



National Electric Power Regulatory Authority Islamic Republic of Pakistan

NEPRA Tower, Attaturk Avenue (East), G-5/1, Islamabad
Ph: +92-51-9206500, Fax: +92-51-2600026
Web: www.nepra.org.pk, E-mail: registrar@nepra.org.pk

No. NEPRA/R/TRF-362/K-Electric-2016/8104-8106
May 9, 2019

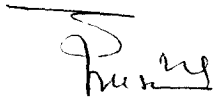
Subject: **Approval of Heat Rate for 560 MW Bin Qasim Power Station-II
(BQPS-II) of K-Electric Ltd.**

Dear Sir,

Please find enclosed herewith subject Approval of the Authority (08 Pages) in the matter of Heat Rate for 560 MW Bin Qasim Power Station-II (BQPS-II) of K-Electric Ltd.

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


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(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 560 MW BQPS-II OF K-ELECTRIC (KE)

Background:

1. 560 MW Combined Cycle Power Plant Bin Qasim-II is located at Bin Qasim Karachi and owned by K-Electric Limited (KE). The plant comprises of three (3) Gas Turbines, three (3) HRSGs and one Steam Turbine. Gas Turbines are General Electric (GE-Model PG9171E) France. HRSGs are of No. 703 Research Institute of CSIC make (China). Steam Turbine is of Harbin Turbine Company Limited (HTC China). BQPS-II achieved its Commercial Operations Date (COD) on May 07, 2012. The EPC Contractor of the Plant was Harbin Electric Corporation (HE).

2. Regarding the issue of heat rate test of 560 MW BQPS-II, the Authority back in December 2012, decided that the results of the heat rate tests conducted by M/s PES cannot be relied upon owing to several reasons and approved the net heat rate of the plant as 7,213.5 Btu/kWh (net efficiency 47.30%) without referring to LHV or HHV basis and the same was communicated to KE vide letter dated March 29, 2013. Further, the Authority time and again through its letters directed KE to conduct the heat rate test afresh.

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

3. The Authority in the matter of reconsideration request filed by the Federal Government regarding Multi-Year Tariff (MYT) petition of K-Electric Ltd. for the period commencing from July 1, 2016 to June 30, 2023 [Case # NEPRATTRF-362/K-Electric-20161 dated July 5, 2018 decided as follows: (Paragraph 34 (vii), Page 49)

"The heat rates of BQPS-II have been determined on the basis of heat rates guaranteed by the EPC contractor. K-Electric has already been directed to conduct heat rate test of BQPS-II and submit the same to the Authority for approval. The adjustment in heat rates will be made based on the results of the performance (Heat Rate) test."

4. Pursuant to the Authority's directions, KE procured the services of an independent Engineer (IE) for conducting the performance test (Heat Rate and Capacity).



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Procedures and Methodology:

5. The guidelines of following applicable standards were approved for preparing test procedure, conducting and evaluating the Heat Rate and Capacity test:

- **ASMEPTC 46-2015** Overall Plant Performance
- **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 2nd& 3rd 2018):

6. Pursuant to the performance test procedures formulated and submitted by the IE and thereafter approved by KE and agreed upon by NEPRA, the performance tests in different plant configuration were conducted on 2nd& 3rd June, 2018 by NESPAK-SGS JV. All the primary and secondary tests were witnessed by KE and NEPRA's representatives.

7. As per NEPRAs requirement all the manual data was recorded by IE instead of KE personnel. Moreover, test instrument calibration, correction factors, fuel gas flow rate measurement, ambient conditions measurement, power output measurement, fuel sampling, isolation of systems / equipment, auxiliary equipment status and stability requirements before the test were carried out under the directions of IE. Further, as required by the test procedure, two (2) Test Runs each of 1 hour duration were performed for the Primary Test and all the required data was recorded and tabulated by NESPAK-SGS JV personnel on the log sheets. Moreover, all manual data was recorded at five (5) minutes intervals throughout the duration of the Test Run and the data through plant DCS/Mark VI e control system was recorded at 30 seconds interval.

8. As per report, for the performance test with all GTs at base load in combined cycle mode, the results of each test run (the Net/Gross HHV/LHV Heat Rates and Net/Gross Capacities) were corrected to reference site conditions (RSC) and subsequently the corrected results of both test run were averaged. However, for the performance tests with GTs at different loads and configurations (3+3+3 at 85% load, 2+2+1, 1+1+1) in combined cycle mode, the results of each test run (the Net/Gross HHV/LHV Heat Rates and Net/Gross Capacities) were calculated on prevailing conditions (not corrected to reference site conditions) and subsequently the results of both test run were averaged.



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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).

10. 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 are true representation of the fuel actually being consumed by the Power Plant.

Test Results:

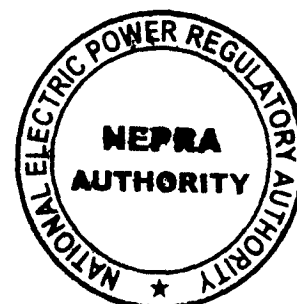
11. Following are the detailed results of the test regarding capacity and heat rate of BQPS II as prepared by the IE and forwarded by KE to NEPRA vide dated November 02, 2018.

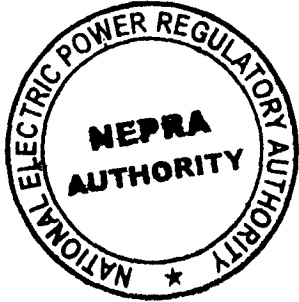
- i. Base Load Corrected Net Capacity = **494.532 MW**;
- ii. Base Load Corrected Net Heat rate (HHV) = **8255.255 Btu/kWh** corresponding to 41.33% efficiency;
- iii. Net Heat Rate (HHV) at 85% loading = **8582.758 Btu/kWh** corresponding to 39.755% efficiency;
- iv. The average degradation factor for net heat rate for remaining life (26 years) is **1.0095** as per annualized degraded net heat rate-HHV;
- v. Auxiliary consumption at Base load = **30.343 MW** (5.969%);
- vi. Auxiliary consumption at 85%-part load = **30.910 MW** (7.274%).

Request of K-Electric:

12. KE through its letter dated January 14, 2019 submitted its request regarding heat rate/efficiency which requires an approval from the Authority for the multiyear tariff control period i.e. FY 2017~23 and the same is tabulated below:

<i>"Financial Year</i>	<i>Net HHV Heat Rate¹ (Btu/kWh)</i>
<i>2017</i>	<i>8570²</i>
<i>2018</i>	<i>8583</i>
<i>2019</i>	<i>8594</i>





2020	8587
2021	8594
2022	8600
2023	8611
Average (FY 2017~23)	8591

1. For further details and basis, IE NESPAK's report.
2. Calculated based on Heat Rate of FY 18, and degradation curve of the plant."

13. The Authority notes that there are two main options for setting up heat rates. The heat rate can 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 are 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 is applied every month. The first option would require verification and counter checking of data every month entailing cumbersome exercise for every period for which fuel cost adjustment would be made whereas, the second option would be straightforward without compromising on the accuracy of results. The Authority further noted that in case of IPPs, since CPPAG is the power purchaser, therefore verification of energy purchased and use of correction curves for part load is a routine matter. In case of KE, however, both the producer and purchaser are part of one entity therefore; it is in the interest of consumers and for transparency also to use one number for plant loading for the overall control period. In view thereof, the second option as mentioned above is approved in the instant case for the purpose of partial load operation of power plant.

14. The Authority noted that based on the historical record, KE Bin Qasim II being a relatively new power plant and having higher rank in merit order, would be expected to run at higher loading conditions. Therefore an average flat loading level of 85% is approved, for the whole control period, on which relevant partial loading factor can be applied.

15. The Authority notes that for the 100% loading conditions, the number corrected to site conditions (RSC) by the IE is acceptable, however for 85% part-load conditions, the IE showed its inability to derive such corrected number. Therefore it is prudent to

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adopt the factor which may be derived from the correction curve based on OEM data and provided as a reference in the Report submitted by the IE which is 1.0125. The Authority further notes that such approach is also consistent with our practice for GENCOs.

16. The response of KE regarding justification of part load factor has been analyzed by the Authority and considered un-acceptable. KE and IE have essentially requested that the performance curve prepared by Beijing Chinovela Engineering and Technology Co Ltd (BCE&T) may not be considered for working out the part load (85%) operation. However, it is also noted that IE and KE utilized all the correction curves prepared by BCE&T for computation of test results so their stance regarding not considering part load curve for finalizing heat rate results is not justified. Therefore, in the opinion of the Authority correction factor for part load operation may be linked to correction curve prepared by BCE&T to be consistent with the overall trends for operation at different loading positions.

17. In addition to the reference to the GENCOs, the Authority also perused the report prepared by Parsons Brinckerhoff for Energy Market Authority of Singapore for the period January 01, 2017 to December 31, 2018 regarding part load factor which shows part load factor as 1.0165 at 85% loading. The correction factor from the curve by BCE&T is noted 1.0125 for 85% loading which is also consistent with Parsons Brinckerhoff report.

Approval of Heat Rates for the Periods (from May 2012 to May 2018) and (June 2018 to June 2023):

18. There are two periods which are to be covered by the Authority for setting up heat rates. The first period spans over May 2012 to May 2018 whereas the second period would start from June 2018 and may cover the useful life of the project. For the first period KE was allowed a provisional net heat rate of 7,213.5 Btu/kWh corresponding to 47.3% efficiency (without referring to LHV/HHV). This heat rate was based on EPC guaranteed value on net LHV basis. On net HHV basis the number works out to be 42.70%. The Authority noted that the number by EPC contractor is correctly referred to LHV basis.

19. Based on the record provided by KE to IE for the present test report it is noted that the number in respect of efficiency would slightly change upwards if test results at COD; carried out earlier by Harbin Electric, are considered, instead of EPC numbers. For



the period from May 2012 to May 2018, the Authority is of the view that either of references i.e. EPC guaranteed number or performance test result at COD may be used however it would be advisable to refer to EPC guaranteed number for continuity purposes. The Authority is of the view that efficiency based on earlier number while referring it to correct basis be maintained and considered for May 2012 to May 2018.

20. The Authority is of the view that OEM correction curves will correctly depict the trend of heat rate for Part-Load operation than using the values based on test and agrees with the option of using a flat factor for partial load conditions. The Authority also notes that claw back mechanism is in place to capture the over earned revenue/extra gains by the power producer. The Authority also considers the applicability period of heat rates and is of the view that the heat rates may not be applicable for the life of the project and the Authority may order fresh testing of heat rates after the tariff control period.

21. For the period from June 2018 to June 2023, the heat rate will be based on IE test result with adjustment of Partial loading (1.0125) at 85% only. No further degradation is allowed during the present MYT period, as the complex has been allowed more than 3.31% degradation from the EPC guaranteed efficiency i.e. 42.70% at base load to the tested efficiency number i.e. 41.33% at base load, therefore further inefficiency shall not be allowed to KE.

22. The Heat rates for the two periods as approved by the Authority are shown below:

Heat Rate for May 2012 ~ May 2018

CCPP	Net HHV Heat Rate (Btu/kWh) at RSC	Corresponding Efficiency (%)
BQPS-II	7990.96¹	42.70%

1. Based on EPC Guaranteed values and no further adjustment for degradation and partial loading is allowed.





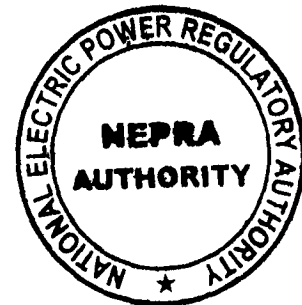


Heat Rate for June 2018 ~ June 2023

CCPP BQPS- II	Net HHV Heat Rate (BTU/kWh) at RSC	Corresponding Efficiency (%)
IE Test Results	8255.26 ¹	41.33%
IE Test Results	8582.76 ²	39.76%
Requested by KE	8590.48 ³	39.72%
Approved	8358.45 ⁴	40.82%

1. Based on IE test results at 100% load.
2. Based on IE test results with adjustment of Partial Loading (1.0397) at 85%.
3. Based on IE test results with adjustment of degradation (1.0009) and Partial loading (1.0397) at 85%.
4. Based on IE test results with adjustment of Partial loading (1.0125) at 85% only. No further degradation is allowed during the present MYT period as the complex has been allowed more than 3.31% degradation from the EPC guaranteed efficiency i.e. 42.70% at base load to the tested efficiency number i.e. 41.33% at the base load, therefore further inefficiency shall not be allowed to KE.

23. In the opinion of the Authority the heat rate tests carried out for different plant configurations i.e. two gas turbines in operations and single gas turbine in operation would serve as a reference for such operations in the future.



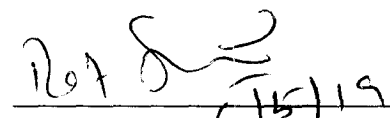
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DECISION OF AUTHORITY:

24. The Authority after detailed deliberation on the heat rate test report, decides as follows:

- i. For the period from May 2012 to May 2018, the heat rate i.e. 7990.96 Btu/kWh - net HHV, corresponding to 42.70% efficiency is approved and no further adjustment for degradation and partial loading is allowed;
- ii. For the period from June 2018 to June 2023, the heat rate of 8358.45 Btu/kWh - net HHV, corresponding to 40.82% efficiency is approved. This heat rate will be applicable for the control period on flat basis, without any additional adjustment for other parameters. The Authority may order fresh heat rate test, after the expiry of the control period of present MYT determination. Such test shall be conducted by an Independent Engineer in presence of NEPRA professionals as per procedure mentioned in MYT and other instructions issued by the Authority.
- iii. Gas Compressors may not be required in case of natural gas/RLNG availability through dedicated pipeline or any alternative arrangement. For such a scenario, relevant capacity and heat rates calculated during the present tests will be used.


(Saif Ullah Chattha) 3.5.2019
Member


(Rafique Ahmed Shaikh)
Member


(Rehmatullah Baloch)
Vice Chairman

