Chapter 5
Assessment of Quality and Quantity of Coal

In coal fired power stations, coal of appropriate quality is essential for proper combustion and operational efficiency of the boiler. Pricing of coal also depends on its quality or 'Grade'. Accurate assessment of quality and quantity of coal is crucial to appreciating the adequacy and efficiency of inputs of the power station. Audit examined assessment of coal quality as well as weighment of coal and the findings are detailed below.

5.1 Sample collection and methods of measurement for coal quality

The most important quality parameter for coal is its heat value referred to as 'Gross Calorific Value' or GCV. Pricing of coal by coal companies and pricing of energy by generating companies depends significantly on the GCV of coal. GCV depends on the location from which samples are collected and the method used for its measurement.

A. Quality of coal

Different methods of measuring GCV were used for different purposes. Three methods[24] were seen to be used:

- For imported coal, GCV was reported on 'Air Dried basis' (ADB) while paying for coal imports.
- For payment to domestic coal companies for supplies, GCV was reported on 'Equilibrated basis' (EB)
- For energy billing, the stations reported GCV on 'Total Moisture basis'(TMB)

The different methods used for assessing GCV lead to the following:

(i) For a given sample, ADB method gives the highest GCV value followed by EB method. The TMB method gives the lowest GCV value among the three methods.

(ii) GCV on ADB basis gave undue advantage to the supplier since moisture present in coal, i.e., the sample, gets dried in the process for determination of GCV for payment to the coal suppliers. As a result, payment was made without taking into account loss of heat value due to moisture, but the coal actually fired in the boilers had the moisture content.

(iii) Energy tariff (as per formula mandated by CERC) is inversely proportional to GCV. A lower GCV would thus lead to higher tariff. TMB method, which gives the lowest GCV, is used by stations for billing which would lead to higher burden on consumers. At the same time, coal companies are reimbursed on ADB (for imports) and EB (for domestic supplies) which gives a higher GCV and hence higher payment.

[24] (i) Total Moisture Basis – GCV is reported taking into consideration the total moisture, *i.e.,* moisture inherently present in coal and surface moisture present in the sample. (ii) Equilibrated Basis – The sample is brought to standardized moisture and humidity levels and GCV of the resultant sample is reported. (iii) Air Dried Basis - The given coal sample is air dried, as per procedure given by the Bureau of Indian Standards and the GCV is measured thereafter.

B. Quantity of coal

The method of estimation of quantity of coal did not provide adequate assurance regarding its accuracy:

(i) The collection of samples was done by private agencies at the stations and control mechanisms such as witnessing of the sample collection by Company's employees and maintenance of log book for collection was not found on record. The significance of representative sampling can be gauged from the fact that a 1000 MW station requires around 25000 tonnes of coal per day and GCV of this quantity of coal is assessed once daily, by placing one gm of the processed coal sample in the Bomb Calorimeter (device used to measure GCV).

(ii) GCV test results given by the Bomb Calorimeter were manually entered into a register maintained for the purpose, and thereafter entered into the computerized system. There was an option to print the GCV test results carried out by the Bomb Calorimeter but such printed results were not maintained by the stations.

Ministry stated (November 2016) that total moisture based GCV is the standard industry practice. Ministry further stated that payment for domestic coal was as per the provisions of FSA and for imported coal it was on the basis of competitive bidding and hence did not result in any undue advantage inter-se to any-one supplier over the others. Ministry added that in case of imported coal, GCV is measured on ADB basis, however, adjustment is made for excess moisture. Regarding collection of samples, Ministry stated that this was highly labour intensive and hence outsourced but appropriate supervision was undertaken by NTPC personnel.

The reply is to be viewed against the following:

(i) Total moisture method, though adopted by power utilities, was not expressly provided for in CERC regulations. GCV reported under total moisture method was lower by around 280 to 350 kCal/kg[25] when compared to EB. CEA has stated that reduction in GCV by 100 kCal/kg would increase consumption by three *percent*. Hence there may be a need for standardising the method of reporting GCV.

(ii) Regarding adjustment for excess moisture in imported coal, it was seen that the specified moisture level, as per contract was 25 *percent* and tolerance limit for rejection was 32 *percent*. Supplies in the range of 25 to 32 *percent* moisture were accepted with reduction in quantity for excess moisture. Hence adjustment carried out for 'excess' moisture vis-a-vis tender specification, did not address the loss of heat value due to determination of GCV on ADB, for payment of imports.

(iii) Though Ministry has stated that appropriate supervision of collection of samples by outsourced agency was undertaken by NTPC personnel, Audit noticed that payment to the agency was made based on quantity of coal brought to the lab. Maintenance of records to ensure integrity of sample collected such as logbook for

[25] As per Fuel Audit Report of Central Power Research Institute uploaded on the web site of Punjab State Electricity Regulatory Commission.

recording collection particulars, witnessing of collection by NTPC personnel etc. were not in practice.

5.2 Reduction in heat value (GCV) of coal

Since GCV was one of the key factors used for energy billing, Audit compared the GCV 'as billed' by coal companies for coal loaded on to wagons, GCV of coal 'as received' at the unloading point of the power station and GCV of coal 'as fired' in the boilers for a year (from October/November 2012 to September 2013)[26] in the stations covered in audit. It was observed that GCV of coal progressively decreased from the 'as billed' stage to the 'as fired' stage, though as per CEA, the three GCV values, *i.e.*, GCV 'as billed', 'as received' and 'as fired' should be approximately same barring minor losses due to storage. The differences in GCV are summarized below:

Table-5.1: Station-wise GCV differences during October 2012 to September 2013

Sl. No.	Name of station	Range of GCV differences between different stages (kCal/kg)					
		'As billed' and 'As received'		'As received' and 'As fired'		'As billed' and 'As fired'	
		Low	High	Low	High	Low	High
1	Dadri Stage– I	286	788	(-)74	618	543	1097
	Dadri Stage– II	286	788	(-)72	703	453	1155
2	Badarpur	1134	1943	573	976	2012	2682
3	Korba Stage-I&II	108	826	144	672	595	1143
	Korba Stage– III	108	826	141	673	592	1136
4	Vindhyachal	13	28	10	17	27	38
5	Talcher Thermal	5	51	326	383	354	395
6	Rihand	674	1178	197	616	971	1715
7	Vallur	(-)180	1405	0	980	(-)95	1405
8	Sipat	N.A.	N.A.	78	632	N.A.	N.A.
9	Farakka	N.A.	N.A.	199	358	N.A.	N.A.

Note: GCV difference between 'As billed'and 'As received' as well as 'As billed' and 'As fired' was not calculated for Sipat and Farakka as the stations did not provide GCV 'As billed' data. Three stations, viz. Jhajjar, Ramagundam and Mouda, did not provide the necessary data for making the comparison. Barh-II was commissioned in November 2014, i.e., subsequent to the period of above comparison.

As can be seen from the above table, except in Vindhyachal, the difference in GCV between 'as billed', 'as received' and 'as fired' was significant irrespective of whether the station was pithead or non-pit head (it is expected that the difference in case of pithead stations would be much lesser than non-pit head stations owing to the shorter transportation of coal). The above

[26] During these months GCV figures were available for the three locations, *i.e.*, at the loading point ('as billed'), at the unloading point at the station ('as received') and at the boiler ('as fired'). GCV 'as received' was not measured by the stations in other months. Beyond July 2014, the location for collection of sample for measurement of GCV was changed to 'secondary crusher' from the 'bunker/firing' stage, hitherto adopted, for billing of energy charges.

GCV reduction increased energy charges billed to the beneficiaries, as explained in subsequent para 5.2.1.

Ministry stated (November 2016) that sampling (for GCV 'As received') was done as a quick check/on trial basis for limited purpose of optimization of combustion in Boiler and the values were used to take up the issue with coal suppliers for taking necessary actions. Ministry further stated that though coal bill payments were regulated based on the GCV analyzed at power station end, the final settlement took place by extrapolating the GCV analyzed by the third party at mine end only, in terms of the communication from Ministry of Finance, Govt. of India. Ministry added that the coal collected from wagons were not representative in nature and did not reflect true GCV.

The reply is to be viewed against the fact that payment to coal companies was regulated by stations based on GCV 'as received' at stations during the above mentioned period. The contention that samples of coal collected from wagons at the receiving end were not representative is not tenable as samples were collected from wagons itself at the mine end to arrive at the 'as billed' GCV of coal. Besides, while the GCV differences between 'as billed' and 'as received' stage involved other parties, *viz.*, coal companies and Railways, difference in GCV between 'as received' and 'as fired' values was attributable entirely to the power stations. However, the same was passed on to consumers while billing for energy.

5.2.1. Impact of GCV differences on efficiency and energy charges

Operational efficiency of power stations is regulated through a parameter called 'Station Heat Rate' (SHR)[27], which denotes the input heat value incurred by the station to produce one unit of energy. SHR depends on the quantity as well as quality/grade of coal used by the station. CEA, in its 'Recommendations on operation norms for thermal power stations, tariff period 2014-19' pointed out that the difference between 'as received' GCV vis-à-vis 'as fired' GCV would be very marginal and would be solely on account of marginal loss of heat during the coal storage. CEA added that 'international publications indicated a loss of heat value of about one *percent* for one year storage for high rank coals and three *percent* coal storage for low rank coals' and went on to comment that even after considering a three *percent* heat loss for Indian coals,' the average loss of heat value for ten days storage would be about 0.08 *percent*' and added that storage losses of coal were almost negligible especially for low storage periods as in Indian stations.

The power stations reported SHR using GCV 'as fired'. The SHR values, so determined, were well within the laid down CERC norms and hence the stations were considered to be efficient. Audit compared the reported SHR (using GCV 'as fired') with the SHR worked out using GCV 'as received'[28] for the period October 2012 to September 2013[29] and found that SHR worked out on the basis of GCV 'as received' was significantly higher at stations indicating lower efficiency **(Annexure 5.1).**

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[27] Station Heat Rate = $\frac{\text{Quantity of coal} \times \text{Gross Calorific Value}}{\text{No. of units of energy generated}}$

[28] GCV 'as received' was reduced by storage loss as envisaged by CEA, i.e. 0.08 *percent* for 10 days. For pit head stations storage loss was calculated for 15 days and for non pit-head stations storage loss was calculated for 30 days, as per CERC norms for coal stock.

[29] The only period when the stations measured GCV 'as received'.

Audit also worked out the difference in energy charges considering the 'as received' and 'as fired' stage for the same period (October 2012 to September 2013). It was seen that during this period, Energy Charge Rate (ECR) worked out on 'as fired' basis was higher than 'as received' basis by ₹0.03 to ₹0.96 *per unit* of electricity for the different stations, as per details given below:

Table-5.2: Summary of higher energy charges due to GCV difference

Sl. No.	Station Name*	Range of difference in ECR	Total impact (₹in crore)
1	Dadri Stage– I	(-)0.06 -0.43	135.64
	Dadri Stage – II	(-)0.07 -0.46	165.06
2	Badarpur	0.58 -0.96	324.73
3	Korba Stage -I&II	0.05 -0.18	161.01
	Korba Stage – III	0.03 -0.16	32.65
4	Vallur	0.06-0.45	58.25
5	Sipat	0.04 -0.23	144.36
6	Rihand Stage I	0.09 - 0.17	87.26
	Rihand Stage II	0.11 -0.21	121.90
	Rihand Stage III	0.05 -0.25	30.89
7	Talcher	0.09-0.11	31.97
8	Farakka I & II	0.17-0.38	110.23
	Farakka III	0.17 -0.38	36.38
9	Vindhyachal	Not calculated as GCV differences were minor	
Total			**1440.33**

Overall, for the eight stations studied in Audit, energy charges billed on 'as fired' basis was higher by ₹1440.33 crore for a one year period (October/November 2012 to September 2013).

Ministry stated (November 2016) that during the period (October/November 2012 to September 2013) CERC Tariff Regulation did not envisage GCV 'as received' for ECR computation. Ministry added that the formula for calculation of energy charges as per CERC Regulations provided for using GCV on 'as fired basis' and billing was made accordingly. Ministry further stated that Dadri and Badarpur stations also used washed coal in significant quantities but GCV 'as received' was not measured for the same and added that GCV was not determined for 'diverted in' and e-auction coal also. Ministry also stated that 'as received' GCV measured to take up with the coal companies was on Equilibrated basis (EB) while GCV 'as fired' was on Total Moisture (TM) basis and the two values would be different depending on the total moisture.

The reply is to be viewed against the following:

(i) Though CERC Tariff Regulations provide for energy billing on GCV 'as fired' values, measurement of GCV on TM basis was not expressly mentioned in the Regulations. It is pertinent to note that TM method gives lower GCV values and correspondingly increases energy charges.

(ii) CEA, in its 'Recommendations on operation norms for thermal power stations, tariff period 2014-19' stated that "any arbitrary practice of using as fired GCV for SHR computations without proper guidelines for determining the same would only lead to inflated claims of coal consumption". This is reflected in the SHR worked out considering GCV 'as received' by Audit.

(iii) The Company has not clarified whether GCV was less for the types of coal mentioned- washed coal, coal procured through e-auction and 'diverted in' coal. Besides, their effect on the overall GCV would be minimal considering that their quantities were marginal.

5.3 Weighment of domestic coal

As per FSA between power stations and coal companies, payment for the coal supplies was made as per the weighment carried out at the delivery/loading point at mine end. The FSAs also provided for weighment at unloading point (power station) in order to ensure recalibration of weigh bridges at loading point. It was, however, noticed that stations covered in audit (pithead as well as non-pithead stations) did not regularly weigh domestic coal (*i.e.,* coal procured through FSA, MOU and e-auction) when the wagons arrived at the station, though in-motion weigh bridges were installed in these stations. Due to non-weighment of coal on arrival, the stations lost the opportunity to cross verify the quantity of coal and ensure that there were no errors in weighment at the loading point.

As a test case, at Vindhyachal station, the in-motion weighbridge remained out of order during 840 days (46 *percent* of time) during five years ended 31 March 2015. After the first calibration in October 2009, the next calibration was carried out five years later, only in February 2014. At Barh station, weighment started only from December 2015, while at Farakka station, weighment started in November 2015. Non-weighment of coal resulted in deficiencies in ascertaining transit loss.

Ministry stated (November 2016) that in terms of the FSA, payment for coal billing is required to be released based on weight measured at loading end and there was no requirement of weighing at station end. Ministry added that coal weighment was done occasionally at station end for the purpose of cross checking. Ministry further stated that weighing system at Vindhyachal is working satisfactorily now.

The reply is to be viewed against the fact that though the payment for coal was to be made as per the weighment at loading point, the Company had the resources to weigh the rakes at the station and cross check the weighment at loading point. But the in-motion weighbridges at stations either were frequently under outage or stations were not following the practice of weighing coal on receipt.

5.4 Weighment of imported coal

The agreements for import of coal provided for payment based on quantity received at the station. Audit observed certain inadequacies at stations in this regard:

(i) Vindhyachal station was not weighing imported coal received at the power station till February 2014 and was making payment on the basis of quantities mentioned in

Railway Receipt (RR). Further, out of total 353 rakes of imported coal received during 2014-15, only 208 rakes were weighed.

(ii) One Wagon Tippler associated with Vindhyachal-III commissioned on 31 December 2014 was without 'in-operation' weighing arrangement. As such, quantity of coal unloaded using this wagon tippler was being accepted based on quantity indicated in RR. Second set of in-motion weigh bridge was commissioned only in July 2015.

Management stated (April 2016) that a lot of efforts were taken up at Vindhyachal station to stabilize the weigh bridge operation at the station end which included various modifications in the weigh bridge in consultation with the supplier and commissioning of the second weigh-bridge in July 2015.

The corrective steps taken by the Company are noted. The fact remains, however, that even imported coal, which was required to be weighed at station for payment purpose, was not weighed in Vindhyachal nearly half the time (imported coal was not weighed for 840 days during five years ended 31 March 2015).

5.5 Assessment of transit loss through indirect method

Transit loss is the difference between quantity of coal dispatched from the mines and quantity of coal received by stations. CERC Tariff Regulations provided normative transit and handling loss of 0.8 and 0.2 *percent* for non-pithead stations and pithead stations respectively. Transit losses up to this extent could be recovered through tariff and any loss beyond this limit was to be borne by the station. The stations adopted an indirect method called 'volumetric method' for ascertaining transit loss instead of weighing the railway rakes when they arrive at the station to find the loss. As per this method, assessment of actual transit loss was carried out by way of physical verification of closing stock of coal stored in the yard and bunker at the end of every quarter. The quantity of coal physically verified on quarterly basis was compared with the quantity that should have been present in the yard as per billing records. The difference between physically verified stock and closing stock as per billing records was worked out and considered as the transit and handling loss. For determining quantity of coal present in the yard, mathematical formula for converting volume into weight is used, based on dimensions of coal stacked in heaps in the coal yard (hence referred to as volumetric method). Audit reviewed the transit and handling loss for domestic and imported coal at the stations in the audit sample and found that the losses were very close to the normative transit loss of 0.8/0.2 *percent* fixed by CERC. The issues noticed regarding transit loss are highlighted below:

(i) Volumetric method of ascertaining transit loss is an indirect method since coal was not actually weighed at station at the time of receipt. Instead, mathematical formula was used to convert volume to weight using density of coal. Density, however, could be subjective since coal is not a homogeneous mixture like oil and, hence, density is likely to vary depending on the point in the coal heap from where the sample are taken for measurement of density.

(ii) Inaccuracy of the transit loss ascertained using this method was further evidenced by the fact that coal physically verified at the coal yard at the following stations was even more than the storage capacity of the yard.

Table-5.3: Coal stock in excess of coal yard capacity

Sl. No.	Name of station[@]	Physical quantity of coal more than the storage capacity of the yard *		Excess coal stored above storage capacity (in percentage)
		Quarters (in No.)	Quarters	
1	Badarpur	6	Q II (2013-14)	17
			Q IV (2013-14)	6
			Q IV (2014-15)	30
			Q I (2015-16)	114
			Q II (2015-16)	94
			Q III (2015-16)	48
2	Sipat	1	Q I (2015-16)	37
3	Mouda	5	Q III (2014-15)	18
			Q IV (2014-15)	22
			Q I (2015-16)	41
			Q III (2015-16)	37
			Q IV (2015-16)	23
4	Rihand	5	Q IV (2010-11)	9
			Q I (2015-16)	36
			Q II (2015-16)	31
			Q III (2015-16)	28
			Q IV (2015-16)	17
5	Ramagundum	3	Q IV (2012-13)	1.7
			Q IV (2014-15)	23
			Q I (2015-16)	5
6	Vindyachal	2	Q IV (2014-15)	16
			Q I (2015-16)	30
7	Farakka	2	Q IV (2013-14)	13
			Q IV (2015-16)	38
8	Korba	5	Q I (2010-11)	13
			Q I (2011-12)	1
			Q II (2011-12)	2
			Q IV (2014-15)	11

* Calculated based on the data regarding storage capacity provided by Corporate Office.

@ Jhajjar did not provide data and Vallur did not provide quarter-wise data. Instances as mentioned above were not seen in the case of Dadri, Talcher and Barh.

In all the above mentioned stations, coal quantity physically verified at the yard was more than the storage capacity in the yard. Notably, at Badarpur station, during two quarters in 2015-16, physical quantity of coal as per the verification reports was 94 to

114 *percent* more than the storage capacity of the yard. This raised doubts on the correctness of coal stock and transit loss reported by the stations.

(iii) Despite investing in facilities like 'in-motion weighbridge', the stations have not been using the same for weighing coal receipts and ascertaining actual transit loss. Local Management Instructions were silent regarding ascertaining transit loss.

(iv) Since the actual transit loss was not properly ascertained, the station did not take up the issue/lodge claim with Railways regarding en-route theft/pilferage, if any, of coal from wagons.

Ministry stated (November 2016) that weighment of coal by volumetric method was being done as per the practices prevalent in the power industry in the country.

The reply is to be viewed against the deficiencies of volumetric method as pointed out above. Since the Company had the resources to ascertain the actual transit loss at the time of receipt of coal itself, the same should have been used.