did not account for the major overhaul it carried out. Authority considers that necessary correction is required to be made in the heat rate proposed by KE. Accordingly the KE's number has been revised only on that account whereas the degradation factor for 85% operation is acceptable as noted by the IE during the tests.

19. For the heat rate during the Control Period (June 2019 to 2023) the heat rate as worked out by the IE during testing has been used and an average degradation (at the middle point of four years) is allowed based on the degradation indicated by IE for 25 years.

20. It is to further state that for the purpose of analysis of Heat Rate report, some information & data was obtained from KE – KE's response has been considered for the purpose of analysis.

Comparison of Primary test performance parameters with and without Gas Compressor(s) Load:

21. Gas Compressors may not be required in case of natural gas/RLNG availability through dedicated pipeline or any alternative arrangement. KE is directed to approach NEPRA in case the



company installs dedicated pipeline or any interim arrangement for provision of gas/RLNG which may bypass the gas compressor load. The results presented in the IE report about the Gas compressors and their impact will be considered for further adjustments in the approved heat rates in future.

Summary of Test Results:

22. The results of capacity and heat rate tests are summarized in the following table.

Heat Rate for July 2016 ~ May 2019

Plant	Net HHV Heat Rate (Btu/kWh) at RSC	Corresponding Efficiency (%)	Net HHV Heat Rate (Btu/kWh) at RSC	Corresponding Efficiency (%)
KCCP	Requested		Recommended	
	8,481 ¹	40.23%	8,250.06²	41.36%

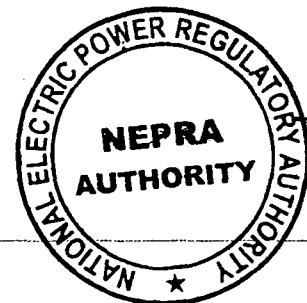
1. Requested by KE
2. Based on IE tested values and adjusted for degradation, MOH and Partial loading (1.0232) at 85%.

Heat Rate for June 2019 ~ 2023

Plant	Net HHV Heat Rate (Btu/kWh) at RSC	Corresponding Efficiency (%)	Net HHV Heat Rate (Btu/kWh) at RSC	Corresponding Efficiency (%)
KCCP	Requested		Recommended	
	8,481	40.23%	8,377.032¹	40.732%

1. Based on IE test results with adjustment of Partial loading (1.0232) at 85% and average degradation adjustment indicated by IE

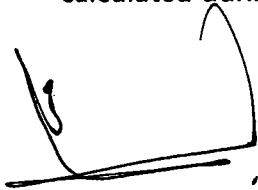
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Decision of the Authority:

The Authority after detailed deliberations upon the working paper decided as follows:

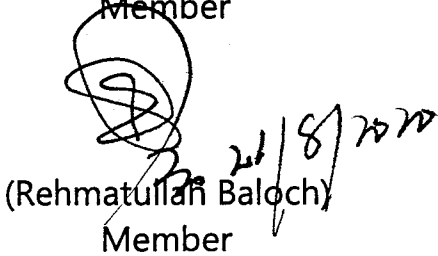
- i. For the period from July 2016 to May 2019, the heat rate i.e. **8,250.06 Btu/kWh - net HHV**, corresponding to 41.36% efficiency is approved with no further adjustment for degradation and partial loading allowed.
- ii. For the period from June 2019 to June 2023; the heat rate i.e. **8,377.032 Btu/kWh - net HHV**, corresponding to 40.732% efficiency is approved. This heat rate will be applicable for the control period on flat basis, without any additional adjustment for other parameters.
- iii. KE is required to conduct maintenance including Major Overhaul of its plants / units as per prudent utility practices and recommendations of OEM.
- iv. In case of non-requirement of Gas compressors – the relevant capacity and Heat rates would be adjusted. For such a scenario, relevant capacity and heat rates calculated during the present tests would be used.



(Engr. Bahadur Shah)
Member



(Rafique Ahmed Shaikh)
Member

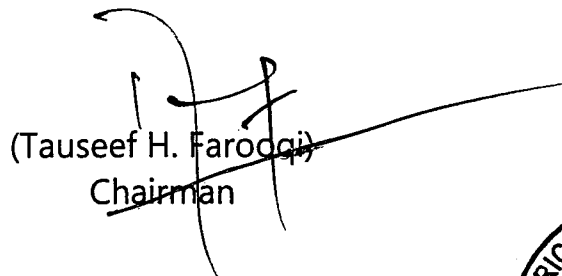


(Rehmatullah Baloch)
Member



(Saif Ullah Chattha)
VC/Member

21-8-2020



(Tauseef H. Farooqi)
Chairman

