

**BEFORE THE GUJARAT ELECTRICITY REGULATORY COMMISSION
AT AHMEDABAD**

Petition No.923/2007

In the matter of: _

Revision of Station Heat Rate approved for PPA governed GIPCL's 160 MW
Combined Cycle Power Station –II at Baroda.

Petitioner : Gujarat Urja Vikas Nigam Ltd.,
Sardar Patel Vidyut Bhavan,
Race Course Road,
Vadodara-390007.

Represented by: S/Shri L.Chuaungo, MD, S.B.Khyalia, GM (Com.) &
J.M.Vachhani, EE.

V/s

Respondents : Gujarat Industries Power Company Ltd.
Vadodara.

Represented by : S/Shri L.Chuaungo, MD, D.G.Naik, ED(T),
A.N.Shah (GM), & P.N.Tomar

CORAM:

**Shri K.P.Gupta, Member(F)
Dr.Man Mohan, Member(T)**

ORDER

[1] The petitioner has filed the present petition seeking approval for the Supplementary Agreement allowing increase in Station Heat Rate (SHR) from 2000 Kcal /KWh to 2050 Kcal/Kwh and increase in Base Load Capacity/ Installed Capacity of the power station from 160 MW to 162 MW for the purpose of Power Purchase Agreement for GIPCL'S Combined Cycle Power Station-II at Vadodara with effect from 1.11.2007.

[2] The facts as mentioned in the petition are briefly as under:-

1 The petitioner has entered into a Power Purchase Agreement with the respondent in respect of their 160 MW Combined Cycle Power Station-II at Vadodara on 1st August,1996.

- 2 The respondent had submitted that their 160 MW power plant is basically Naphtha based power plant but the same is being operated on Gas only for more than last two years. This has affected respondent badly in terms of the higher Heat Rate while using Gas as compared to the Naphtha because of a wide variation in GCV to NCV ratio for liquid fuel like Naphtha and that for Natural Gas.
- 3 The respondent has submitted a technical opinion from OEM i.e. M/s.Bharat Heavy Electrical Ltd. in support of their claim for higher SHR and requested to enhance the SHR to 2050 Kcal/KWh in order to avoid heavy operational loss in Station-II on account of such higher SHR.
- 4 The Station Heat Rate as per PPA is 1950 Kcal/Kwh for first 10 years and 2000 Kcal /Kwh for the remaining term. The Commercial operation of 160 MW power plant began from 18.11.1997. Therefore, the period of 10 years get completed on 18.11.2007.
- 5 The respondent has submitted vide their letter No.COMML/06/07-08/1557 dated 2.8.2007 that the enhancement of SHR to 2050 Kcal/ Kwh may include increase in heat rate specified by PPA due to aging of plant on completion of 10 years of Combined Cycle operation.
- 6 From the report submitted by M/s.BHEL, it was observed that the design based load power output of the plant is higher by around 2.6 MW when Natural Gas is used as a fuel instead of Naphtha. The petitioner therefore claimed that the base load capacity/ Installed Capacity of the Station should be increased to 162 MW instead of 160 MW so as to achieve some savings in fixed cost and/or incentive payment, if SHR is increased to 2050 instead of 2000 Kcal/Kwh.
- 7 Looking to the above merits of the case, the petitioner agreed to allow the SHR of 2050 Kcal/Kwh on GCV basis and at a Base Load Capacity/ Installed capacity of 162 MW for the purpose of PPA for the said power station with effect from 1.11.2007. Therefore, a supplementary agreement has been signed by the petitioner and the respondent.

[3] The aforesaid petition was uploaded on the website of the Commission as well as the website of the petitioner for inviting objections/ suggestions from all stakeholders.

[4] In response to above, no objection is received from any of the stakeholders.

[5] The aforesaid petition was kept for hearing on 4.12.2007. On that day, the respondent was directed to provide the detailed back up calculation of power output of the plant, heat rate based on LHV and HHV achieved during the performance test of the gas turbine on Naphtha and Natural gas fuel. Any information about the impact of ageing on these parameters as furnished by the manufacturer was also required to be furnished.

[6] In response to this, the respondent submitted the report of M/s.BHEL. The aforesaid report indicates as under:

- 1 The 160 MW Combined cycle power plant of GIPCL at Vadodara consisting of a Frame 9E gas turbine, HRSG and steam turbine was designed to fire multiple fuels like Naphtha, HSD and Natural gas. Originally Naphtha was the primary fuel for this plant.
- 2 The plant was commissioned in August 1997 on Naphtha fuel and the performance test on Naphtha fuel was carried out in January 1999. The operation of the plant was gradually switched over from Naphtha to Natural gas by the respondent. The on-base gas fuel system of the gas turbine including the stop ratio valve, control valve and fuel nozzles was modified in consultation with BGGTS. Now GIPCL has requested BHEL for predicting the performance of the plant, on Natural gas fuel, with respect to power output and heat rate specifically based on the higher heating value (HHV) of the fuel.
- 3 Based on the data provide by the respondent (GIPCL) which includes the specifications of Natural gas currently being used in Gas turbine and Naphtha as originally envisaged, the predicted plant performance is as below.

Sl.No.	Parameter	Unit	Naphtha	Natural gas
1.	Design Base Load Power output of the plant	MW	162.5	165.1
2.	Heat rate based on LHV achieved during performance test	Kcal/kwhr	1790.15	1776.82*
3.	Heat rate based on HHV achieved during performance test	Kcal/kwhr	1925.62	1971.36**

- Predicted heat rate based on the performance test of the gas turbine on Naphtha fuel.
- ** Predicted based on the composition of the Natural gas fuel furnished by GIPCL .

[7] It was further submitted that when compared to Naphtha, Heat rate on Natural gas based on LHV is better while that based on HHV is worse. Natural gas contains higher percentage of hydrogen when compared to that in Naphtha fuel, leading to formation of higher amount of water on a relative basis during the combustion process.

1 According to definition HHV is the amount of heat liberated when a unit mass of fuel is burnt, which includes the latent heat of vaporization of water formed during the combustion process. Hence, the HHV when compared with respect to the LHV is farther away in case of Natural gas than that in Naphtha. Thermal performance of the plant, including that of Heat rate, is always based on LHV and not on HHV for the simple reason that the heat content in water vapor formed during the combustion process is not available for conversion to useful energy. The quality of natural gas fuel proposed by the respondent has LHV 8576.05 kcal/sm³ and HHV 9515.003 kcal/sm³ whereas in respect of Naphtha fuel, LHV is 10592.22 kcal/kg and HHV is 11393.8 kcal/kg.

2 Since the machine is originally designed for usage of Naphtha as a fuel, when operated on Natural Gas, heat rate based on NCV shall get reduced but heat rate based on GCV shall increase considerably. As clarified in the report, this analysis is related to performance test which is conducted at full load.

3 It appears that GCV to NCV ratio for Natural Gas is higher by 5% when compared to that of Naphtha. Thus, for each Kwh to be generated, heat rate on GCV basis for usage of gas will always be higher by 5% than that for liquid fuel.

[8] Thereafter the matter was kept for hearing on 24.1.2008. On that day, the Commission directed both petitioner and respondent to submit the following:

- (i) Justification as to how does the ageing account for the difference between the SHR of 2050 Kcal/Kwh claimed and 1971.36 Kcal/Kwh as found during the performance test?
- (ii) The values of various parameters like PLF, quality of gas viz. analysis of its composition corresponding to which SHR of 1971.36 was recorded.

- (iii) What type of maintenance and R&M works were carried out by the petitioner in the past and what would be the schedule proposed by the manufacturer?
- (iv) What was the expenditure made for the R&M works?
- (v) Whether the efficiency gain in term of PLF, SHR, etc. was achieved by way of R&M or not?

Any information about the impact of ageing on these parameters as furnished by the manufacturer may also be furnished.

[9] In response to this direction, respondent submitted the details as under:

- 9.1 The performance guarantee test was conducted by BHEL on Naphtha as primary fuel. The actual measured SHR was 1855.22 Kcal/Kwh (on NCV) and 1995.61 Kcal/Kwh (on GCV). After applying correction factors at site conditions, the same works out to be 1790.15 Kcal/Kwh (NCV) and 1925.62 Kcal/kwh (GCV) at base load.
- 9.2 Subsequently, Station-II was operated on Natural Gas. At that time, the Performance Guarantee Test was carried out on Natural Gas. The SHR was found 1841.89 Kcal/Kwh (NCV) and 2043.55 Kcal/Kwh (GCV). After applying correction factors at site conditions, the SHR values works out to be 1776.82 Kcal/Kwh (NCV) and 1971.36 Kcal/Kwh (GCV).
- 9.3 It is further stated that difference of 24.38 Kcal/kwh between achieved SHR of 1925.62 on Naphtha (GCV) and 1950 Kcal/Kwh (PPA Norms) is to take care of start/ stop partial load operation conditions.. If the aforesaid difference of 24.38 Kcal/Kwh is applied to SHR on Natural Gas it works out to be 1996 Kcal/Kwh (GCV) basis.
- 9.4 Ageing Curves for Heat Rate de-rate and output de-rate given by BHEL indicates that on completion of 10 years operation with 72,729 operating hours (as on 17.11.2007), de-rating in SHR is 2.5% i.e. 50 Kcal/Kwh. Hence, SHR after 10 years works to be 2000 Kcal/kwh (GCV) on Naphtha and 2046 Kcal/Kwh (GCV) on Natural gas basis.

- 9.5 The performance test on Natural Gas, base load condition was conducted on 16.6.2006. The SHR was found to be 2059.52 Kcal/Kwh on GCV basis. The net correction factor was 0.9896. The corrected SHR on GCV basis work out to be 2038 Kcal/Kwh. The actual measured plant output was 148.8 MW applying the net correction factor of 1.0264, it comes to 152.72 MW.
- 9.6 The actual plant performance parameter achieved during the last three years has been given as follows:

Financial Year	SHR in Kcal/Kwh (GCV basis)	PLF in %	Plant Availability Factor in %
2005-06	2048	86.76	95.95
2006-07	2075	74.47	88.77
2007-08 (upto Dec.07)	2100	81.06	96.67

- 9.7 The respondent submitted that all scheduled maintenance / repairs/ services were carried out by M/s.BGGTS who are the sole authorized and expert service provider of BHEL/ GE Gas Turbines in India. Total expenses incurred towards various activities by the respondent is Rs.6,50,63,817/-.
- 9.8 It is further submitted that due to above works, the performance improvement found in the plant is as under:

(A) Gas Turbine and Generator:

Sr.No	Parameter	Before Shutdown	After Shutdown
1.	Heat Rate (on GCV)	3070.69 Kcal/Kwh.	3035.68 Kcal/Kwh.
2.	Output at Base Load	98.39 MW	102.41 MW
3.	CPD at FSNL	6.0 Bar	6.4 Bar
4	Turbine Compartment Temperature	120 °C	75°C
5	Load-coupling Compt. Temperature.	180 °C	140°C
6	Seal Air Pressure of Diverter Damper	0	15 MMWC
7	Bypass Stack Temp.		70°C

(B) Steam Turbine & Condenser:

Sr.No	Parameter	Before Shutdown	After Shutdown
1.	Condenser Vacuum	-0.79 Kg/Cm ²	-0.88 Kg/Cm ²
2.	Exhaust Hood Temp.	59°C	51°C
3.	CW Inlet Temperature	32.8°C	32.4°C
4.	CW Outlet Temperature	41.9°C	40.3°C
5.	Hot well temperature	59°C	51°C

(C) HRSG:

Sr.No	Parameter	Before Shutdown	After Shutdown
1.	Flue Gas Temp. before CPH	168°C	173°C
2.	Flue Gas Temp. after CPH	133°C	127°C
3.	Condensate Temp. I/L to CPH	59°C	51°C
4.	Condensate Temp. O/L to CPH	105°C	106°C
5.	Pegging Steam Control Valve position	75°C	50°C

(D) Overall Plant (Combined Cycle):

Parameter	Before Shutdown	After Shutdown	Improvement
CCPP Output at Base Load	153 MW	156 MW	+ 3 MW

From the above, it can be seen that there was improvement in the performance of the plant after carrying out maintenance and R&M works etc.

[10] The aforesaid matter was kept for hearing on 20.2.2008. S/Shri S.B.Khyalia, GM(Com.) & J.M.Vachhani, EE were present on behalf of the petitioner. S/Shri D.G.Naik, ED(T), A.N.Shah (GM) & P.N.Tomar (GM) were present on behalf of respondent at the time of hearing.

10.1 The petitioner submitted that in view of report on predicted performance on Natural Gas fuel for 160 MW CCPP, GIPCL, Vadodara and in view of submissions made by the petitioner, the approval should be granted. Both the parties entered into the Supplementary Agreement (PPA) which is to be approved by the Commission. It is

dt.27th August,2007. It is a bilateral agreement and both the parties have according to clause 14.1 agreed to modify the terms and conditions in clause 7.2 of Schedule VIII of the previous Power Purchase Agreement dt.1.8.1996 said supplementary agreement. become effective from 1.11.2007.

10.2 Shri D.G.Naik, on behalf of the respondent, reiterated the facts as mentioned above in paras 2,6 & 8 . He submitted that the SHR was varying from time to time due to backing down, difference in amb. temperature, etc. The respondent has carried out regular maintenance and R&M works to achieve the performance of the plant to the optimum level. Due to change of fuel utilization from Naphtha to Natural Gas, according to BHEL, the capacity increased to 165.1 MW but both the petitioner as well as the respondent have agreed to the capacity of 162 MW which is a nominal capacity looking to plant condition.

[11] We have carefully considered the pleas and submissions made by the parties. The combined cycle power plant of the respondent consists of one Gas Turbine of 106 MW and one Steam Turbine of 54 MW, totaling 160 MW capacities. The Gas turbine is capable of firing liquid fuel like Naphtha, High speed diesel and Natural Gas.

11.1 The design guaranteed Station Heat Rate (SHR) of the machine on Naphtha fuel gas was 1771 Kcal/Kwh. and when Natural gas as a fuel, it was 1757.82 Kcal/Kwh.

2 The performance test on naphtha fuel was carried out by BHEL and the SHR was found as 1790.15 Kcal/Kwh on LHV (NCV basis). Thus, the difference between guaranteed SHR and SHR achieved during the performance test was 19 Kcal/Kwh, Naphtha fuel having HHV value of 11393.8 and LHV value 10592.22. Thus, the SHR worked out to 1925.62 Kcal/Kwh on HHV (GCV) value for Naphtha fuel, whereas in the case of Natural Gas as fuel, the SHR works out to 1776.82 Kcal/Kwh on LHV (NCV) basis and 1771.36 Kcal/Kwh on HHV (GCV) basis.

- 3 According to definition HHV is the amount of heat liberated when a unit mass of fuel is burnt, which includes the latent heat of vaporization of water formed during the combustion process. Hence, the HHV when compared with respect to the LHV is farther away in case of Natural gas than that in Naphtha. Thermal performance of the plant, including that of Heat rate, is always based on LHV and not on HHV for the simple reason that the heat content in water vapor formed during the combustion process is not available for conversion to useful energy
- 4 In the Power Purchase Agreement dt.1.8.1996, both the parties have agreed, in clause 7.2 of Schedule VII, to the SHR on GCV basis as 1950 Kcal/Kwh for combined cycle power plant for the first 10 years and 2000 Kcal/Kwh for remaining terms. The difference between the SHR agreed by the parties in PPA and the SHR found during the performance test is $1950 - 1925.62 = 24.38$ Kcal/Kwh which covers the margin of loss on account of start/stop and partial loading of the machine.
- 5 From the BHEL Technical Report dt.11th July, 2007 submitted by the respondent, the Design based capacity of the plant is 162.5 MW with Naphtha & 165.1 MW with natural gas. The High Heat Value (HHV) i.e. GCV based heat rates achieved during performance test are 1925.62 Kcal/Kwh with Naphtha & 1971.36 with Natural gas. On the LHV basis, their values are 1790.15 & 1776.82 respectively.
- 6 When the respondent has started utilizing natural gas as fuel with effect from January 2005, they have carried out performance test on 16.6.2006. During the test, on base load the SHR on GCV basis was found as 2059.62 Kcal/Kwh and after applying the correction factor of 0.9896 it was worked out as 2038.26 Kcal/Kwh.
- 7 The respondent has submitted that according to expected gas turbine plant performance following normal maintenance and off-line compressor water wash (ageing effect curve), the loss provided by the manufacturer was 2.5% on thermal efficiency after a period of 30000 hours operation. The machine has completed 72729 hours of operation on 17.11.2007. Thus, the loss due to ageing effect is worked out as 50 Kcal/Kwh.

8 According to guaranteed heat rate by the manufacturer, the SHR was 1971.36 Kcal/Kwh in which if we add 24 Kcal/Kwh as loss due to start/stop and partial load of the machine, it comes to 1996 Kcal/Kwh. In this, if we add loss due to ageing effect (i.e. 50 Kcal/Kwh) the total SHR comes to 2046 Kcal/Kwh. On 16.6.2006 the performance guarantee test was carried out by the respondent, the SHR was found as 2038 Kcal/Kwh. The respondent has admitted that (in para 8.8) they had carried out regular maintenance as well as R&M works and incurred expenses towards various activities. The impact of the maintenance and R&M works clearly establishes the fact that the machine has not completed its full ageing. Also the effect of starts/stops and ageing cannot be added arithmetically as has been proposed as ageing effect covers operating hours/ number of starts.

9 According to BHEL report, the plant capacity increased to 165.1 MW if Natural gas is utilized as fuel. Both the parties have agreed (in clause 1.1 of Article 1 and first para of schedule I) to increase the capacity of the plant to 162 MW instead of 165.1 MW. Due to reduction in capacity of the plant, the respondent shall lose fixed capacity charges and the petitioner (consumers) were also affected by way of getting less energy from this plant. Neither the petitioner nor the respondent have justified their claim in respect of such reduction in capacity of the plant from 165.1 MW to 162 MW. It is therefore essential to evaluate SHR on the basis of increased capacity of the plant which has been worked by BHEL due to change over of fuel from Naphtha to natural gas.

10 Both the petitioner and the respondent are directed not to change the technical parameters which are based on the technical design of the machine. If they feel that there is need to compensate financially either of the party, they are at liberty to negotiate in commercial terms & conditions of the PPA.

[12] In view of the above observations, we are approving the Supplementary Agreement between the petitioner and respondent signed on 27.8.2007 by directing them to revise the Station Heat Rate in terms of clause 7.2 (a) of Schedule VII of the existing PPA by stating

Station Heat Rate as 2038 Kcal/Kwh for Combined cycle operation and capacity of 165 MW in Article 3 instead of 162 MW.

[13] A copy of the approved supplementary Power Purchase Agreement is enclosed as Appendix I with this order.

[14] We order accordingly.

[15] With this order, the petition stands as disposed of.

Sd/-

(K.P.GUPTA)
MEMBER(F)

Sd/-

(Dr.MAN MOHAN)
MEMBER (T)

Place: Ahmedabad

Date : 29/03/2008