b) The history and forecasts for TISCO's production of ammonium sulphate, crude tar and crude benzene

The production records and forecasts of TISCO for ammonium sulphate, crude tar and crude benzene were estimated using the following method.

Output of each product (t) =
coal intake to coke oven (t) x
yield of each product

TISCO's yield for each product (output for each product (ton) per ton of coal intake) was as follows:

Year	Ammonium Sulphate	Crude Tar	Crude Benzene
1984-85	0.00559	0.0298	0.00457
1985-86	0.00567	0.0277	0.00402
1986-87	0.00667	0.0293	0.00453
1987-88	0.00586	0.0282	0.00468
1988-89	0.00569	0.0252	0.00459
1989-90	0.00569	0.0252	0.00459
1994-95	0.00569	0.0252	0.00459
1999-2000	0.00569	0.0252	0.00459

2) Production of Coke Oven Gas

a) Production History

The total output of coke oven gas in India's main steel plants increased from 3.1 (American) billion 80.33 million N cubic m in 1984-85 to

4.1 (American) billion 76.32 million N cubic m in 1989-90. Of this the SAIL output of coke oven gas was 2.5 billion 33.77 million N cubic m in 1984-85 which increased to 3.4 billion 80.87 million N cubic m in 1989-90.

Table 2.2.8 shows the plantwise output of coke oven gas for the main Indian steel plants from 1984-85 to 1989-90.

b) Production Forecasts

It is forecast that the total coke oven gas output of India's main steel plants will reach 5 billion 45.6 million N cubic m in 1994-95 and that this will increase to 5.3 billion 56 million N cubic m in 1999-2000. Of this coke oven gas output the contribution of SAIL is forecast to be 4.3 billion 12 million N cubic m in 1994-95 which is expected to increase to 4.6 billion 51 million N cubic m in 1999-2000.

Table 2.2.9 shows forecasts for the plantwise output of coke oven gas at India's main steel plants in 1994-95 and in 1999-2000.

3) Ammonium Sulphate Production

a) Production History

The total output of ammonium sulphate in India's main steel plants increased from 86,712 tons in 1984-85 to 101,687 tons in 1989-90. Of this the SAIL output of ammonium sulphate was 73,850 tons in 1984-85 which increased to 88,413 tons in 1988-89.

Table 2.2.8 shows the plantwise output of ammonium sulphate for the main Indian steel plants from 1984-85 to 1990-91.

b) Production Forecasts

It is forecast that the total ammonium sulphate output of India's main steel plants will reach 145,000 tons in 1994-95 and that this will increase to 155,100 tons in 1999-2000. Of this ammonium sulphate output the contribution of SAIL is forecast to be 130,200 tons in 1994-95 which is expected to increase to 140,800 tons in 1999-2000.

Table 2.2.9 shows forecasts for the plantwise output of ammonium sulphate output at India's main steel plants in 1994-95 and in 1999-2000.

4) Crude Benzene Production

a) Production History

The total output of crude benzene in India's main steel plants increased from 34,445 tons in 1984-85 to 48,597 tons in 1988-89. Of this the SAIL output of crude benzene was 24,981 tons in 1984-85 which increased to 38,960 tons in 1988-89.

Table 2.2.8 shows the plantwise output of crude benzene for the main Indian steel plants from 1984-85 to 1989-90.

b) Production Forecasts

It is forecast that the total crude benzene output of India's main steel plants will reach 101,500 tons in 1994-95 and that this will increase to 107,800 tons in 1999-2000. Of this crude benzene output the contribution of SAIL is forecast to be 90,700 tons in 1994-95 which is expected to increase to 97,400 tons in 1999-

2000.

Table 2.2.9 shows forecasts for the plantwise output of crude benzene output at India's main steel plants in 1994-95 and in 1999-2000.

5) Crude Tar Production

a) Production History

The total output of crude tar in India's main steel plants increased from 313,618 tons in 1984-85 to 358,860 tons in 1988-89. Of this the SAIL output of crude tar was 245,050 tons in 1984-85 which increased to 300,072 tons in 1988-89.

Table 2.2.8 shows the plantwise output of crude tar for the main Indian steel plants from 1984-85 to 1990-91.

b) Production Forecasts

It is forecast that the total crude tar output of India's main steel plants will reach 515,700 tons in 1994-95 and that this will increase to 536,200 tons in 1999-2000. Of this crude tar output the contribution of SAIL is forecast to be 442,100 tons in 1994-95 which is expected to increase to 465,400 tons in 1999-2000.

Table 2.2.9 shows forecasts for the plantwise output of crude tar output at India's main steel plants in 1994-95 and in 1999-2000.

(4) Production of Secondary Coke By-products

The Benzene group (aromatics) and Tar group of products constitute the secondary by-products of Coke. However, the only data available relating to these was the production history and forecasts of SAIL. Further, it was not possible to obtain the data required to estimate figures of TISCO and VSP. The present report is constrained therefore to limit the report on production history and forecasts for the Benzene (aromatic) and Tar groups to the SAIL plants.

1) Benzene Group Production

a) Production History

The total output of benzene group products by SAIL increased from 19,983 kls in 1987-88 to 33,217 kls in 1988-89.

Benzene production has a predominant share of 80.6% among the Benzene group products produced by SAIL, which is followed in importance by toluene which accounts for 13.2% of the total benzene group output.

The SAIL production history of individual products in the Benzene group products are as follows:

The output of Benzene increased from 15,868 tons in 1987-88 to 26,782 kls in 1988-89. Toluene output increased from 2,776 kls in 1987-88 to 4,394 kls in 1988-89. Xylene output increased from 324 tons in 1987-88 to 560 kls in 1988-89. Output of other benzene group products (the total output for naphtha, solvent oil, still bottom oil) increased from 1,303 kls in 1987-88 to 1,481 kls in 1988-89.

Table 2.2.10 shows the plantwise and productwise production of Benzene group products in India (SAIL) from 1987-88 to 1989-90.

b) Production Forecasts

Forecasts for the productwise output of SAIL's benzene group products are as shown below.

Benzene output will be 57,860 tons in 1994-95 and this will increase to 60,670 tons in 1999-2000. Toluene output will be 9,520 tons in 1994-95 and this will increase to 10,190 tons in 1999-2000. Xylene output is forecast to be 1,460 tons in both 1994-95 and in 1999-2000. Solvents output will be 4,130 tons in 1994-95 and this will increase to 5,308 tons in 1999-2000.

Table 2.2.11 shows productwise and plantwise production forecasts for products of the benzene group in 1994-95 and 1999-2000 in India (at SAIL plants).

2) Tar Group Production

a) Production History

The total output of tar group products by SAIL (except IISCO) increased from 242,641 tons in 1987-88 to 301,003 tons in 1988-89 but this fell to 287,101 tons in 1990-91.

Pitch-creosote mixtures have the largest production output among the tar group products produced by SAIL, with a share of 46.9-52.6% of total production. This is followed in order of importance by pitch which accounts for 31.9-36.7% of the total tar group output, then coal tar oil (3.9-12.7%) and HP naphthalene (2.0-3.5%).

The SAIL production history of individual products in the Tar group products are as follows:

The output of pitch-creosote mixtures increased from 127,609 tons in 1987-88 to 155,870 tons in 1988-89 and in 1989-90 117,949 tons were produced and in 1990-91 127,962 tones were produced. Pitch output increased from 75,207 tons in 1987-88 to 110,547 tons in 1988-89 and fell to 83,941 tons in 1989-90. In 1990-91, 107,277 tons were produced.
Coal tar heavy oil output increased from 9,445 tons in 1987-88 to 9,327 tons in 1989-90. In 1990-91, 7,976 tons were produced.
H. P. Naphthalene output increased from 8,370 tons in 1987-88 to 9,467 tons in 1989-90 and fell to 7,180 tons in 1989-90. In 1990-91 7,093 tons were produced.
Sodium phenolate output fell from 1,599 tons in 1987-88 to 529 tons in 1988-89 increased then to 586 tons in 1989-90 and 548 tons were produced in 1990-91.

Table 2.1.12 shows the plantwise and productwise production of tar group products in India (SAIL except IISCO) from 1987-88 to 1990-91.

b) Production Forecasts

Forecasts for the productwise output of SAIL's tar group products (except IISCO) are as shown below:

Pitch output will be 219,910 tons in 1994-95 and this will increase to 235,410 tons in 1999-2000.
Tar oils output will be 123,930 tons in 1994-95 and this will increase to 133,930 tons in 1999-2000.
H. P. Naphthalene output is forecast to be 13,440 tons in 1994-95 and 14,560 tons in 1999-2000.

Sodium phenolate output will be 1,710 tons in 1994-95 and this will increase to 1,880 tons in 1999-2000.

Table 2.2.13 shows productwise and plantwise production forecasts for products of the tar group in 1994-95 and 1999-2000 in India (at SAIL plants).

In India benzene production is also carried out in petrochemical plants which produce petroleum based benzene using naphtha as raw material. The benzene produced as a by-product of coke is termed coal based benzene. The history of the totaled production of petroleum based and coal based benzene is as follows:

Year	1984	1985	1986	1987
Output (in thousand tons)	105.3	82.9	75.8	407.6

Source: United Nations Statistics

Indian ammonia is mostly produced in fertilizer plants using natural gas or naphtha as raw material. The fertilizer produced using this ammonia as raw material is termed synthetic fertilizer. The ammonium sulphate which results as a by-product of coke production is termed by-product ammonium sulphate and the following shows the history of overall production in India of ammonia.

Year	1984	1985	1986	1987
Output (in thousand tons)	4,505	5,108	5,366	5,366

2.3 Study of Coking Coal Consumption by Grade

In addition to being used as a raw material for metallurgical coke the feedstock coal is used in India as raw material for production of the other different varieties of coke also (such as that for non metallurgical use, for casting, for gasification, for general use, etc.). In the present study details of categorywise supply, overall demand and categorywise consumption are given for the coal feedstock used for metallurgical coke production in India.

2.3.1 Supply of Coal Feedstock for Metallurgical Coke in India

In India supplies of metallurgical coking coal are met with domestic production of prime, medium and semi-coking (or blendable) coal together with imports.

(1) Supply of Metallurgical Coking Coal

1) Supply of Domestic Metallurgical Coking Coal

The major part of the supply of domestic metallurgical coking coal in India is supplied as clean coal after undergoing cleaning in washeries. The main part of the prime coking coal is supplied by the Bharat Coking Coal Limited (BCCL) which is under the control of Coal India Limited (CIL). In addition to this TISCO and IISCO also supply prime coking coal. Besides Central Coalfields Limited (CCL) which is the major supplier of the medium coking coal, TISCO also supplies this variety. The semi-coking coal is supplied by Eastern Coalfields Limited (ECL) under the CIL and NEC (North Eastern Coalfields Division).

Table 2.3.1 shows the supply sources of metallurgical coking coal and the supply records by category of coal for the year 1990-91.
The total supply of domestic metallurgical coking

coal in India was 12.27 million tons in 1986-87 and is projected to reach 14.87 million tons in 1990-91 and 19.39 million tons in 1994-95.

The categorywise supply records for domestic metallurgical coking coal over the years 1986-87 and 1987-88 are shown in Table 2.3.2 while the estimates for 1989-90, schedules for 1990-91 and forecasts for the period of 1991-92 to 1994-95 are shown in Table 2.3.3.

Moreover, details of the categorywise production schedules and of the supply schedules for metallurgical coking coal for 1990-91 (from the Indian Ministry of Energy, Coal Department : Annual Plan 1990-91) are noted in Table 2.3.4.

2) Import of Metallurgical Coking Coal

Since the ash content of domestic Indian metallurgical coking coal is high at an average level around 18.5%, coking coal with an ash content under 10% is imported for blending with domestic coal in order to improve the quality of the feedstock to coking furnaces to the level set (which is 17% ash content for 1990-91).

Records of the imported quantity of coal to India indicated in Table 2.3.5 show that the total varies in a range between 2.2 and 2.3 million tons with 2.331 million tons being imported in 1985-86, 2.259 million tons in 1986-87, and 2.209 million tons in 1987-88.

The larger part of Indian imports of coal are from Australia, and the share of Australian coal in total Indian imports was overwhelmingly the largest with 95.7% for 1985-86, 86.5% for 1986-87, 99.5% for 1987-88. Other import sources included Canada, Finland, Poland, Japan, West Germany, Nepal and the

U.S.A. However with the exception of a rapid increase of imports from Poland to 306,000 tons in 1986-87 imports from the other sources were all extremely small amounting to less than 40,000 tons per source.

The Department of Coal of the Ministry of Energy has estimated the import requirement of coal for 1990-91 at 5.2 million tons using the following method:

a) Calculation of Metallurgical Coking Coal Requirement

   The projected hot metal production for 1990-91 of 15.65 million tons is multiplied by the coal ratio (1.28) to give the metallurgical coking coal requirement of 20.09 million tons.

b) Calculation of the Coking Coal Import Requirement

   The import coking coal requirement of 3.6 million tons was calculated in view of the amount of low ash content coal (under 10% ash content) required for blending with the high ash content domestic coking coal (18%) to give the required ash content of a 17% level.

c) Estimated Demand Supply Balance of Domestic Coal

   The domestic coking coal requirement can be calculated by subtracting the 3.6 million tons of import coking coal requirement from the total metallurgical coking coal requirement of 20.09 million tons. The domestic coking coal requirement is therefore 16.49 million tons. However, since the supply of domestic coal for 1990-91 is only 14.06 million tons there is a deficiency in supply of 2.43 million tons.

d) Calculation of Imports to Meet the Deficient Supply of Domestic Coal

It is necessary to make up for the deficiency in the supply of domestic coal indicated above with imports. This deficiency when calculated in terms of import coking coal represents 1.6 million tons of imports (equaling the 2.43 million tons of domestic coal given the different quality).

e) Calculation of the Total Import Coal Requirement

The total import coal requirement for 1990-91 is calculated by adding the 3.6 million tons required for blending adjustment of the ash content (b above) with the deficiency compensation supply of 1.6 million tons (c above) to give a total of 5.2 million tons.

2.3.2 Consumption of Metallurgical Coking Coal in India

(1) Records of Consumption of Metallurgical Coking Coal

Table 2.3.6 indicates the consumption of metallurgical coking coal by the main steel plants (SAIL and TISCO) of India. This shows that consumption increased from 13.55 million tons in 1984-85 to 15.19 million tons in 1988-89. The consumption of metallurgical coking coal in SAIL, TISCO and VSP were 17.44 million tons in 1989-90 and 19.76 million tons in 1990-91.

(2) Forecasts of Metallurgical Coking Coal Requirement

Table 2.3.7 indicates the forecast requirement of the main steel plants (SAIL, TISCO and VSP) of India for metallurgical coking coal. This shows that an increase from 21.12 million tons in 1990-91 to 23.20 million tons in 1994-95 is forecast to occur.

2.3.3 Supply and Demand of Metallurgical Coking Coal in India

According to the estimates for supply and demand of metallurgical coking coal in India in data issued by the MECON the deficiency in supply will continue in the future and the deficiency of 3.53 million tons of 1989-90 will increase to reach 6.14 million tons in 1992-93.

However, this is forecast to decrease to a level of 3.81 million tons in 1994-95.

Estimates of Demand/Supply of Metallurgical Coking Coal in India

(Unit: million ton)

	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95
Demand	17.44	19.76	21.22	22.42	23.36	23.20
Supply	13.91	14.87	15.75	16.28	18.32	19.39
Demand/ Supply Balance	-3.53	-4.89	-5.47	-6.14	-5.04	-3.81

2.3.4 Categorywise Consumption of Metallurgical Coking Coals in India

(1) Categorywise Consumption of Metallurgical Coking Coals

1) The Categorywise Consumption Records for Metallurgical Coking Coal

Data concerning the actual records of categorywise consumption of metallurgical coking coal in India could not be obtained. The categorywise consumption for 1986-87 and 1987-88 was estimated by the following method:

a) Estimate of Actual Consumption of Domestic Metallurgical Coking Coal

By subtracting the metallurgical coking coal imports from the total metallurgical coking coal consumption the domestic consumption of metallurgical coking coal was obtained.

b) Estimate of the Categorywise Consumption of Metallurgical Coking Coal

Taking all imported coal to be prime coking coal the categorywise consumption of domestic metallurgical coking coal was calculated by multiplying the domestic metallurgical coking coal consumption by the ratios of the constituent categories of coal as found in the categorywise supply records (in Table 2.3.2).

Results of the above calculations are as follows:

Coal Category	Source	1986-87		1987-88	
		Consumpt'n (1,000 t)	Ratio (%)	Consumpt'n (1,000 t)	Ratio (%)
Prime Coking Coal	Domestic	6,452.0	46.4	6,527.8	45.8
Prime Coking Coal	Imported	2,331.5	16.8	2,559.6	17.9
Medium Coking Coal	Domestic	4,625.7	33.3	4,778.6	33.4
Semi-coking Coal	Domestic	480.8	3.5	449.1	3.1
TOTAL		13,890.0	100.0	14,315.0	100.0

2) Estimate of Categorywise Consumption of Metallurgical Coking Coal in 1990-91

The estimates for categorywise consumption of metallurgical coking coal in 1990-91 were based on the demand-supply schedules for metallurgical coking coal in 1990-91.

It is estimated that the categorywise consumption of metallurgical coking coal in 1990-91 will be 7.61 million tons for domestic prime coking coal, 4.615 million tons for imported prime coking coal, 7.95 million tons for domestic medium coking coal and 0.85 million tons for domestic semi-coking coal giving a total of 21.025 million tons. The breakdown of the estimated categorywise shares are that domestic prime coking coal will account for 36.1%, imported prime coking coal for 22.0%, domestic medium coking coal for 37.8% and domestic semi-coking coal for 4.1%.
Table 2.3.4 shows the categorywise consumption of metallurgical coking coal.

3) Forecasts of Categorywise Consumption of Metallurgical Coking Coal in 1994-95

Categorywise Consumption of Metallurgical Coking Coal in 1994-95 was estimated using the following method:

a) Forecast of the Categorywise Demand-Supply Balance for Domestic Metallurgical Coking Coals

Forecasts of the amount of inadequate categorywise supply for domestic metallurgical coking coal can be estimated on the basis of the categorywise forecasts for total Indian demand for metallurgical coking coal (Table 2.3.9) together with the forecasts for categorywise supply of metallurgical coking coal in India (Table 2.3.3). As a result of these calculations we find that there is an excess supply of 1.358 million tons for domestic prime coking coal, a deficiency of 1.018 million tons for domestic medium coking coal, and an excess supply of 0.112 million tons for domestic semi-coking coal.

b) Calculation of Categorywise Consumption of Metallurgical Coking Coal

The categorywise consumption of metallurgical coking coal was calculated on the basis of the following assumptions:

That the surplus in supply of domestic prime coking coal will be allocated to making up for the deficiency of 1.018 million tons in the supply of domestic medium coking coal. That the consumption of domestic semi-coking coal and the requirement of this are the same and that the consumption of imported prime coking coal and the requirement of this are the same.

Estimates for the categorywise consumption of metallurgical coking coal in 1994-95 are 9.67 million tons of prime domestic coking coal, 4.262 million tons of prime imported coking coal, 8.37 million tons of medium domestic coking coal and 0.898 million tons of semi-blending coking coal giving a total estimated consumption of 23.20 million tons. Table 2.3.9 shows forecasts of the categorywise consumption of metallurgical coking coal in 1994-95.

The following table shows a comparison of the forecasts for categorywise consumption of metallurgical coking coal in the years of 1990-91 and of 1994-95.

Coal Category	Source	1990-91		1994-95	
		Consumpt'n (1,000 t)	Ratio (%)	Consumpt'n (1,000 t)	Ratio (%)
Prime Coking Coal	Domestic	7,610	36.1	9,670	41.7
	Imported	4,615	22.0	4,262	18.4
	Sub-total	12,225	58.1	13,932	60.1
Medium Coking Coal	Domestic	7,950	37.8	8,370	36.1
Semi-blending Coal	Domestic	850	4.1	898	3.8
TOTAL		21,025	100.0	23,200	100.0

(2) Categorywise Requirement for the Metallurgical Coking Coals

1) Estimates for the Categorywise Requirements of Metallurgical Coking Coals in 1990-91

The estimated requirements for metallurgical coking coal in the year 1990-91 indicated by steel plant and by category are shown in the 1990-91 Demand and Supply Plan for metallurgical coking coal indicated in Table 2.3.4 and this data is revised by JICA Team based on MECON's information.

2) Estimates for the Categorywise Requirements of Metallurgical Coking Coals in 1994-95

Estimates of the categorywise metallurgical coking coal requirement for 1994-95 were calculated by multiplying the forecasts of metallurgical coking coal requirement for 1994-95 by the ratio of each coal category in the separate metallurgical coking coal demand forecasts of SAIL, TISCO, and VSP. Next these separate companywise forecasts were added up to forecast the total Indian metallurgical coking coal requirement by category. The values used for the ratios of component coal categories in each company were taken from figures for 1990-91 shown in Table 2.3.9.

Table 2.3.9 shows the forecasts for the categorywise requirement of metallurgical coking coal in 1994-95.

Table 2.1.1 HISTORICAL PLANT-WISE PRODUCTION CAPACITY OF HOT METAL IN INDIA

(1,000 t/y)

Plant / Year	Bhilai	Bokaro	Durgapur	Rourkela	IISCO	SAIL Total	TISCO	Grand Total
1976-77	2,970	2,735	1,700	1,600	1,300	10,305	2,160	12,465
1977-78	2,970	2,735	1,700	1,600	1,300	10,305	2,160	12,465
1978-79	2,970	2,735	1,700	1,600	1,300	10,305	2,160	12,465
1979-80	2,970	2,735	1,700	1,600	1,300	10,305	2,160	12,465
1980-81	2,970	2,735	1,700	1,600	1,300	10,305	2,160	12,465
1981-82	2,970	2,735	1,700	1,600	1,300	10,305	2,160	12,465
1982-83	2,970	2,735	1,700	1,600	1,300	10,305	2,160	12,465
1983-84	2,970	3,668	1,700	1,600	1,300	11,238	2,160	13,398
1985-86	2,970	3,877	1,700	1,600	1,300	11,447	2,160	13,607
1986-87	3,150	4,585	1,700	1,600	1,300	12,335	2,160	14,495
1988-89	4,080	4,585	1,700	1,600	1,300	13,265	2,160	15,425
1989-90	4,080	4,585	1,700	1,600	1,300	13,265	2,750	16,015

Source ; SAIL : Corporate Plan upto 2000 AD, MAY 1987

Table 2.1.2 PLANT-WISE BLAST FURNACE CAPACITY IN INDIA AS OF 1989-90

Steel Plant	Blast Furnace Number	Useful Volume m3	Hot Metal Production Capacity t/d	Hot Metal Production Production t/d	Hot Metal Production Productivity t/d/m3	Comissioned
Bhilai	1	1,033	1,135	1,064	1.030	04-02-1959
	1	1,033	1,135	1,064	1.030	28-12-1959
	1	1,033	1,135	1,064	1.030	28-12-1960
	1	1,738	1,719	1,529	0.880	08-12-1964
	1	1,738	1,719	1,529	0.880	27-11-1966
	1	1,738	1,719	1,529	0.880	31-07-1971
	1	2,000	2,640	2,100	1.050	30-08-1987
Sub Total	7	10,313	11,202	9,880	0.958	
Bokaro	1	2,000	2,640	1,816	0.908	03-10-1972
	1	2,000	2,640	1,771	0.886	12-04-1974
	1	2,000	2,640	1,977	0.989	26-02-1978
	1	2,000	2,640	2,024	1.012	27-05-1981
	1	2,000	2,640	1,977	0.989	09-06-1985
Sub Total	5	10,000	13,200	9,565	0.957	
Durgapur	1	1,333	1,270	1,080	0.810	26-12-1959
	1	1,333	1,270	813	0.610	02-02-1961
	1	1,333	1,270	560	0.420	18-05-1962
	1	1,754	1,500	1,035	0.590	04-12-1967
Sub Total	4	5,753	5,310	3,488	0.606	
Rourkela	1	1,139	1,000	939	0.824	27-01-1959
	1	1,139	1,000	838	0.736	12-01-1960
	1	1,139	1,000	907	0.796	08-01-1962
	1	1,658	1,500	882	0.532	03-07-1967
Sub Total	4	5,075	4,500	3,566	0.703	
IISCO	1	1,000	1,200	830	0.830	10-11-1922
	1	1,000	1,200	910	0.910	07-01-1924
	1	1,170	1,200	772	0.660	11-10-1958
	1	1,170	1,200	807	0.690	30-01-1958
Sub Total	4	4,340	4,800	3,320	0.765	
TISCO	1	553	743	702	1.270	1907
	1	800	1,057	1,032	1.290	1923
	1	880	1,199	1,170	1.330	1931
	1	1,100	1,341	1,309	1.190	1959
	1	1,100	1,442	1,408	1.280	1976
	1	1,292	1,793	1,537	1.190	1988
Sub Total	6	5,725	7,575	7,159	1.251	
TOTAL	30	41,206	46,587	36,977	0.897	

Source : SAIL : Statistics for Iron & Steel Industry of India, 1987
SAIL : Corporate Plan upto 2000 AD, MAY 1987.

Table 2.1.3 PROJECTED PRODUCTION CAPACITY OF HOT METAL IN INDIA

(million t/y)

Steel Plant	1990-91 I	1994-1995 II	1999-2000 II
Bhilai	4.080	4.410	5.730
Bokaro	4.585	4.730	6.112
Durgapur	1.700	1.890	2.635
Rourkela	1.600	1.840	3.271
IISCO	0.950	0.950	2.402
SAIL Total	12.915	13.820	20.150
TISCO	2.600	2.600	2.600
VSP	3.400	3.400	6.000
Grand Total (Integrated Steel Plant)	18.915	19.820	28.750

Source : I : SAIL ; Coporate Plan upto 2000 AD, MAY 1987.

II : Report of Working Group on Iron & Steel for Ministry of Steel & Mines, Oct., 1989.

Table 2.1.4 PROJECTED PLANT-WISE PRODUCTION CAPACITY OF HOT METAL IN INDIA

Year		Blast Furnace					
		Number	Useful	Hot Metal Production			
			Volume	Capacity	Capacity	Operation	Prodctivity
			m3	t/d	t/y	d/y	t/d/m3
1999-2000	Bhilai	7	12,099	15,729	5,729,965	364.3	1.300
	Bokaro	5	11,000	17,600	6,112,480	347.3	1.600
	Durgapur	4	6,328	8,226	2,634,916	320.3	1.300
	Rourkela	5	7,075	9,198	3,271,551	355.7	1.300
	IISCO	5	6,590	8,870	2,402,034	270.8	1.346
	SAIL Total	26	43,092	59,623	20,150,946	338.0	
	TISCO	6	5,725	7,443	2,599,665	349.3	1.300
	Grand total	32	48,817	67,065	22,750,611	339.2	466.039

Source : Compiled based on SAIL's Corporate Plan upto 2000 AD, MAY 1987.

Table 2.1.5 HISTORICAL HOT METAL PRODUCTION IN INDIA

(1,000 ton)

Year	Production	Average Annual Growth Rate (%)		Year	Production	Average Annual Growth Rate (%)	
1950	1,687			1970-71	7,030		
1951	1,829			1971-72	6,860		
1952	1,843			1972-73	7,527		
1953	1,798	2.55		1973-74	7,912	4.01	
1954	1,951	(50-55)		1974-75	7,815	(70/71-	
1955	1,913		10.07	1975-76	8,559	75/76)	1.98
1956	1,960		(50-60/61)	1976-77	10,071		(70/71-
1597	1,932			1977-78	9,537		80/81)
1958	2,109	18.15		1978-79	9,523	-0.01	
1959	3,130	(55-		1979-80	8,649	(75/76-	
1960-61	4,405	60/61)		1980-81	8,554	80/81)	
1961-62	5,156			1981-82	9,691		
1962-63	6,229			1982-83	9,630		
1963-64	6,589	10.35		1983-84	9,236	3.50	
1964-65	6,728	(60/61-		1984-85	9,364	(80/81-	
1965-66	7,208	65/66)	4.79	1985-86	10,159	85/86)	4.32
1966-67	7,090		(60/61-	1986-87	10,535	5.69	(80/81-
1967-68	6,958	1.97	70/71)	1987-88	10,968	(85/86-	88/89)
1968-69	7,306	(65/66-		1988-89	11,997	88/89)	
1969-70	7,416	70/71)		*1989-90	11,935		
1970-71	7,030			*1990-91	12,175		

Source : 1950-1988-89 ; SAIL : Statistics for Iron & Steel Industry in India,1990.

Note : *1989-90 & *1990-91 : exclude Production in Secondary Producers.

Table 2.1.6 HISTORICAL PRODUCER WISE HOT METAL PRODUCTION IN INDIA

(1,000 ton)

Year	Bhilai	Bokaro	Durgapur	Rourkela	IISCO	Total SAIL	TISCO	Total Main Producer	Secondary Producer	Total
1976-77	2,796.3	1,738.0	1,220.2	1,461.6	939.1	8,155.2	1,754.0	9,909.2	162.0	10,071.2
1977-78	2,696.4	1,547.3	1,135.0	1,324.8	908.2	7,611.7	1,762.0	9,373.7	163.2	9,536.9
1978-79	2,520.2	1,900.2	1,052.3	1,324.1	857.7	7,654.5	1,671.8	9,326.3	196.6	9,522.9
1979-80	2,338.5	1,694.0	985.0	1,250.8	689.8	6,958.1	1,516.3	8,474.4	175.0	8,649.4
1980-81	2,214.1	1,677.9	820.5	1,227.3	788.1	6,727.9	1,648.1	8,376.0	178.0	8,554.0
1981-82	2,376.8	2,192.3	1,022.7	1,335.8	800.0	7,727.6	1,773.9	9,501.5	190.0	9,691.5
1982-83	2,330.3	2,193.8	1,056.2	1,202.7	912.1	7,695.1	1,792.8	9,487.9	141.9	9,629.8
1983-84	2,124.1	2,275.1	977.4	1,150.0	843.6	7,370.2	1,745.7	9,115.9	119.9	9,235.8
1984-85	2,338.7	2,400.2	883.9	1,139.3	676.8	7,438.9	1,804.8	9,243.7	121.2	9,364.9
1985-86	2,604.0	2,523.6	1,064.5	1,229.2	861.6	8,282.9	1,752.7	10,035.6	123.1	10,158.7
1986-87	2,510.1	2,812.6	1,125.1	1,223.0	824.5	8,495.3	1,940.4	10,435.7	99.6	10,535.3
1987-88	2,556.1	3,122.9	1,138.4	1,212.0	818.4	8,847.8	2,018.2	10,866.0	102.2	10,968.2
1988-89	3,306.2	3,220.8	1,096.0	1,252.0	768.1	9,643.1	2,238.9	11,882.0	115.4	11,997.4
1989-90	3,486.0	3,200.0	997.0	1,261.0	677.0	9,621.0	2,314.0 e	11,935.0	NA	11,935.0
1990-91	3,549.0	3,257.0	972.0	1,326.0	711.0	9,815.0	2,360.0 e	12,175.0	NA	12,175.0

Note : NA; Not available, e; estimate.

Table 2.1.7 PROJECTED PLANT-WISE PRODUCTION OF HOT METAL IN INDIA

(million ton)

Steel Plant	1991-92	1992-93	1993-94	1994-95	1999-2000
Bhilai	4.08	4.08	4.25	4.41	5.12
Bokaro	4.58	4.58	4.65	4.72	5.25
Durgapur	1.20	1.54	1.88	1.88	2.40
Rourkela	1.59	1.65	1.72	1.84	3.18
IISCO	0.67	1.67	0.95	0.95	2.20
SAIL Total	12.12	13.52	13.45	13.80	18.15
VSP	2.55	3.40	3.40	3.40	5.70
TISCO	2.55	2.60	2.60	2.60	2.60
Grand Total (Integrated Steel Plant)	17.22	19.52	19.45	19.80	26.45

Source : Report of Working Group on Iron & Steel for Ministry of Steel & Mines, Oct., 1989.

Table 2.1.8 HISTORICAL PIG IRON SALES IN INTEGRATED PLANT IN INDIA

(1,000 ton)

Year	Bhilai	Bokaro	Durgapur	Rourkela	IISCO	Total SAIL	Secondary Producer	Total
1976-77	854	707	204	63	143	1,971	70	2,041
1977-78	699	511	102	16	145	1,473	96	1,569
1978-79	606	608	145	-	123	1,482	104	1,586
1979-80	519	280	121	-	52	972	120	1,092
1980-81	430	730	102	12	64	1,338	99	1,437
1981-82	504	452	88	66	59	1,169	105	1,274
1982-83	457	393	105	29	119	1,103	82	1,185
1983-84	544	528	159	47	130	1,407	75	1,482
1984-85	534	436	64	22	69	1,125	64	1,189
1985-86	388	502	143	30	96	1,159	90	1,249
1986-87	314	642	154	60	92	1,262	96	1,358
1987-88	202	641	179	97	84	1,203	102	1,305
1988-89	297	345	129	68	170	1,009	103	1,112
1989-90	322	390	207	76	243	1,238	110	1,348

Source : Report of Working Group on Iron & Steel for Ministry of Steel & Mines, Oct., 1989.

Table 2.1.9 PROJECTED PIG IRON SALES IN INTEGRATED PLANT IN INDIA

(1,000 ton)

Year	Bhilai	Bokaro	Durgapur	Rourkela	IISCO	Total SAIL	Other Producer	Total
1990-91	461	598	48	34	210	1,351	438	1,789
1991-92	461	598	48	115	210	1,432	240	1,672
1992-93	461	441	48	131	210	1,291	1,209	2,500
1993-94	396	504	120	188	210	1,418	1,382	2,800
1994-95	331	594	191	227	18	1,361	1,639	3,000
99-2000	558	711	352	734	295	2,650	1,350	4,000
Growth Rate (%/y)								
90/91-94/95	-6.4	-0.1	31.8	46.2	-38.8	0.1	30.2	10.9
94/95-99/2000	11.0	3.7	13.0	26.5	74.9	14.3	-3.8	5.9

Source : Report of Working Group on Steel & Iron for Ministry of Steel & Mines, Oct., 1989.

Table 2.2.1 PLANT-WISE COKE OVEN FACILITIES IN INDIA

Year	1989-90		1994-95		1999-2000	
	Number of		Number of		Number of	
Steel Plant	Batteries	Ovens	Batteries	Ovens	Batteries	Ovens
Bhilai	7	455	7	455	7	455
	1	65	1	65	1	65
	1	67	1	67	1	67
Sub Total	9	587	9	587	9	587
Bokaro	4	276	4	276	4	276
	3	207	3	207	3	207
Sub Total	7	483	7	483	7	483
Durgapur	4	312	4	312	4	312
	0.5	39	0.5	39	0.5	39
	-	-	2	78	2	78
Sub Total	4.5	351	6.5	429	6.5	429
Rourkela	3	210	3	210	3	210
	2	160	2	160	2	160
	-	-	-	-	1	80
Sub Total	5	370	5	370	6	450
IISCO	1	72	1	72	1	72
	3	234	3	234	3	234
Sub Total	4	306	4	306	4	306
SAIL Total	29.5	2,097	31.5	2,175	32.5	2,255
TISCO	5	270	5	270	5	270
GRAND TOTAL	34.5	2,367	36.5	2,445	37.5	2,525

Source ; SAIL ; Statistics for Iron & Steel Industry in India, 1990.
SAIL ; Corporate Plan upto 2000 AD, MAY 1987.

Table 2.2.2 PLANT-WISE COKE (DRY) PRODUCTION IN INDIA

(1,000 ton)

Year	SAIL							
	Bhilai	Bokaro	Durgapur	Rourkela	IISCO	Total	TISCO	TOTAL
1982-83	2,334	2,577	1,313	1,219	1,392	8,835	1,351	10,186
1983-84	2,260	2,693	1,113	1,221	1,244	8,531	1,363	9,894
1984-85	2,266	2,290	980	1,385	228	7,149	1,410	8,559
1985-86	2,444	2,829	1,087	1,410	164	7,934	1,390	9,324
1986-87	2,327	2,843	1,262	1,205	135	7,772	1,469	9,241
1987-88	2,354	3,060	1,234	1,311	104	8,063	1,502	9,565
1988-89	2,780	3,045	1,172	1,320	141	8,458	1,603	10,061
1989-90	2,868	2,796	1,151	1,344	NA	8,159	1,657	9,816
1990-91	1,491	2,624	949	1,323	NA	6,387	1,690	8,077
1994-95	3,046	3,264	1,525	1,401	*	9,235	1,862	11,097
1999-2000	4,620	4,740	2,990	2,260	*	14,610	1,862	16,472

Source : MECON's Information

SAIL : Annual Statistics of Rourkela Steel Plant 1989-90 & 1990-91.

Note : Coke production of TISCO is caluculated based on Hot Metal production and coke (dry) rate.

Table 2.2.3 PLANT-WISE DEMAND FOR BLAST FURNACE COKE (DRY)

(1,000 ton)

Year	SAIL								GRAND
	Bhilai	Bokaro	Durgapur	Rourkela	IISCO	Total	TISCO	VSP	TOTAL
1982-83	1,918	1,650	952	1,070	978	6,567	1,434	0	8,001
1983-84	1,733	1,663	914	1,018	889	6,217	1,388	0	7,605
1984-85	1,841	1,702	763	972	804	6,081	1,410	0	7,491
1985-86	1,883	1,837	925	997	910	6,552	1,390	0	7,942
1986-87	1,780	1,986	1,011	932	837	6,546	1,469	0	8,015
1987-88	1,843	2,120	1,013	926	811	6,714	1,502	0	8,216
1988-89	2,585	2,145	938	921	786	7,376	1,511	0	8,887
1994-95	2,867	3,068	1,316	1,251	713	9,214	1,690	2,040	12,944
1999-2000	3,072	3,150	1,500	1,988	1,375	11,085	1,625	3,278	15,988

Source : MECON's Information

Table 2.2.4 COKE (DRY) RATE/TON OF HOT METAL BY PLANT IN INDIA

(kg)

Year	SAIL						
	Bhilai	Bokaro	Durgapur	Rourkela	IISCO	TISCO	VSP
1979-80	850	756	1,003	908	1,125	N.A.	-
1980-81	837	777	1,017	875	1,136	N.A.	-
1981-82	842	759	957	835	1,154	N.A.	-
1982-83	823	752	901	890	1,072	800	-
1983-84	816	731	935	885	1,054	795	-
1984-85	787	709	883	853	1,188	781	-
1985-86	723	728	869	811	1,056	793	-
1986-87	709	706	899	792	1,015	757	-
1987-88	721	679	890	764	991	744	-
1988-89	782	666	856	736	1,023	716	-
1989-90	692	664	852	725	N.A.	N.A.	-
1994-95	650	650	700	680	750	650	600
1999-2000	600	600	625	625	625	625	575

Source : SAIL ; Corporate Plan upto 2000 AD, May 1987.
SAIL ; Statistics for Iron & Steel Industry in India,1990.
Report of Working Group on Iron & Steel for Ministry of Steel & Mines, Oct., 1989.
IIM (1989-90)

Table 2.2.5 SPECIFICATION AND USES OF BENZOL PRODUCTS IN SAIL

Product	Specification	Specific Gravity	Distillation Range	Residue on Evaporation	Common uses	Plant
Benzene (Nitration Grade)	(IS 534-1974) Grade I Hydrogen sulphide: To pass the test Total sulphur percent by mass; Max. 0.015	at 15℃/15℃ 0.877 to 0.884 at 27℃/27℃ 0.866 to 0.873	The difference between the temperature (running point) at which 1 and 96 percent of the volume taken have been collected shall not exceed within 0.6℃ when a sample is tested by standard method. This range shall include the temperature of 80.1℃.	mg/100 ml: Max. : 5	Raw material for various Drugs and Dye-stuff, Synthetic rubber, Styrene. It is also employed for disolving rubber and lac for making linoleum used for dry-washing also.	BSP RSP BSL DSP
Toluene (Nitration Grade)	(IS 537-1967) Hydrogen sulphide: To pass the test Total sulphur percent by mass; Max. 0.1	at 15℃/15℃ 0.870 to 0.874 at 27℃/27℃ 0.866 to 0.873	The difference between the temperature (running point) at which 1 and 96 percent of the volume taken have been collected shall not exceed within 0.6℃ when a sample is tested by standard method. This range shall include the temperature of 110.6℃.	mg/100 ml: Max. : 5	Solvents, Artificial Sweetnings, Paint Industries, Rubber Industries, Rubber Chemicals, Thinner and Varnishes, Benzoic Acid, Sodium Benzoates, Synthetic Fibres, Adhesives, Benzyl Chloride, Printing Ink.	BSP RSP BSL DSP
Toluene (Industrial Grade)	(IS 536-1968) Hydrogen sulphide: To pass the test	at 15℃/15℃ 0.860 to 0.875 at 27℃/27℃ 0.849 to 0.864	Upto 105℃ : 5 ml, Max. Upto 120℃ : 90 ml, Min.	mg/100 ml: Max. : 10.0	Solvents, Artificial Sweeteningfs, Paint Industries, Rubber Industries, Rubber Chemicals, Thinner and Varnishes, Benzoic Acid, Sodium Benzoates, Synthetic Fibres, Adhesives, Benzyl Chloride, Printing Ink.	BSP RSP BSL DSP
Xylene	(IS 359-1955) Hydrogen sulphide: To pass the test	at 30℃/30℃ 0.845 to 0.860	Between 137.0℃ to 145.5℃ Difference 5 and 9 ml not exceeding 5.0℃.	10 mg/100 ml, (Wholly organic)	Paints, Thinners and Varnishes, Printing Ink, Phthalic anhydride, Rubber Industries.	BSP
Light Solvent Naphtha	(IS 213-1968) Type I Hydrogen sulphide & Mercaptans: Shall give no psitive reaction.	at 15℃/15℃ Min. 0.850 at 27℃/27℃ Min. 0.840	Upto 125℃ (running point): 5 ml, Max. Upto 160℃ (stop point) : 90 ml, Min.	mg/100 ml; Max. : 10.0	Solvents, Starting materials for dyes, Printing Ink.	RSP BSL DSP
Heavy Solvent Naphtha	(IS 213-1968) Type II Hydrogen sulphide & Mercaptans: Shall give no psitive reaction.	at 15℃/15℃ Min. 0.855 at 27℃/27℃ Min. 0.845	Upto 125℃ (running point): 10 ml, Max. Upto 190℃ (stop point) : 90 ml, Min.	-	Paints, and Varnishes,	RSP
Solvent Oil	IS 213-1956	at 15℃/15℃ Min. 0.855 at 30℃/30℃ Min. 0.842	More than 5 ml : At 125℃ 90 ml : At 170℃ Max.	-	Solvents for resin and paints.	BSP
Still Bottom Oil	Contains differnt polymer products of acid washing reractions along with unrecovered benzol hydrocarbons	1.05 to 1.10	0-160℃ : 10% Max.	-	Can be mixed with other materials and is used as fuel.	BSP BSL

Source : SAIL Central Marketing Organization ; THE CHEMICAL FACE OF SAIL.

Table 2.2.6 SPECIFICATION AND USEE OF PITCHES AND HOT PRESSED NAPHTHALENE IN SAIL

Product	Softening Point	Density Gravity	Cooking Value	Quinoline Insoluble	Benzene Insoluble	Resin	Ash	Other Item	Common usws uses	Plant
Medium Hard Pitch	85 to 105℃ (R & B)	-	50% to 55%	10% to 12%	32% to 38%	Beta Resin 22% to 26%	0.3%		Uses as roof binders, in preparation of Road Tar and in many other ways in building materials, sheeting, tiling, etc. and also with refractory brics as refractory pitches. Used for the production of pitch-fibres pipes. Pitch with higher softening points are used as target pitches as they are brittle enough to get shattered on getting hit by the bullets.	BSL
Soft Pitch	65 to 75℃ (R & B)	-	48% to 52%	8% to 10%	25% to 30%	Beta Resin 17% to 20%	0.3%		ditto	BSL
Extra Hard Pitch	108 to 120℃ (R & B)	-	55% (Min.)	(Q.I.) 10% to 15%	(B.I.) 35% Min.	Beta Resin 22% (Min.)	-		EHP is used in industries requiring Pitch Carbon for electrodes like Aluminium Industry. It is also used for manufacturing graphite and in blast furnaces laddle repairs.	BSL
Extra Hard Pitch BAL Grade	(R & B) 90 to 95℃	-	(Quardson) 50% (Min.)	(ASTM-D2318) 10% Max.	(ASTM-D2317) 30% Min.	Beta Resin 20% (Min.)	0.3% (Max.)	upto 300℃ 1% (ASTM-D2569) 300-360℃ 7% (ASTM-D2569)		RSP
Extra Hard Pitch H Grade	(R & B) 109 to 113℃	Real Density 1.3% g/ml (Min.)	(Conardson) 54% (Min.) (ASTM-2416-84)	10% Max.	30% Min.	Beta Resin 22% (Min.)	0.2% (Max.)	Iron : 0.20 Max.		RSP
Extra Hard Pitch NAL Grade	(Mettler) (Degrees Calcium) 113.4℃	1.312	Wetting Power (Degrees Calcium) 149%	10% Max.	-	Alfa Resin 9.6% Beta Resin 21.4% Gamma Resin 69.0%	0.09% (Max.)	C/H Pitch Ratio 1.81 C/A Alfa Ratio 5.5		RSP
Granulated Pitch and Liquid Pitch (GRADE I) (Specifications)	by K&S 75-85℃	-	(Quardson) 50% (Min.)	Anthracene Oil Insoluble 10-15%	(B.1) 34% Max.	Beta Resin (C-2) 16-20%	0.5% arround	0-300℃ 3% Max. 300-360℃ 7% Max.		BSP
Granulated Pitch and Liquid Pitch (GRADE I) (Expected Range)	-	-	(Quardson) 53-56%	Anthracene Oil Insoluble 11-14%	(B.1) 30-33%	Beta Resin (C-2) 16-20%	0-3%	0-300℃ 1-2% 300-360℃ 3-5%		BSP
Granulated Pitch and Liquid Pitch GRADE II (Specification	by R&B 95-103℃	-	(Quardson) 52% (Min.)	Anthracene Oil Insoluble 11-16%	(B.1) 35% Max.	Beta Resin (C-2) 17-21%	0.5% (Max.) arround	0-300℃ 3% Max. 300-360℃ 7% Max.		BSP
Granulated Pitch and Liquid Pitch GRADE II (Expected Rang	-	-	(Quardson) 55-60%	Anthracene Oil Insoluble 12-15%	(B.1) 32-34%	Beta Resin (C-2) 17-21%	0-3%	0-300℃ 1-2% 300-360℃ 3-4%		BSP

Product	Specification	Crystallising Point	Moisture	Benzene Insoluble	Sulphur	Ash		Common uses	Plant
Hot Pressed Naphthalene	(IS 539-1955)	78.5% Min.	0.5% Max.	0.2% Max.	0.4% Max.	0.2% (Max.) by weight	-	Dye Intermediates, Insecticides Dispersing Agents, Tanning Agents Beta Naphthol, Refined Naphthalene H-Acid Sodium Naphthalate, Alpha Naphtol	BSP BSL DSP RSP

Source : SAIL Central Marketing Organization ; THE CHEMICAL FACE OF SAIL.

Table 2.2.7 SPECIFICATION AND USES OF CARBON BLACK FEED STOCKS AND OTHER COAL TAR PRODUCTS IN SAIL [LIQUID]

Product	Specification	Specific Gravity	Distillation Range	Moisture	Common uses	Plant
Carbon Black Feedstocks						
Light Creosote Oil	Residue above 300℃ : 5% Max.	1.04-1.08 at 60℃	0-230℃ : 10% Max. 200-300℃ : 85% Min.	2% Max.	Carbon Black Feed Stocks	BSP
Light Special Creosote Oil	Residue above 300℃ : 5% Max.	1.04-1.08	0-200℃ : 10% Max. 200-300℃ : 85% Min.	2% Max.	Carbon Black Feed Stocks	BSP
Heavy Creosote Oil	Residue after 315℃ : Soft & non-sticky Liquidity at 32℃ : passes Matter insolubie in Benzene : 0.5% Max.	1.03-1.10 at 38℃ Distillate between 235-315℃ : 1.025	Upto 210℃ : 5% Max. Upto 235℃ : 30% Max. Upto 315℃ : 75% Max.	2%	Carbon Black Feed Stocks Carbon Black Feed Stocks	BSP
Anthracene Oil	The material contains a small quantities of solid residues (Anthracene, Phenanthrene and Carbazol) which may separate out on cooling during transit. This material, however, can be brought into liquid stage by heating upto 70-80℃ in the road tanker itself.	1.1 Min.	0-300℃ : 5 to 12% 300-360℃ : 40% Min.		Carbon Black Feed Stocks	BSP
Coal Tar Heavy Oil			At 300℃ (V/V)10% Max.	(V/V)2% Max.		RSP
Other Coal Tar Products	**Composition**	**Specific Gravity**	**Distillation Range**	**Moisture**	**Common uses**	**Plant**
Wash Oil	-	1.08 at 30℃	200 to 300℃	2% Max.	-	RSP
Dephenolised Oil	Naphtahlene Content 20-50%	0.97 at 60℃	0-170℃ : 10% Max. 170-230℃ : 70% Min.	2% Max.	Naphthalene bearing feed stocks Naphthalene and Coal Tar Oils separated and used for their specific use	BSL
Drained Naphthlene Oil	Naphtahlene Content 20-50%	1.0 at 60℃ Min.	0-170℃ : 10% Max. 170-230℃ : 70% Min.	2% Max.	Ditto	BSL
Heavy Benzol	Naphtahlene Content 20-50%	0.950 at 38℃	0-180℃ : 5% Max. 180-270℃ : 80% Min.	2% Max.	Ditto	BSP
Meta Para Cresol	Meta Para Content Above 40%	1.030 at 25℃	V/V below 180℃ : Not more than 25% V/V between 195℃ to 205℃ more than 25%		Disinfects, Fluxes, Mineral Enrichment, Synthetic Resins. Cable Enamels	BSP
Crude Pyridine Bases	Pyridine 45% Alpha Picoline 15% Beta Picoline, Gamma Picoline, and Lutidine 20%, Higher bases and residues (including losses) 20%	-	-	-	Zinc salt of pyridine (Antidandruff shampoos) Pure pyridine, Alpha pyridine, Beta pyridine are used in drug industry. Used as denaturing Agents, used for water-proofing in textiles, used as an agrochemicals. Mixture of picolins (solvent of dye) Vinyl pyridine (improving dye-ability and for improving bending strength of tyrecord chips), Cetyl pyridine (antiphistamzin) 'Pyridne-SO3' complex is usesd inconjuction with a material (CO/Fe/Zn) to improve the applicability of dyes.	BSL
Sodium Phenolate	Liberated Phenol : 18% Max., Neutral Oil : 0.1% Max., Pyridine Base : 0.1% Pyridine Base : 0.1% Free Alkali : 1.5% Max.				The Phenols liberated from the Sodium Phenolate are virtually free from Neutral Oils and Pyridine Bases and can be used for synthetic purposes.	BSL

Source : SAIL Central Marketing Organization : THE CHEMICAL FACE OF SAIL.

Table 2.2.8 HISTORICAL PLANT-WISE PRODUCTION OF PRIMARY BY-PRODUCT OF COKE IN INDIA

Product	Year / Plant	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
Coke Oven Gas (1,000 Nm3)	Bhilai	801,045	884,255	840,207	868,878	989,321	1,252,420	N.A.
	Bokaro	870,757	1,039,023	1,064,769	1,152,494	1,128,147	947,974	N.A.
	Durgapur	274,569	698,371	429,515	427,996	377,773	376,180	N.A.
	Rourkela	487,964	507,791	444,839	457,556	475,156	475,556	N.A.
	IISCO	99,432	69,415	56,107	42,006	58,396	428,742	N.A.
	Total	2,533,768	3,198,856	2,835,437	2,948,930	3,028,793	3,480,872	N.A.
	TISCO	646,557	638,581	661,240	671,998	655,537	695,450	N.A.
	Grand Total	3,180,325	3,837,436	3,496,677	3,620,928	3,684,330	4,176,322	N.A.
Ammonium Sulphate (ton)	Bhilai	27,896	29,332	27,841	27,562	36,057	40,100	N.A.
	Bokaro	28,604	28,131	22,025	25,560	28,621	27,300	N.A.
	Durgapur	3,684	5,926	6,014	5,222	5,488	3,800	N.A.
	Rourkela	11,906	11,160	10,083	7,777	12,684	12,000	N.A.
	IISCO	1,760	2,291	3,102	3,718	5,563	N.A.	N.A.
	Total	73,850	76,840	69,065	69,839	88,413	83,200	N.A.
	TISCO	12,862	12,978	15,865	14,114	13,274	14,082	N.A.
	Grand Total	86,712	89,818	84,930	83,953	101,687	97,282	N.A.
Crude Benzol (ton)	Bhilai	18,468	18,454	17,274	19,256	27,668	20,050	24,385
	Bokaro	-	-	-	1,552	3,614	6,410	9,102
	Durgapur	2,669	3,557	3,642	3,426	3,930	2,671	2,840
	Rourkela	2,341	957	1,171	1,406	2,538	4,115	4,202
	IISCO	1,503	1,378	1,053	859	1,210	N.A.	N.A.
	Total	24,981	24,346	23,140	26,499	38,960	33,246	40,529
	TISCO	9,464	8,281	9,697	10,145	9,637	10,224	N.A.
	Grand Total	34,445	32,627	32,838	36,644	48,597	43,470	N.A.
Crude Tar (ton)	Bhilai	82,478	89,064	82,803	85,664	109,570	121,312	136,806
	Bokaro	77,510	90,110	94,917	102,391	96,134	86,758	88,202
	Durgapur	21,842	35,632	38,447	39,381	36,988	34,105	102,120
	Rourkela	54,472	56,163	48,058	49,791	51,901	47,209	46,273
	IISCO	8,748	5,431	4,751	3,763	5,479	N.A.	N.A.
	Total	245,050	276,400	268,976	280,990	300,072	289,384	373,401
	TISCO	68,567	63,400	69,692	67,922	58,788	69,792	N.A.
	Grand Total	313,618	339,801	338,668	348,913	358,860	359,176	373,401

Source : MECON ; Working Group Report, Oct., 1989. (excludes Coke Oven Gas production).
SAIL ; Corporate Plan upto 2000 AD, 1987.
SAIL ; Annual Statistcs of Rourkela Steel Plant.
JICA Team ; Estimation of Coke Oven Gas production of TISCO and SAIL (excludes RSP)

Table 2.2.9 PROJECTED PLANT-WISE PRODUCTION OF PRIMARY BY-PRODUCT OF COKE IN INDIA

Product	Unit	Plant \ Year	1994-95	1999-2000
Coal Carbonised (Net)	million ton	Bhilai	4,480.0	4,620.0
		Bokaro	4,800.0	4,740.0
		Durgapur	2,060.0	2,260.0
		Rourkela	2,242.0	2,990.0
		IISCO	1,640.0	1,900.0
		Total	15,222.0	16,510.0
		TISCO	2,609.2	2,508.9
		Grand Total	17,831.2	19,018.9
Coke Oven Gas	million Nm3	Bhilai	1,298.0	1,339.0
		Bokaro	1,382.0	1,341.0
		Durgapur	565.7	626.0
		Rourkela	616.7	822.0
		IISCO	450.0	523.0
		Total	4,312.4	4,651.0
		TISCO	733.2	705.0
		Grand Total	5,045.6	5,356.0
Ammonium sulphate	1,000 ton	Bhilai	42.7	44.0
		Bokaro	43.1	42.7
		Durgapur	14.4	15.8
		Rourkela	20.2	26.9
		IISCO	9.8	11.4
		Total	130.2	140.8
		TISCO	14.8	14.3
		Grand Total	145.0	155.1
Crude Benzol	1,000 ton	Bhilai	29.3	30.0
		Bokaro	31.2	30.8
		Durgapur	9.2	10.2
		Rourkela	11.2	15.0
		IISCO	9.8	11.4
		Total	90.7	97.4
		TISCO	10.8	10.4
		Grand Total	101.5	107.8
Crude Tar	1,000 ton	Bhilai	134.2	138.0
		Bokaro	124.7	123.0
		Durgapur	51.7	56.5
		Rourkela	85.7	94.7
		IISCO	45.8	53.2
		Total	442.1	465.4
		TISCO	73.6	70.8
		Grand Total	515.7	536.2

Source : SAIL ; Corporate Plan upto 2000 AD, MAY 1987.

Table 2.2.10 HISTORICAL PRODUCTION OF AROMATIC PRODUCTS IN SAIL

(kl)

Year	Products / Plant	Benzene	Toluene	Xylene	L.S.Naphtha	H.S.Naphtha	Solvent Oil	Still Bottom Oil	TOTAL
1987-88	Bhilai	11,839	2,065	324	-	-	142	595	14,965
	Bokaro	-	-	-	-	-	-	-	0
	Durgapur	1,784	318	-	81	-	-	-	2,183
	Rourkela	970	310	-	115	29	-	-	1,424
	IISCO	1,275	83	-	27	-	-	26	1,411
	Total	15,868	2,776	324	223	29	142	621	19,983
1988-89	Bhilai	19,238	3,521	560	-	-	268	900	24,487
	Bokaro	2,336	-	-	-	-	-	-	2,336
	Durgapur	2,431	386	-	71	-	-	-	2,888
	Rourkela	1,145	361	-	158	29	-	-	1,693
	IISCO	1,632	126	-	33	-	-	22	1,813
	Total	26,782	4,394	560	262	29	268	922	33,217
1989-90	Bhilai	12,725	2,882	463	-	-	286	524	16,880
	Bokaro	5,368	594	-	-	-	-	335	6,297
	Durgapur	1,243	233	-	55	-	-	-	1,531
	Rourkela	3,649	957	-	315	66	371	-	5,358
	IISCO	NA	NA	NA	NA	NA	NA	NA	NA
	Total	22,985	4,666	463	370	286	657	859	30,286
1990-91	Bhilai	13,711	2,496	535	-	-	324	636	17,702
	Bokaro	6,428	564	48	-	-	-	678	7,718
	Durgapur	2,103	320	-	63	-	-	-	2,486
	Rourkela	2,003	790	-	372	286	-	-	3,451
	IISCO	NA	NA	NA	NA	NA	203	NA	NA
	Total	24,245	4,170	583	435	286	527	1,314	31,560

Source : MECON and Rourkela Steel Plant: Annual Sratistics (1989-90 and 1990-91).
Note : Fore runnings production in Rourkela Steel Plant are listed as Solvent Oil in this Table.

Table 2.2.11 PROJECTED PLANT-WISE PRODUCTION OF AROMATIC PRODUCTS IN SAIL

Year	Plant	Plant Unit	Benzene	Toluene	Xylene	Solvents
1994-95	Bhilai	ton	17,660	2,930	590	1,170
	Bokaro	ton	22,510	3,380	870	1,310
	Durgapur	ton	5,070	1,110	-	220
	Rourkela	ton	6,720	1,120	-	450
	IISCO	ton	5,900	980	-	980
	Total	ton	57,860	9,520	1,460	4,130
1999-2000	Bhilai	ton	18,080	3,010	600	1,200
	Bokaro	ton	21,120	3,330	860	1,290
	Durgapur	ton	5,600	1,210	-	310
	Rourkela	ton	9,030	1,500	-	600
	IISCO	ton	6,840	1,140	-	1,140
	Total	ton	60,670	10,190	1,460	4,540
1994-95	Bhilai	kl	19,977	3,360	692	1,368
	Bokaro	kl	25,464	3,876	1,020	1,532
	Durgapur	kl	5,735	1,273	-	257
	Rourkela	kl	7,602	1,284	-	526
	IISCO	kl	6,674	1,124	-	1,146
	Total	kl	65,452	10,917	1,712	4,829
1999-2000	Bhilai	kl	20,452	3,452	703	1,403
	Bokaro	kl	23,891	3,819	-	1,508
	Durgapur	kl	6,335	1,388	-	362
	Rourkela	kl	10,215	1,720	-	702
	IISCO	kl	7,738	1,307	-	1,333
	Total	kl	68,631	11,686	703	5,308

Source : SAIL ; Corporate Plan upto 2000 AD, MAY 1987.

Table 2.2.12 HISTORICAL PLANT-WISE PRODUCTION OF TAR PRODUCTS IN SAIL

(ton)

Plant / Products	1987-88 BSP	1987-88 BSL	1987-88 DSP	1987-88 RSP	1987-88 TOTAL	1988-89 BSP	1988-89 BSL	1988-89 DSP	1988-89 RSP	1988-89 TOTAL	1989-90 BSP	1989-90 BSL	1989-90 DSP	1989-90 RSP	1989-90 TOTAL	1990-91 BSP	1990-91 BSL	1990-91 DSP	1990-91 RSP	1990-91 TOTAL
Special Tar	-	-	-	880	880	-	-	-	-	-	-	-	-	840	840	-	-	-	760	760
Road tar	988	1329	-	-	2317	1035	3175	-	-	4210	1080	595	-	-	1675	1080	595	-	-	1675
Pitch	17485	32802	-	24920	75207	30960	53407	-	26180	110547	28880	29461	-	25600	83941	43390	40470	-	23417	107277
HP Naphthalene	3594	1278	1148	2350	8370	3564	2631	1130	2142	9467	2871	1302	980	2027	7180	2323	2075	1020	1675	7093
Pitch creosote mixture	55929	39540	32140	-	127609	63278	63549	29043	-	155870	47570	35391	34988	-	117949	57902 *1	51630 *1	18430 *1	-	127962
Creosote oil	275	-	799	-	1074	2180	-	845	-	3025	2944	-	1131	-	4075	4526	-	2440	-	6966
Sodium phenolate	444	-	64	1091	1599	461	-	68	-	529	483	-	103	-	586	390	-	158	-	548
Dephenolised oil	648	-	-	-	648	790	-	-	-	790	541	-	-	-	541	383	-	-	-	383
Drained naphthalene oil	1012	-	-	-	1012	2876	-	-	-	2876	2757	-	-	-	2757	3571	-	-	-	3571
Wash Oil	1066	-	-	5110	6176	316	-	-	2780	3096	1045	543	-	5444	7032	1231	1711	-	5123	8065
Light oil	155	-	119	297	571	76	-	60	-	136	82	-	48	154	284	8	-	54	422	484
Crude anthracene oil	1435	-	-	-	1435	3978	-	-	-	3978	10906	-	-	-	10906	8747	-	-	-	8747
Dehydrated tar	-	1596	-	-	1596	-	1080	-	-	1080	-	-	-	-	-	-	-	-	-	0
Mould coating varnish	-	35	-	-	35	-	240	-	-	240	-	380	-	-	380	-	320	-	-	320
Coal tar fuel	-	-	-	3700	3700	-	-	-	-	0	-	-	-	2600	2600	-	-	-	2600 *2	2600
Coal tar heavy oil	-	-	-	9445	9445	-	-	-	3830	3830	-	-	-	9327	9327	-	-	-	7976	7976
Neutral oil	-	-	-	830	830	-	-	-	1132	1132	-	-	-	1075	1075	-	-	-	1052	1052
Pure phenol	-	-	-	52	52	-	-	-	69	69	-	-	-	70	70	-	-	-	35	35
MP cresol/cresylic acid	-	-	-	85	85	-	-	-	128	128	-	-	-	127	127	-	-	106	102	208
Crude carbolic acid	-	-	-	-	-	-	-	-	-	-	-	-	-	1424	1424	-	-	-	1379	1379
TOTAL	83031	76580	34270	48760	242641	109514	124082	31146	36261	301003	99159	67672	37250	48688	252769	123551	96801	22208	44541	287101

Source : MECON ; Production of SAIL's Steel Plant (excludes IISCO)

Note : *1 C.T.Fuel is also included.

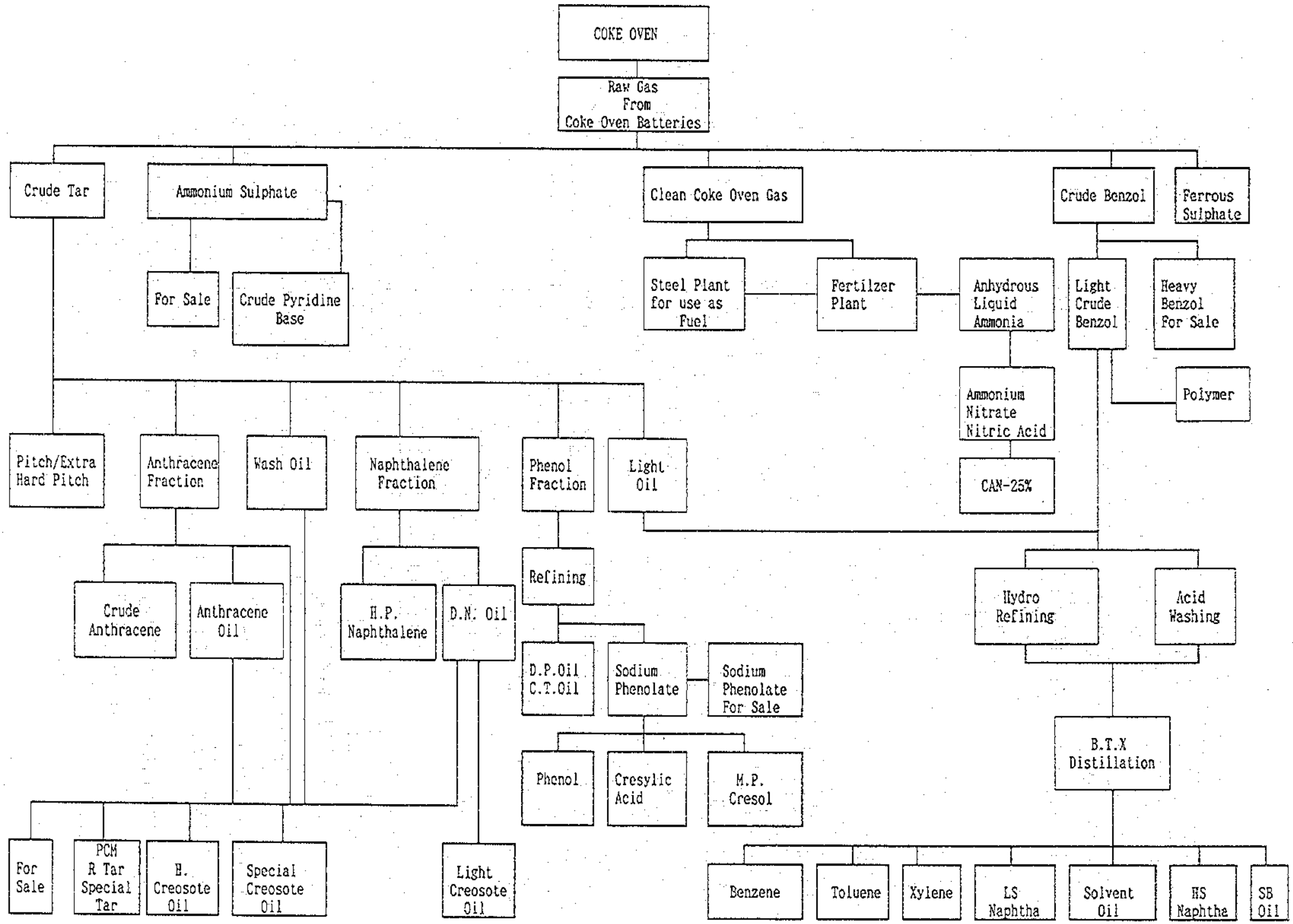
*2 icludes pitch creosote mixture.

Table 2.2.13 PROJECTED PLANT-WISE PRODUCTION OF TAR PRODUCTS IN SAIL

(ton)

Year	Plant	H.P.Naphthalene	Pitch	Tar Oils	Sodium Phenolate
1994-95	Bhilai	5,370	73,790	49,700	1,340
	Bokaro	3,740	84,410	33,760	-
	Durgapur	1,810	28,480	19,120	-
	Rourkela	2,520	33,230	21,350	370
	IISCO	-	-	-	-
	Total	13,440	219,910	123,930	1,710
1999-2000	Bhilai	5,540	76,170	51,220	1,380
	Bokaro	3,700	83,780	33,270	-
	Durgapur	1,960	31,100	28,520	-
	Rourkela	3,360	44,360	20,920	500
	IISCO	-	-	-	-
	Total	14,560	235,410	133,930	1,880

Source : SAIL ; Corporate Plan upto 2000 AD, MAY 1987.



Source : SAIL Central Marketing Organisation ; THE CHEMICAL FACE OF SAIL 'SAIL'S wide range of By-products'

Figure 2.2.1 FLOW CHART OF CHEMICAL RECOVERY IN SAIL

Table 2.3.1 WASHERY-WISE CLEAN COAL PRODUCTION BY CATEGORY

Type		Washery	Clean Coal Quantity (1,000 ton)	Production Percentage (%)
I	Prime Coking	Dudga	1,230	8.7
		Bhojudih	1,140	8.1
		Patherdih	670	4.8
		Sudamdih	600	4.3
		Moonidih	700	5.0
		Londa	250	1.8
		DCOP	100	0.7
		DSP	450	3.2
		Chasnalla	720	5.1
		Jamadoba	1,000	7.1
		Direct Feed (BCCL)	200	1.4
		Hard coke Manufacture	0	0.0
		Sub Total	7,060	50.2
II	Medium Coking	Kargali	840	6.0
		Kathara	730	5.2
		Swang	500	3.6
		Gidi	1,000	7.1
		Rajrappa	1,030	7.3
		Baroa	110	0.8
		Mahuda	330	2.3
		DSP	270	1.9
		Nandan	340	2.4
		West Bokaro	1,100	7.8
		Direct Feed (BCCL)	150	1.1
		Sub Total	6,400	45.5
III	Semi Coking	NEC	300	2.1
	(Direct Feed Only)	ECL	300	2.1
		Sub Total	600	4.3
	Grand TOTAL (I+II+III)		14,060	100.0

Source : GOVERNMENT OF INDIA MINISTRY OF ENERGY DEPARTMENT OF COAL; ANNUAL PLAN 1990-91.

Table 2.3.2 WASHERY-WISE CLEAN COAL DESPATCHES BY CATEGORY

Category	Source	Despatches			
		1986-87		1987-88	
		Quantity (1,000 ton)	Ratio (%)	Quantity (1,000 ton)	Ratio (%)
I Prime Coking	CIL (BCCL)				
	Washed Coal	4,010	32.7	4,260	33.9
	Direct feed	1,000	8.1	860	6.8
	Total BCCL	5,010	40.8	5,120	40.7
	TISCO				
	Jamdoba	990		920	
	Washed Coal	970		920	
	Direct feed	20		-	
	TISCO				
	Washed Coal	320		390	
	Total TISCO	1,310	10.7	1,310	10.4
	Washed Coal	1,290	10.5	1,310	10.4
	Direct feed	20	0.2	-	0.0
	DSP				
	Washed Coal	530	4.3	550	4.4
	SUB TOTAL	6,850	55.8	6,980	55.5
	Washed Coal	5,830	47.5	6,120	48.7
	Direct feed	1,020	8.3	860	6.8
II Medium Coking	CIL(CCL)				
	Washed Coal	3,740	30.5	3,790	30.2
	CIL (WCL)				
	Washed Coal	180	1.5	250	2.0
	TISCO				
	Washed Coal	990	8.1	1,070	8.5
	SUB TOTAL				
	Washed Coal	4,910	40.0	5,110	40.7
III Blendable Coal	CIL (ECL)	280		220	
	CIL (NEC)	230		260	
	SUB TOTAL	510	4.2	480	3.8
Grand TOTAL (I+II+III)		12,270	100.0	12,570	100.0

Source : GOVERNMENT OF INDIA MINISTRY OF ENERGY DEPARTMENT OF COAL; ANNUAL PLAN 1990-91.

Table 2.3.3 PROJECTED CATEGORY-WISE AVAILABILITY OF COKING COAL FOR STEEL PLANTS IN INDIA

(million ton)

Year	Prime Coking Coal	Medium Coking Coal	Semi Coking Coal	Total Coking Coal
1989-90	7.00	6.41	0.50	13.91
1990-91	7.61	6.60	0.66	14.87
1991-92	8.20	6.83	0.72	15.75
1992-93	8.36	7.12	0.80	16.28
1993-94	9.32	8.11	0.89	18.32
1994-95	10.01	8.37	1.01	19.39

Source : MECON's Information.

Table 2.3.4 HOT METAL PRODUCTION, COKING COAL REQUIREMENT IN INDIA (1990-91)

(1,000 ton)

	SAIL	VSP	TISCO	MAIN PRODUCER TOTAL	DCOP	FCI	TOTAL (A)	SUPPLY (B)	BALANCE (B-A)
1 Hot Metal Production	11,950 *1	1,400 *1	2,300 *1	15,650 *1	- *1	- *1	15,650		
Total Coaking Coal 2 Requirement	15,370 *2	1,840 *2	2,550 *2	19,760 *2	100 *1	150 *1	20,010		
3 Imports	2,710 *1	390 *1	500 *1	3,600 *1	- *1	- *1	3,600		
4 Total Indigenous Coal	12,660 *1	1,450 *3	2,050 *3	16,160 *3	100 *1	150 *1	16,410	14,870	-1,540
5 1) Prime Coking	5,800 *1	650 *1	1,000 *1	7,450 *1	100 *1	60 *1	7,610	7,610	0
6 2) Medium Coking	6,010 *1	800 *1	1,050 *1	7,860 *1	- *1	90 *1	7,950	6,600	-1,350
7 3) Semi Coking	850 *1	- *1	- *1	850 *1	- *1	- *1	850	660	-190
8 Import Equivalent of Supply Deficit							1,015		
9 Total import (3+8)							4,615		

Source : *1 ; INDIAN GOVERNMENT MINISTRY OF ENERGY DEPARTMNET OF COAL ; ANNUAL PLAN 1990-91.
*2 ; MECON's Information, 1991.
*3 ; Compiled by JICA Team based on *1 and *2.

Table 2.3.5 HISTORICAL IMPORT QUANTITY OF COKING COAL IN INDIA

(ton)

Year / Article Code / Origin	1985-86	1986-87	1987-88
Article Code	3222003	3222003	27011901
Australia	2,230,458	1,953,694	2,198,172
Canada	38,003	61	-
Finland	33,965	-	-
German F Rep.	53	-	-
Nepal	-	140	-
Japan	150	-	11,000
Poland	28,895	305,724	-
USA	-	1	-
Total	2,331,524	2,259,620	2,209,172

Source : Ministry of Commerce : STATISTICS OF THE FOREIGN TRADE OF INDIA BY COUNTRIES.

Table 2.3.6 TREND OF COKING COAL CONSUMPTION BY MAIN PRODUCERS

(1,000 ton)

Year / Steel Plant	1984-85	1985-86	1986-87	1987-88	1988-89
Bhilai	3,123	3,363	3,203	3,189	3,840
Bokaro	3,644	3,917	3,935	4,239	4,168
Durgapur	1,259	1,472	1,676	1,673	1,549
Rourkela	1,932	1,979	1,729	1,810	1,847
IISCO	1,307	1,209	1,049	1,075	1,456
SAIL TOTAL	11,265	11,940	11,592	11,986	12,860
TISCO	2,285	2,267	2,298	2,329	2,325
VSP	-	-	-	-	-
GRAND TOTAL	13,550	14,207	13,890	14,315	15,185

Source : SAIL ; Statistics for Iron & Steel industry in India, 1990.

Table 2.3.7 PLANT-WISE COKING COAL DEMAND FOR STEEL PLANTS IN INDIA

(million ton)

	Year	SAIL	TISCO	VSP	TOTAL
ACTUAL	1984-85	11.265	2.285	-	13.550
	1985-86	11.940	2.267	-	14.207
	1986-87	11.592	2.298	-	13.890
	1987-88	11.986	2.329	-	14.315
	1988-89	12.860	2.325	-	15.185
	1989-90	14.510	2.550	0.380	17.440
	1990-91	15.370	2.550	1.840	19.760
FORECAST	1991-92	15.210	2.550	3.360	21.120
	1992-93	15.550	2.840	4.030	22.420
	1993-94	16.490	2.840	4.030	23.360
	1994-95	16.330	2.840	4.030	23.200

Source : Compiled by JICA Team based on MECON's Information

Table 2.3.8 PROJECTED CATEGORY-WISE COKING COAL REQUIREMENT IN INDIA AS OF 1994-95

		Requirement (A) (1,000 ton)	Availability (B) (1,000 ton)	Balance (B-A) (1,000 ton)
Indigenous	Prime Coking	8,652	10,010	1,358
	Medium Coking	9,388	8,370	-1,018
	Semi Coking	898	1,010	112
Indigenous	Sub Total	18,938	19,390	452
Import	Prime Coking	4,262	4,262	0
	Total	23,200	23,652	452

Projected Consonsumption		Quantity (1,000 ton)	Percentage (%)
Indigenous	Prime Coking	9,670	41.7
	Medium Coking	8,370	36.1
	Semi Coking	898	3.9
Indigenous	Sub Total	18,938	81.6
Import	Prime Coking	4,262	18.4
	Total	23,200	100.0

Source : JICA Team's Projection

Table 2.3.9 PROJECTED CATEGORY-WISE COKING COAL REQUIREMENT OF MAJOR STEEL PRODUCER IN INDIA AS OF 1994-95

(1,000 ton)

		SAIL	VSP	TISCO	TOTAL
Total Coking Coal Requirement (1)		16,330	4,030	2,840	23,200
Category-wise Coal Requirement (2)					
Prime Coking	Indigenous	6,156	1,402	1,094	8,652
	Import	2,874	843	545	4,262
	Sub Total	9,030	2,245	1,639	12,914
Medium Coking	Indigenous	6,401	1,785	1,201	9,387
Semi Coking	Indigenous	898	0	0	898
Total		16,330	4,030	2,840	23,200
Percentage in each Category (%)(3) [1990-1991]					
Prime Coking	Indigenous	37.7	34.8	38.5	37.3
	Import	17.6	20.9	19.2	18.4
	Sub Total	55.3	55.7	57.7	55.7
Medium Coking	Indigenous	39.2	44.3	42.3	40.5
Semi Coking	Indigenous	5.5	-	-	3.9
Total		100.0	100.0	100.0	100.0

Source : (1) MECON's Information, 1991.
(2) JICA Team's Projection.
(3) Ministry of Energy Department of Coal ; ANNUAL PLAN 1990-91.

Chapter 3 RAW MATERIAL STUDY

Chapter 3 RAW MATERIAL STUDY

3.1 Supply and Demand of Coal

3.1.1 Review of Major Coalfields

This chapter outlines the major aspects of India's coal resources and coal industry with especial attention to the reserves and production output of its coalfields. The figures for reserves included as Annex 3.1.1 are based on data obtained from MECON during the on site visit of the Japanese mission and dated January 1, 1989. Figures for lignite reserves are according to the data in the 'A Profile' issued by the NLC. Further, production output data for the CIL coalfields is based on the areawise indications noted in the 'Operational Statistics 1985-86 to 1988-89, Vol. II' of the CIL. The CMPDIL's 'Coal Atlas' was used as a basis for inferring the coalfields found in each area and in conjunction with the above the operational statistics totals were calculated. For calculating the production of other coalfields the 'Annual Plan 1990-91' and 'Annual Report 1988-89' of Department of Coal were used. The location of the coalfields is according to 'Indian Coals Vol. 1-8' issued by the CFRI.

(1) Indian Coal Reserves and Industrial Production

1) Geological Categories and Characteristics of India's Coal Resources

In terms of geological age India's coal resources can be roughly divided into coal of the Permian Period of the Paleozoic era (so called Gondwana) and coal or lignite of the Tertiary period of the Cenozoic era. Of these resources 176.3 (American) billion tons representing 99% of the total coal resources are of the Gondwana type. Further, in order of importance the leading reserves are found in the coalfields of Raniganj, Talcher, Jharia and Ib-River, followed by the Karanpura coalfield (both North and South sections taken together).

Coal of the Gondwana type is divided into categories of sub-bituminous and bituminous coals. The sulphur and phosphorous content is low but ash content is high and this mineral matter is finely distributed throughout the coal substance so that it is difficult to wash. Also compared to coal produced in the northern hemisphere the inertinite content of this coal is high.

Compared to Gondwana coal, Tertiary period coal has a high sulphur content but the ash and inertinite contents are low giving this coal a special position among India's coal resources. Coalfields are on a small scale and the Makum coalfield has the largest reserves of this type.

The larger part of the lignite resources are of a comparatively low ash content but have a moisture exceeding 50%. The largest reserves are found in the lignite coalfield of Neyveli.

Table 3.1.1 shows the characteristics of coals from the representative coalfields and Table 3.1.2 indicates their petrographic characteristics.

2) Coking Coal Resources and their Main Coalfields

The total approximate reserves of coking coal in India are 27.7 (American) billion tons, representing less than 16% of the total coal resources. Coking coal is classified as prime coking coal, medium coking coal and semi- (or weakly) coking coal.

Reserves of prime coking coal amount to 5.3 (American) billion tons and are only found in the

Jharia coalfield. Deposits of medium coking coal are found in a number of coalfields but the reserves of the Jharia, (East and West) Bokaro and (North and South) Karanpura coalfields account for 90% of the total with more than 20.3 (American) billion tons of deposits. Besides prime and medium coking coal reserves there are about 2 (American) billion tons of coking coal and about 52% of these reserves are located in the Raniganj coalfield.

Table 3.1.3 shows the estimated life of the prime coking coal as per indications given by the Indian party to the preliminary JICA mission. Given a 5% increase in consumption by the steel industry the life span would only be 30 years. This is one reason for India's request for cooperation in the introduction of SRC technology. As reserves including the indicated reserves amount to 5.3 billion tons as noted above, on the same conditions to calculate only a slight increase in life could be anticipated.

3) Main Coalfields for Non-coking Coal

Large deposits of non-coking coal are found in the Gondwana formation coalfields of Raniganj, Talcher, Ib-River, Karanpura and Godavari Valley. The amount of these non-coking coal reserves account for almost 60% of total India's Gondwana non-coking coal reserves reaching nearly to 148 (American) billion tons.

The certain reserves, that is reserves of proved or indicated nature, are classified into grades according to their Useful Heat Value (UHV). This UHV is determined on the basis of moisture and ash contents on an air dry basis. On the UHV scale the Grade A coal is the best in quality (UHV superior to 6,200 kcal/kg, less than 19.6% for the combined moisture and ash contents) but deposits of this account for less than 2% of the total reserves with an estimated 1.6 billion tons. The largest deposits of Grade A are found in the coalfields of Karanpura, Korba and Raniganj with 308.94 million tons, 230.43 million tons and 180 million tons respectively. There are about 5 billion tons of the Grade B coal which is below Grade A in terms of quality. Nearly half of these Grade B reserves are concentrated in the Raniganj coalfield.

For a non-coking coal to act as a substitute coal for the coking coal used as SRC feedstock or in conjunction with SRC the ash content must be low. If introduction of SRC technology is found suitable and it becomes necessary to diversify the non-coking coal supply sources used in response to increased demand then the possible role of coalfields with comparatively rich high grade non-coking coal deposits would need to be examined.

4) Geographical Distribution of Coalfields and Mining Companies

a) Geographical Distribution

Figrue 3.1.1 shows the distribution of Indian coalfields and the companies mining and working these sites.

The coalfields of Gondwana type coal are concentrated in the south eastern part of the peninsular India below a latitude 24 degrees North and east of a longitude 78 degrees East. They are found in the main river basins that is along the valleys of Damodar, Koel, Sone-Mahanadi, Penchi-Kanhan and Pranhita Godavari. In terms of scale of reserves and production the main centers are found in the states of Bihar, West Bengal, Orissa, Madhya Pradesh and Andhra Pradesh where the above regions are located.

The revenue accruing to the State Governments in the form of royalties and Cesses from these surpassed 9 billion rupees in the year of 1987.

Coal deposits of the Tertiary period are found scattered in the North Eastern States and in the state of Jammu & Kashmir.

Lignite is found in the states of Jammu & Kashmir, Rajasthan, Gujarat and Tamil Nadu and the largest reserves are located in the Neyveli coalfield of Tamil Nadu and this serves as a major energy source for the southern part of India.

The regionally uneven distribution of the Gondwana type coal resources which form the larger part of India's reserves and output necessitates the transport of the coal. Coal transportation in fact accounts for 40% of the freight carried on India's railway network which is the largest in Asia. It is therefore worthy of note that the coalfields which carry out large scale dispatch of coal due to the availability of transport routes to the end users are not necessarily the coalfields of producers which have the largest reserves.

b) Coal Producers

India's performance record for coal production was 200.88 million tons in 1989, with an estimated production of 215.01 million tons for 1990 but 89% of this output was accounted for by the Central Government public enterprise Coal India Limited (CIL) and its subsidiaries, while 9% was taken by Singareni Collieries Company Limited (SCCL) which is a joint venture of the Central Government and the State Government of Andhra Pradesh.

Producers operating under the control of CIL are Bharat Coking Coal Limited (BCCL), Central Coalfields Limited (CCL), Eastern Coalfields Limited (ECL), Western Coalfields Limited (WCL), Northern Coalfields Limited (NCL) and South Eastern Coalfields Limited (SECL). The coal-fields under the jurisdiction of each company are shown in Figure 3.1.1. The Tertiary type coalfields of the North Eastern States are administered directly by CIL. BCCL and NCL undertake production at the Jharia coalfield and Singrauli coalfield respectively. The four other coal companies administer a number of coalfields of which the main in terms of present output are the Raniganj coalfield of ECL, the East and West Bokaro coalfields and the North and South Karanpura coalfields of CCL, the Korba and Talcher coalfields of SECL and finally the Wardha coalfield of WCL.

SCCL is also engaged in production at the Godavari Valley coalfield.

The Neyveli Lignite Corporation (NLC) which is a public enterprise run by the Central Government carries out lignite production. Almost all of the output is produced at the Neyveli coalfield.

(2) Details of the Main Coalfields

1) Jharia Coalfield

This coalfield possesses the third largest reserves in India and is at present the sole source of domestic prime coking coal. Further, it has the largest reserves of medium coking coal after those of the combined East and West Bokaro coalfields.

This coalfield has continued to play a central role in the national coal mining industry since mining activities were begun nearly a hundred years ago in the 19th century. Until nationalization in 1971 almost all collieries were private enterprises and the resulting unsystematic mining was the cause of great waste.

The oil agglomerated middlings which represents one candidate coal feedstock for the SRC is produced from the washery middlings resulting when coking coal is washed at this coalfield. The washery middlings are milled and de-ashed by oil agglomeration to produce the oil agglomerated middlings.

a) Location

Jharia coalfield, between latitudes 23°37′-23°52′ N and longitudes 86°06′-86°30′ E, is situated in the Dhanbad district of Bihar state and it occupies an area of 480 km^2. The river Damodar with its several tributaries traverses through the coalfield from west to east.

b) Reserves

The total reserves estimated to a depth of 1,200 metres amount to 19,417 million tons, and 73.2% of these reserves lie in deposits of relatively shallow depth up to 600 metres. The percentage of total reserves accounted for by prime coking coal, medium coking coal and non-coking coal are 27.3%, 31.7% and 41.0% respectively. However 90% of the non-coking coal is of poor quality being classified as only E or even inferior grade. The certainty of reserves is said to be 70.8% proved and 29.2% indicated.

c) Output

This coalfield is administered by BCCL, and was divided into 18 areas with 107 collieries in 1988-89. Production records for the last four years are as follows:

1985-86	21.1 million tons
1986-87	24.0 million tons
1987-88	25.1 million tons
1988-89	26.3 million tons

The main collieries in terms of output for 1988-89 were the Block II colliery of area Block II, the Moonidih colliery of the Moonidih area, the Muraidih colliery of the Barora area and the Goluckdih colliery of the Bastacolla area which had production records of 1.018 million tons, 1.2 million tons, 0.989 million tons and 0.887 million tons respectively.

2) Raniganj Coalfield

Raniganj Coalfield has the largest reserves of any coalfield in India and deposits of almost all types of coal in a range from medium coking to non-coking are found as well as large deposits of non-coking coal with a high UHV.

This coalfield initiated the Indian coal mining industry and it has continued to act as a focus point of interest in the coal mining sector since its initial development. The coalfield continues to act as the main coalfield of ECL and maintains its role as a large scale coal source.

The Samla coal indicated as a candidate SRC feedstock in the present report comes from this coalfield.

a) Location

Raniganj coalfield covering an area of 1,550 km^2 between latitudes 23°33'-23°52' N and longitudes 86°38'-87°20' E, lies mainly in the Burdwan district of West Bengal. However, parts of the coalfield at its western, northern and southern fringes fall in the Dhanbad and Santhal Pargana districts of Bihar, Birbhum, Purulia and Bankura districts of West Bengal.

b) Reserves

Reserves lying up to a depth of 1,200 metres are estimated to amount to 27,237 million tons and 66.2% lie at a depth shallower than 600 metres. The certainty of deposits is said to be 26.6% proved reserves, 43.7% indicated reserves and 29.7% inferred reserves.

For coking coal there is 2.1% medium coking coal and 3.9% blendable coal. The non-coking coal reserves constitute 94% of the total reserves accounting for 25,607 million tons. Of these 18,320 million tons are proved or indicated and also are classified as to UHV. According to these UHV 13.8% are Grade A-B, 67.6% are Grade C-D and 18.6% are in the poor quality range of Grade E and below.

c) Output

This coalfield belongs to ECL and was divided into 16 areas with 133 collieries in 1988-89. The production records for the last four years are as follows:

1985-86	23.4 million tons
1986-87	24.8 million tons
1987-88	25.6 million tons
1988-89	27.4 million tons

The largest colliery of this coalfield is the Badjna colliery of the Nirsha area which mined 1.392 million tons of coal in 1988-89.

3) Bokaro Coalfield

This ranks nine in terms of size of reserves among Indian coalfields, and possesses the largest reserves for medium coking coal in India. It serves as one of the most productive of CCL's coalfields and is a major source of medium coking coal.

a) Location

The Bokaro coalfield is situated in Hazaribagh and Giridih districts of Bihar. The Lugu hill divides the field into two parts, known as East Bokaro coalfield and West Bokaro coalfield. River Damodar flows on the southern flank of East Bokaro while the river Bokaro, a tributary of the Damodar, forms the main drainage of the basin of West Bokaro coalfield.

The East Bokaro coalfield, between latitudes 23°44'30"-23°48'30" N and longitudes 85°44'30"-86°02'30" E, extends over an area of 208 km^2. The West Bokaro coalfield, between latitudes 23°44'00"-23°50'30 N and longitudes 85°24'00"-85°44'30" E, covers an area of 259 km^2.

b) Reserves

Total reserves up to a depth of 900 metres are estimated to be 8,988.33 million tons of which 92.6% are found at a depth less than 600 metres.

In terms of quality 97.4% of total reserves are medium coking coal. The certainty of deposits is said to be 50.7% proved and 48.0% indicated.

c) Output

The Bokaro coalfield belongs to Division II of CCL and in 1988-89 it was divided into 5 areas with 30 collieries. The production records for the last four years are shown as follows:

1985-86	12.2 million tons
1986-87	12.9 million tons
1987-88	12.3 million tons
1988-89	12.8 million tons

The major collieries of the coalfield in terms of output in 1988-89 were the Bokaro colliery of Kargali area producing 0.913 million tons, the Kargali colliery of the Kargali area with 0.925 million tons, the South Dhori colliery of the Dhori area with 1.91 million tons and the Kathara colliery of the Kathara area with 1.292 million tons.

4) Karanpura Coalfield

Taking the North and South coalfields together Karanpura ranks number five in terms of reserves among Indian coalfields, and has the largest medium coking coal reserves after those of the Bokaro and Jharia coalfields.

It has the largest amount of high quality non-coking coal with a UHV of Grade A.

In terms of output this coalfield is the most productive of CCL's coalfields.

The Argada-Sirka coal chosen in the present report as a candidate feedstock for SRC originates from the South Karanpura coalfield.

a) Location

North Karanpura coalfield covering an area of about 1,230 km^2 lies between latitudes 23°38'-23°56' N and longitudes 84°46'-85°23' E and forms the westernmost part of Upper Damodar Valley coalfields. The major portion of the coalfield lies in Hazaribagh district, while the western and southern fringes occur in Palamau and Ranchi districts of Bihar. The coalfield is a saucer-shaped basin having a maximum length of 64 km in the east-west direction and a width of about 36 km in the north-south direction.

South Karanpura coalfield covering an area of about 175 km^2 lies between latitudes 23°38'-23°43' N and longitudes 85°07'-85°28' E. Situated mostly in Ranchi district and a small portion in Hazaribagh district of Bihar. The coalfield is a narrow semi-elliptical basin of Upper Damodar Valley coaldfield having a maximum east-west extension of about 37 km, while in the north-south direction, its width is less than 9 km.

b) Reserves

The reserves of the North Karanpura coalfield up to a depth of 600 metres are estimated to amount to 13,499.8 million tons.

Of these 18.8% are classified as proved, 57.6% as indicated and 23.6% as inferred. By coal category about 75% is non-coking coal with the remaining deposits being medium coking coal.

As regards the grade of the non-coking coal of the 7,518.82 million tons of proved or indicated coal reserves which have been graded 83.5% is classified as E or below with a UHV less than 4,200 kcal/kg, but close to a hundred million tons of deposit is Grade A with a UHV above 6,200 kcal/kg. The coalfield ranks relatively high in terms of high grade coal reserves.

The total reserves of the South Karanpura coalfield lying up to a depth of 900 metres are estimated to amount to 3,853.74 million tons and about 99% of these are found at a depth less than 600 metres.

Non-coking coal accounts for 92.8% of the reserves and as regards the grade of the 2,592.27 million tons of the above which are proved or indicated 210.94 million tons is classified by UHV as Grade A. This means that the coalfield ranks second after Korba in terms of high grade coal reserves.

c) Output

The North Karanpura coalfield belongs to Division I of CCL and was divided into two areas with 6 collieries in 1988-89. The production records for the last four years are as follows:

1985-86	4.7 million tons
1986-87	5.4 million tons
1987-88	6.4 million tons
1988-89	6.5 million tons

The largest collieries of this coalfield in 1988-89 were the D. Bukbuka colliery with 1.735 million tons output, K. Dewarkhand colliery with 2.411 million tons and the Karkatta colliery with 1.64 million tons.

The South Karanpura coalfield also belongs to Division I of CCL and was divided into two areas with 14 collieries in 1988-89. The production records over the last four years are as follows:

1985-86	5.3 million tons
1986-87	4.9 million tons
1987-88	5.4 million tons
1988-89	5.5 million tons

5) Korba coalfield

The reserves of this coalfield rank as number ten in size among Indian coalfields and the deposits of Grade A non-coking coal are the largest in India.

This coalfield produces the largest output of the coalfields in the SECL group.

a) Location

Korba coalfield, between latitudes 22°17′-22°38′ and longitudes 82°15′-82°55′ E is situated in Bilaspur district of Madhya Pradesh. It covers an area of 520 km^2. The Hasdo river flowing from north to south through the field divides it into the western sector and the eastern sector.

b) Reserves

Total reserves up to a depth of 600 metres amount to 5,513.03 million tons. Of the 5,475.48 million tons of graded non-coking coal 4,873.79 million tons or nearly 90% are Grade E or below, while deposits classified as Grade A amount to 230.43 million tons.

c) Output

This coalfield belongs to the SECL and there were ten collieries in the combined east and west areas in 1988-89. Production records for the last four years are as follows:

1985-86	12.1 million tons
1986-87	13.2 million tons
1987-88	14.1 million tons
1988-89	15.5 million tons

The main collieries in terms of output for 1988-89 were the Manickpur OCP colliery of the Korba East area, the Kusmunda OCP colliery and Gevera OCP colliery of the Korba West area, which produced 1.707 million tons, 3.745 million tons, 8.210 million tons respectively.

6) Talcher Coalfield

This coalfield has the second largest reserves of any in India and in recent years has achieved the largest scale of output to become the major coalfield of SECL.

a) Location

Talcher coalfield, between latitudes 20°50'-21°15' N and longitudes 84°20'-85°25' E, lies in Bramhani River Valley of Dhenkanal district of Orissa. The coalfield covers an area of about 1,800 km^2.

b) Reserves

Total reserves up to a depth of 1,200 metres are estimated at 22,854.7 million tons and 99.8% of these are found up to a depth of 600 metres.

All coal produced at this coalfield is of non-coking coal variety and the 9,802.7 million tons classified as proved or indicated is graded according to the UHV index. Only 32.61 million tons of the reserves are classified as Grade A quality with a UHV of more than 6,200 kcal/kg, and 91.4% of the reserves are Grade E or below with a UHV less than 4,200 kcal/kg.

c) Output

Talcher coalfield belongs to the South Division of SECL and there were eight collieries operating in 1988-89. The collieries with the largest outputs of these were the Jaganath OCP colliery and the Bharatpur colliery producing 2.5 million tons and 2.721 million tons respectively. The production records for the last four years of the entire coalfield are shown below:

1985-86	3.5 million tons
1986-87	4.0 million tons
1987-88	4.9 million tons
1988-89	6.1 million tons

7) Ib-Valley Coalfield

The Ib-Valley coalfield has the fourth largest reserves among Indian coalfields and is of equal importance with the Korba and Talcher coalfields in terms of output of SECL.

a) Location

Ib-Valley coalfield, between latitudes 21°40′-21°55′ N and longitudes 83°30′-84°00′ E, lies in Sambalpur district of Orissa. Covering an area of 590 km^2 it forms a continuous part of Korba and Mand coalfields of Madhya Pradesh and

Talcher coalfield of Orissa.

b) Reserves

Reserves up to a depth of 600 metres are estimated to amount to 18,701.94 million tons and all reserves are classified as non-coking coal type.

The 10,410.76 million tons of the above reserves which are proved or indicated are graded according to UHV. There are only just over 10 million tons of Grade A coal and 83.5% of the coal is classified as Grade E or below.

c) Output

The Ib-Valley coalfield belongs to the South Division of the SECL and there were nine collieries here in 1988-89. Of these the Belpahar OCP and Lajkuta collieries recorded large outputs, producing 1.849 million tons and 1.448 million tons respectively. The production records for the entire coalfield for the last four years are as follows:

1985-86	2.5 million tons
1986-87	3.1 million tons
1987-88	4.0 million tons
1988-89	4.7 million tons

8) Singrauli Coalfield

The Singrauli coalfield ranks eighth in India in terms of the importance of its reserves. Production is carried out by NCL and mined coal is used to satisfy the demand for power generation in the northern regions. This coalfield was the first in India to introduce opencast mining which was initiated on a 10 MMt/y scale. Also, large scale pit head power plants were constructed and a merry-go-round method of supply was introduced, firstly in India.

a) Location

Singrauli coalfield, between latitudes 23°47'-24°12' N and longitudes 81°48'-82°52' E, covers an area of 2,201 km^2 and extends over Sidhi and Shadol districts of Madhya Pradesh and Mirzapur district of Uttar Pradesh.

b) Reserves

Reserves, all of which are of non-coking coal type, are estimated to be 9,207.13 million tons up to a depth of 600 metres. Of these 5,241.8 million tons are classified as proved or indicated and are graded according to the UHV index. According to this grading there are no deposits of either Grade A or B coal while Grade C to D coal with a UHV of between 4,200 and 5,600 kcal/kg accounts for 33.1% and Grade E or below with a UHV of less than 4,200 kcal/kg accounts for 66.9% of reserves.

c) Output

The Singrauli coalfield belongs to NCL and while the number of collieries is small each of these is of a large scale of production. The production records for the individual collieries in 1988-89 are as follows:

Jhingurda	3.200 million tons
Gorbi	1.416 million tons
Bina	4.530 million tons
Jayant	6.752 million tons
Kakri	1.663 million tons
Dudhichua	1.600 million tons

Amolori	0.473 million tons

The overall production records for the entire coalfield for the last four years are as follows:

1985-86	11.6 million tons
1986-87	13.6 million tons
1987-88	16.5 million tons
1988-89	19.6 million tons

9) Chanda-Wardha Coalfield

This coalfield has the twelfth important coal reserves in India. In terms of output it is the largest of the WCL coalfields.

a) Location

Wardha Valley coalfield, between latitudes 19°30′-20°97′ N and longitudes 78°50′-79°45′ E, covers an area of about 4,130 km^2. Extending from north-west to south-east direction, the coalfield is mainly situated in Chanda district of Maharashtra. Only a small portion of it, towards north-west, extends over to Yeotmal district of the state. From north of Warora, the coalfield extends to the south up to Wirur-Chincholi area near the boundary of Andhra Pradesh.

b) Reserves

Reserves lying up to a depth of 600 metres are estimated to amount to 3,646.44 million tons and these are all of the non-coking coal variety.

2,026.44 million tons of these reserves are classified as proved or indicated and graded according to the UHV index. The amount of middle grade quality coals of Grade C or D is roughly equal to the amount of poor quality coals of Grade E or below, while there are no reserves graded A or B quality.

c) Output

This coalfield belongs to the WCL and there were eight collieries operating in 1988-89. Of these the Durgapur OCP had the largest scale of output producing 1.942 million tons. The production records of this coalfield over the last four years are as shown below:

1985-86	3.1 million tons
1986-87	3.6 million tons
1987-88	4.2 million tons
1988-89	4.4 million tons

10) Godavari Valley Coalfield

This coalfield possesses the sixth most important reserves in terms of size among Indian coalfields. Production is carried out by SCCL.

a) Location

Stretching from north-west to south-east direction, Godavari Valley coalfield lies between latitudes 17°00'-19°30' N and longitudes 79°00'-81°30' E, and covers part of Adilabad, Karimnagar, Warangal, Khamman, and East Godavari districts of Andhra Pradesh.

b) Reserves

Total reserves lying up to a depth of 1,200 metres are 10,086.2 million tons of which 81.2% are found in a depth under 600 metres. All reserves are of non-coking coal variety and of the 5,603.35 million tons which are proved or indicated the middle grade C and D varieties account for 58% while the low grade types of Grade E and below account for 38%. There is only about 25 million tons of Grade A type.

c) Output

Production records for the last four years are as follows:

1985-86	15.66 million tons
1986-87	16.58 million tons
1987-88	16.40 million tons
1988-89	18.60 million tons

11) Makum Coalfield

In terms of the total Indian reserves of coal this particular coalfield is of minor importance but it is significant as it possesses the largest deposits of low ash content Tertiary coal resources. Further, it is the best equipped of the coalfields under direct control of CIL in North East India in terms of infrastructural aspects. Almost all of the coal in North East India is supplied from this coalfield and the output is also used for metallurgical coke making because of its low ash content and caking property.

The Assam coal which was examined in the present report as a candidate SRC feedstock is produced at this coalfield.

a) Location

Makum coalfield lies between latitudes 27°15'-27°25' N and longitudes 95°40'-95°55' E in Assam. On the southern and south-eastern side of the field are hills, which rise abruptly to heights of 300 to 500 metres from the alluvial plains of the Buri, Dihing and Tirap rivers. These hill ranges are traversed by the Namdang, Ledopani and Tirap rivers.

b) Reserves

Reserves lying up to a depth of 600 metres are estimated to amount to 235.66 million tons. These are classified into proved reserves which account for 10.2% and indicated reserves which account for 61.0% of the total.

c) Output

The production records for the past four years are as follows:

1985-86	0.84 million tons
1986-87	0.91 million tons
1987-88	1.00 million tons
1988-89	0.90 million tons

12) Neyveli Coalfield

This is the largest lignite coalfield in India and together with the Godavari Valley coalfield it acts as an important source of energy supplies for the southern part of India.

The lignite chosen as a candidate SRC feedstock for the present report is produced at this coalfield.

a) Location

The Neyveli coalfield is located in South Arcot district of Tamil Nadu and occupies an area some 480 km^2 ranging between latitudes 11° 15′ to 11° 40′ N and longitudes 79° 25′ to 79° 40′ E.

b) Reserves

Total reserves in the Neyveli coalfield area amount to 3,300 million tons and of these 2,000 million tons are proved reserves. Boring data for Mine I and Mine II, where mining is currently done and expanded of Mine I and Mine III prove that reserves amounting to 287 million tons, 398 million tons, 106 million tons and 470 million tons exist respectively in areas of 16.69 km^2, 27.00 km^2, 11.00 km^2 and 38.00 km^2 respectively.

c) Output

The annual production capacity of Mine I, and Mine II where mining is currently carried out is 6.5 and 4.7 million tons respectively. In order to meet the increased demand in the southern part of India for electricity, expansion plans to raise output by 10.5 million tons annually for Mine I and Mine II and opening plan of Mine III cut of 11.0 million tons annually have been drawn up.

The production records for the past four years are as shown below:

1985-86	7.22 million tons
1986-87	8.52 million tons
1987-88	10.15 million tons
1988-89	11.41 million tons

3.1.2 Coal Seams and Coal Characteristics of Major Coalfields

This section presents details of the coal seams and coal characteristics of the major coalfields which were summarized in the comments of section 3.1.1 on reserves and output of the preceding section.

The values employed here are according to those indicated in Vol.s 1 to 8 of INDIAN COALS.

This analytical data is for test samples which were obtained through boring, and it was not possible to secure data for large quantities of coal. The arithmetic mean values for analytical aspects of the samples taken from individual seams have been calculated. Figures should therefore be taken as no more than guidelines to the representative average properties of coal of individual seams.

(1) Jharia Coalfield

From the bottom formation up this coalfield has the following coal bearing formations of a Gondwana type; Karharbari, Barakar and Raniganj. The Barakar and Raniganj seams of this coalfield both have strata of minable value.

1) Raniganj Formations

In Raniganj formations of the coalfield, the occurrence of 15 coal horizons is established by the GSI. These horizons are numberred from XII C to '0' in the descending succession. Of these, the horizons XI, V, III, II and '0' bearing the local names as Lohapti, Bhurungiya, and Mahuda Top, Middle and Bottom seams respectively are important in terms of thickness, quality and regional persistence.

These coals all show a caking index (CI) over 20 and E to G7 (GKLT) coke type, the volatile matter on a dry mineral matter-free basis (dmf VM) is 35 to 39% so that this coal is classified among Indian coking coals as a high volatile, medium coking coal or blendable coal. The ash content of the Mahuda top and Mahuda bottom seams is comparatively low being just above 20%.

2) Barakar Formation

The Barakar formations comprise over 25 important coal horizons which occur in wide regional persistence all over. These horizons are numbered from XVIII A to I in the descending order; the horizons bearing the numbers XVIII A, XVI A, XIV A, etc. overlie the seams XVIII, XVI, XIV, etc. Splitting of the horizons into top and bottom parts is fairly common occurrence in certain areas, and where the parting thickness is high, the splits are treated as individual seams. On the other hand, over fairly large tracts two to three consecutive seams have merged into thick horizons as well which are numbered as for example, seams XI/XII/XIII, V/VI/VII, etc. In addition to these horizons certain local seams of importance are also known. In the coal seams of the Barakars, differences in the extent of regional metamorphism are clearly discernible. In the western zone, the seams IX and above have retained prime coking characteristics while the underlying horizons exhibit a more or less progressive devolatalisation, accompanied by decrease of coking propensities. As against this, in the eastern zone, where the counterparts of the different horizons register relatively higher volatiles, the prime coking character extends down to V/VI/VII seam.

In the central zone under Barren cover, not infrequently, even the younger horizons record comparatively lower volatiles.

In general, the Barakar horizons up to seam IX from top downwards are less interbanded by dirts and inter-sectional partings and, usually the ex-dirt coals analyse less than 24 % ash. On the contrary, with the exception of the basal horizon, the lower horizons are commonly interbanded with dirts and moreover, the coals (ex-dirt) show higher ash figures. The intrinsic feature of overmaturity of coals in the lower seams due to regional metamorphism in conjunction with the inferior coal qualities and extraneous heating effects owing to the proximity of igneous intrusives has, in several instances, resulted in shifting these otherwise prime coking types and as well to what have been termed as the non-coking types.

(2) Raniganj Coalfield

Seams of minable value exist in both the Raniganj and Barakar formations. Raniganj formations occur in many coalfields but the only other coalfields where economic deposits occur besides the Raniganj coalfield are the Jharia and Singrauli coalfields. In these latter two coalfields the development of the strata where the Raniganj formations occur is limited.

1) Raniganj Formation

Coals of Raniganj formation occur in as many as 10 regular horizons designated as Seams R-X to R-I in order of descent, besides a few local ones. The coal horizons are, however, more popularly known by their local names which change from area to area.

All the 10 coal horizons as also some of the local ones hold economic deposits and are being worked in different parts of the field.

The rank of coal generally increases from east to west. The major bulk of coal is low in rank and non-coking in nature. It is only in the western sector of the field, the coals develop coking propensities, and are weakly coking to semi-coking in nature. Some of the lower horizons in the dipside of the western sector, as observed in deep drilling, have attained medium coking nature.

Coal of comparatively low ash content is found in the two seams of R-IV and R-II and the respective arithmetic mean values for this parameter are 17% and 16% but there are supposed considerable deposits with values in a range between 10% and 15%.

Further values for the air dry base moisture (adb M) and volatile matter (VM) on a dry mineral matter-free basis, carbon percentage (C), hydrogen - carbon ratio (H/C) and fuel ratio (FR) are as indicated below:

	adb M	adb Ash	dmf VM	dmf C%	H/C	FR
R-IV	5.6	17.2	40.7	82.4	0.79	1.38
R-II	3.7	15.6	40.0	83.8	0.78	1.42

2) Barakar Formation

In the Barakar strata there occur 7 regular coal horizons having regional extent and are designated as Seam B-VII to B-I in order of descent. Besides, a few other seams of local importance have also been encountered. Like those of Raniganj measures, the coal horizons of Barakar formation are more popular by their local names.

All the regular coal horizons including some of the local ones are being worked in different parts of the field.

While bulk of the coals are medium coking in nature, inferior coal qualities and extraneous heating effects due to proximity of igneous intrusives have resulted in lower coking propensities in many instances. Broadly the upper seams viz. Seam B-V and above are classed as medium coking for the purpose of metallurgical coke making. In the north-eastern part, in Kasta-Kankartala sector, however, the coals gradually become semi-coking to feebly coking in nature from west to east, and in the extreme east, become completely non-coking, as observed in drilling in Madhaiganj area. Below the Ironstone shales the Barakar Measure seams, proved so far, are medium coking to almost prime coking in nature.

The arithmetic mean values for the comparatively low ash content seams of B-VII, B-VI, B-V and B-I are 16.4%, 18.2%, 19.3% and 17.9% respectively.

(3) Bokaro Coalfield

In the Raniganj formation, occurrence of a few coal seams has been proved by drilling, but no correlation of seams is available and the seam thickness varies between 1 and 2 metres.

The Barakar formation comprise the chief coal bearing strata containing a number of coal seams, some of which are remarkably thick (10-40 m) and hold substantial reserves of good to medium quality coals. Some of the thick seams are interbanded and quality of them are deteriorated. However, there are small numbers of persistent strata of good but thin coal deposits in both the east and west sections of the coalfield.

Although there is a geological continuity between the two coalfields the coal stratification differs and so a correlation was not possible. The two coalfields have therefore been treated separately in the following:

1) East Bokaro Coalfield

In the East Bokaro coalfield, occurrence of about 27 regionally persistent coal seams has been established. The Barakars with a thickness of up to 750 metres contain about 23 coal horizons and the underlying Karharbaris with a thickness varying from 30 to 60 metres contain 4 basal coal seams.

Compared to the western side, the erosion is pronounced increasingly easterwards and as a result, in the south-east dip side, a number of upper seams have not been encountered.

In general, the coals of different horizons in the eastern part of the coalfield are more matured in comparison to their otherwise normal counterparts in the west. However, the trough zone that resulted owing to the more or less parallel traversing Govindpur-Pichri and Borea faults is a special feature in East Bokaro field. A consequence of this effect is that in the central part, viz. Govindpur-Asnapani-Jarangdih region, the coals have attained greater maturity in comparison to the same horizons outside the trough. The rank enhancement is more marked in a part of the Aspani area where the Barakars have been overlain by nearly the entire Barren measure thickness due to the maximum throw of the faults in this area.

Occurrence of Jarangdih group of seams at great depths in Phusro area is also due to similar situation, but the proximity of the southern boundary fault has limited the extent of the coalfield in this area. To a smaller extent a similar trough-fault leading to enhancement of rank has been observed in Sawang area as well.

The coal seams are called by distinct names and comprise more or less distinct groups, viz. Jarangdih, Sawang, Kathara-Uchitdih, Kargali, Bermo, and Karo groups of seams in descending succession.

Of these, the Kargali Top and Bottom seam or the Kargali composite horizon is the most important from the point of view of thickness, regional continuity, quarriability and quality, and are extensive exploitation in the entire tract.

The underlying Bermo seam, though relatively high in ash content and somewhat interbanded in nature, exhibit better coking propensities than other coal seams of this field and would perhaps prove industrially important on this count.

The basal four coal horizons of Karo group, viz. Karo IV - Karo I seams, pertain to the Karharbari formations. Of these, the Karo III seam, though thin, has low ash content and fairly wide persistence, particularly in the eastern parts of the field.

The coal seams occurring in Koiyotanr - Gumia area in the extreme western part of the field have a similarity of sequence with those in the West Bokaro coalfield.

The coals of the upper horizon up to Kargali seam and those of Karo III seam are normally fair to medium in quality. The Bermo seam coals, in general, are medium in quality while the rest of the lower seams are mostly inferior. The coals are medium to high in rank and medium coking in nature. In general, coals of the upper horizons up to Bermo seam, and also of Karo III seam, may find use, after suitable beneficiation, in blends for metallurgical coke making.

The inferior quality coals of the lower horizons would normally find use as fuel for power generation, soft coke manufacture, and in general industries.

2) West Bokaro Coalfield

In this field, the existence of about 25 coal seams has been established. Of these, the Barakars with a thickness of 300-550 metres contain about 23 coal horizons, whereas the underlying Karharbaris, in strata 15-30 metres, contain as few as one or two coal horizons.

Coal seams of Barakar formations are numbered as Seams XIII to I in order of descent, of which some comprise group of seams designated as Seams IXD, IXC, etc. in descending succession. Of these, Seam V is by far the most important because of its persistently high thickness and great regional extent.

The coal seams of Karharbari formation are designated as Special 'B', Special 'A' (in Taping), and Special (in Kedla) seams.

The quality of coal from individual seams varies significantly from area to area. In general, the coal horizons above Seam V are less interbanded and the coals are fair to medium in quality. Seams V to I, though thick, are mostly interbanded and contain coals of medium to inferior quality. The coal seams of Karharbari formation normally have fair quality coals, except for the Special 'B' seam which contains medium quality coals.

The coals in this field are medium to high rank and semi-coking to medium coking in nature. In general, a west to east rank enhancement is noticeable in the field, in the south-western part of the field, the coals exhibit an overall maturity in comparison to that in the north-western part. The coals from Taping, Ghato, Kedla, Loiyo, and Choritanr areas are medium to strongly coking. In general, the coals of the upper horizon up to Seam V and the Special 'A' and Special seams may find their use as semi-coking and medium coking coals in coking blends for metallurgical coke making after suitable beneficiation. The inferior quality coals from other seams may be used for power generation, soft coke manufacture, and in general industries.

(4) Karanpura Coalfield

1) North Karanpura Coalfield

Drillings have indicated the existence of coal horizons in all the three coal measures. In the Raniganj Measures, the existence of four to six coal seams has been established, which are yet to be correlated. In the Barakar Measures, seven regular seams, numbered as Seam VII to I in order of descent, have been identified along with a few local ones, while in the Karharbaris two regular seams, viz. 2K and 1K in order of descent, along with two local ones are already proved.

The coal seams of the Raniganj Measures are thin (1-2 metres) and have inferior quality coal.

The seams of the Barakar Measures show wide lateral variation in thickness and are, in general, highly interbanded in nature. The coals are consistently inferior quality, except for those from Seam IV which are medium to inferior. Among the Karharbari horizons, coals from Seam 1K are cleaner with occurrences of minor dirt bands in its section and the coals therefrom are normally fair in quality. The other Karharbari seams are somewhat interbanded and the coals from these seams are mostly medium to inferior in quality.

As regards the rank of coal, it is seen that the coals of the Raniganj Measures seams are low rank, high volatile and non-coking type. The coals from the Barakar and Karharbari seams in the eastern part of the coalfield, comprising Chano-Rikba-Ronhe-Ranthpara sector, are generally medium to high rank, high to medium volatile and semi-caking to medium coking in nature. From here and onwards in anti-clockwise direction through Badam-Pakri Barwadih to Bundu, it is seen that the rank of the coals gradually deteriorates. Whereas the coals of Badam area are medium rank, high volatile semi to weakly caking in nature, those of Pakri Barwadih become feebly caking to non-caking, and in the rest of the field, they are low rank, high volatile non-caking type.

The high ash inferior quality coals of this field would be suitable mainly for thermal power generation, while the low ash non-coking (Karharbari seam) coals may find their use in locomotives, gasification and general industries. The high ash semi-coking to medium coking coals would be suitable for production of domestic coke. Besides, the medium to high rank medium coking coals of this field may also find their use in coking blends for metallurgical coke making provided they could be suitably beneficiated. The cleaning possibilities of these coals are, however, not very encouraging.

2) South Karanpura Coalfield

The South Karanpura coalfield has the distinction of possessing the maximum number of coal seams among the coalfields in India. Occurrences of any coal seam in the Raniganj Measures has not been reported. The Barakar Measures alone contain as many as 40 regular coal horizons, besides 10 to 12 local ones. In addition, the Karharbari possesses three regular and two local seams. The Barakar Measures seams are named Saunda to Argada R in order of descent, of which the Sirka and Argada seams are by far the most important in view of their thickness, extension, and quality.

The following shows the arithmetic mean values for these seams.

	adb M	adb Ash	dmf VM	dmf C%	H/C	FR
Sirka	4.1	16.9	37.9	83.0	0.73	1.49
Argada	3.5	18.7	39.7	82.9	0.76	1.42

In the eastern part of the coalfield, mainly Argada area, the Argada L,M,N and O seams merge together to form a composite thick coal horizon, i.e. the Naditoli seam, attaining a maximum thickness up to 79 metres.

The three regular Karharbari coal horizons are named Argada S, Argada T, and Below Argada T in order of descent and are developed in Argada area only.

In fact, the seams of the lower sequence below Argada K have developed only in the eastern sector of the field.

The coals from the upper seams above Sirka are low rank, high volatile non-coking types, whereas those from Sirka and below are low to medium rank, high volatile non-caking to feebly caking in nature. While in a normal process the rank of coals increases from upper to lower horizons, a subtle increase in rank is also discernible from the west to east direction of the field.

The high ash inferior quality coals of this coalfield would mainly be suitable as a fuel for thermal power generation. Some of these coals from the lower seams may also find their use in the production of domestic coke.

While the fair to medium quality coals would be quite useful for the locomotives, general industries, total gasification and other industrial purposes, the feebly caking coals from Sirka, Sirka A, Argada, Argada S and Argada T seams would also be eminently suitable for low temperature carbonization industries. Some of these coals may also have restricted use as blends in metallurgical coke making.

(5) Korba Coalfield

22 Seams have been identified in this coalfield. These are divided into an upper and lower group but all were seen as belonging to the Barakar formation though after the GSI it was held that those of the lower group in fact belong to the Karharbari formation.

In the upper group thick strata such as the Upper Jatraj/Upper Kusmunda seam and Jatraj/Lower Kusmunda seam are found but interbanding is frequent and quality poor. Conversely, the individual seams G III, G II and G I found in the lower group are of relatively good quality and the following shows the arithmetic mean values for these seams.

	adb M	adb Ash	dmf VM	dmf C%	H/C	FR
G III	6.4	15.7	31.6	83.9	0.65	2.04
G II	5.4	14.4	28.9	84.3	0.62	2.32
G I	4.6	16.2	33.0	84.7	0.67	1.91

The low quality coal mined in the upper sections is used for power generation while the relatively good quality coal mined from the lower section is used for general industrial use.

(6) Talcher Coalfield

Drilling has indicated the existence of some 20 coal horizons in this field, out of which 6 horizons pertain to Raniganj, 11 to Barakars and 2 to Karharbaris.

The field thus presents a unique example of possessing workable coal horizons in all the three measures. IBM has correlated the regular horizons numbered as Seams IV to I in order of descent. Of these, Seam I is considered by GSI as part of the Karharbari stage which was originally regarded as a part of Lower Barakars. GSI has correlated 9 regular coal horizons in Barakars (so long regarded as Upper Barakars), numbered as Seam 9 to 1 in order of descent. Seams 5 to 1 are equivalent to Seams IV to II of IBM.

The eastern part of the coalfield has been under exploitation since long. Detailed drilling has resulted in opening up of some new mines in this area.

At present 3 coal horizons viz. Seams I, II and III are being worked. Only Seam I is comparatively clean and possesses coals of fair to medium quality.

The following shows the arithmetic mean values for these seams.

	adb M	adb Ash	dmf VM	dmf C%	H/C	FR
I	7.7	16.2	40.5	80.1	0.76	1.39
I Bottom	7.5	11.5	43.8	81.9	0.82	1.24

The other seams are highly interbanded and coals are consistently inferior in quality. The coals are high volatile, low rank and non-coking type. The coals of upper seams would be mainly suitable for power generation and those of Seam I may be suitable for gasification and other industries. The bottom section of this seam has inherently low ash and high hydrogen content and would therefore be suitable for specific industries.

(7) Ib-Valley Coalfield

The consistent occurrence of 4 coal horizons has been identified within the Barakar strata. These are Parkani, Lajkura, Rampur and Ib seams, starting from the top. The coal seams are, in general, highly interbanded except for the bottom one i.e. Ib seam. Coals are generally medium to inferior in quality, and are low rank and non-coking in nature.

(8) Singrauli Coalfield

The country's thickest coal horizon, the Jhingurdah Top seam (135 metres maximum) is encountered in Raniganj formation; below this the Jhingurdah Bottom seam occurs.

In areas other than Jhingurdah, the Barakars extend all over, wherein the thick coal horizons (usually 15-25metres), known as Purewa seam (Top, Bottom and Merged) and the underlying Turra seam, are encountered. Also, three other seams known as Panipahari (4-6 metres) and Khadia (1.0-2.5 metres) above Purewa seam and Kota (1-2 metres) below Turra seam occur with limited regional persistence. GSI have indicated that the basal seam (Kota) belongs to the Karharbari stage.

The coals of the Jhingurdah seams are of inferior quality as also those from the Barakar horizons, in general. Normally, the Singrauli coals are of high moisture, high volatile, low rank and non-coking type suitable for power generation.

(9) Chanda-Wardha Coalfield

Only one coal horizon, in two or three sections, occurs throughout the coalfield which is known as Thick Seam or Major Seam. Different sections of this seam, which are sometimes called by some local names, are worked in a numbered collieries.

In the extreme south, in Wirur-Chincholi area, there occur 4 regular coal horizons, as revealed in drilling. The seams numbered 1 to 4 in order of descent. Of these, Seam 3 is thick which generally ranges between 6 and 9 metres and occurs in three sections. The other seams are thin, normally varying between 1 and 2 metres in thickness. The correlation of Seam 3 with 'Thick Seam' occurring in major part of the field, is not yet certain.

The coals of Thick Seam are generally medium in quality with the tendency of becoming inferior at places. The coals from the upper three seams, i.e. Seams 1 to 3 in Wirur-Chincholi area are mostly inferior in quality, those from Seam 3 being a shade better. In contrast to this the coal of seam 4 is of good quality and the following indicates the arithmetic mean values for the data on the characteristics of coal of this seam.

	adb M	adb Ash	dmf VM	dmf C%	H/C	FR
Seam 4	8.2	11.4	42.5	77.6	0.80	1.31

The Wadhra coals are in general of a non-coking coal variety and contain a relatively high sulphur content. The main application is for power generation.

(10) Godavari Valley Coalfield

There are two seams in the south part of this coalfield named Queen and King for the upper and lower seams respectively. In the north part of the coalfield there are four seams numbered 1 to 4. The following indicates the arithmetic mean values of data concerning the characteristics of coal in the seams where coal of relatively low ash content is found.

	adb M	adb Ash	dmf VM	dmf C%	H/C	FR
King	7.2	17.1	34.4	82.6	0.63	1.79
Seam 4	6.7	19.4	36.6	81.6	0.71	1.60

These of relatively good quality are used for railways and general industry, other coals are used for power generation.

(11) Makum Coalfield

There are 5 regular coal horizons in this field, known as 8-foot Seam, 20-foot Seam, 60-foot Seam, etc. They vary in thickness from 1 to 20 metres, and at places, even more.

The coal seams are mostly free from dirt bands and contain good quality coals with low ash, normally ranging between 3 and 7%. The coals are highly caking with Caking Index mostly between 17 and 30, GKLT coke type E-G3, and Swelling Index 3-5. One of the drawbacks of these coals is that they have high total sulphur (mostly 2-6%).

60-foot Seam is the thickest and most important seam of this field, and serves as a datum for correlation of the other seams. This seam is split into Top and Bottom and sometimes even greater number of sections. Arithmetic mean values for the characteristics of coal of representative seams of coalfields formed in the Tertiary period located in the north eastern states bordering this coalfield are shown below:

	adb M	adb Ash	dmf VM	dmf C%	H/C	FR
Makum						
60 foot	2.4	10.1	45.7	80.5	0.86	1.16
60 foot Bottom	2.0	5.7	45.0	81.6	0.87	1.20
20 foot	2.2	9.5	45.8	79.3	0.86	1.16
West Daranggiri						
Main Seam	8.2	6.5	47.4	75.5	0.87	1.09
Jaipur						
No.1	5.1	6.0	47.2	76.9	0.90	1.10

The air dry basis sulphur content is high in each case ranging from 2.5 to 3.5%.

In some cases the ash content is quite high and this results in raising the average and the values of a large amount of deposits ranges between 2 and 5%. Since it is relatively easy to separate extraneous rock, etc. mixed in during quarrying and mining it is considered possible to obtain clean coal of low ash content.

(12) Neyveli Coalfield

Drilling has proved the existence of only one lignite seam in the area, having a gentle east-south easterly dip. The seam thins down along the north and north-western margins and has a varying thickness, generally between 3 and 16 metres in different parts of field.

The lignite is generally compact, deep brown or black in colour and is devoid of any dirt bands. It has a low calorific value of 2,000-3,000 kcal/kg with moisture 50 to 60% and is very low in ash (5-7% on dry basis), also low in sulphur, mostly below 1%.

The lignite is being used mainly in power generation.

3.1.3 Demand and Supply for Coal

(1) Demand and Supply Patterns up to the Sixth Five Year Plan

Five year plans have been implemented in India since 1951-52. In that year the annual production of coal was 34.4 million tons. Nationalization of the coal mining industry proceeded after this and by 1971-72 in the Fourth Five Year Plan production had been increased to 72.72 million tons. The increase in production became marked after nationalization and in 1980-81 which was the first year of the Sixth Five Year Plan production had reached 114.01 million tons effecting a similar increase to that achieved between

1951-52 and 1971-72 in half the time. By the end year of the Sixth Five Year Plan production had reached 147.41 million tons.

Consumption by industrial sector over this period is shown below:

(Unit : million tons)

Year	Iron and Steel	Electric Power	Rail-Ways	Cement	Others	Total
1953-54	3.9	5.1	13.0	1.1	17.6	40.7
1960-61	9.1	9.1	15.5	2.3	17.2	53.2
1970-71	13.5	13.5	15.6	3.5	25.9	71.7
1980-81	21.0	38.2	11.8	4.7	33.8	109.5
1984-85	23.75	64.35	9.53	7.11	38.32	143.06

Sources: 'Coal Mining in India', 1984, CMPDIL.
'Report 1985-86', Dept. of Coal

The consumption of the railway sector declined after the 1970s as electrification and the switch to diesel proceeded in Indian rail. Apart from this sector, other sectors show a continuing increase which is very rapid in some cases as with the consumption of the electrical power industry.

(2) Demand and Supply in the Seventh Five Year Plan

1) Consumption by Industrial Sector

The Seventh Five Year Plan of India began in 1985-86 and finished in 1989-90. The attached Table 3.1.4 indicates the coal consumption recorded over this period by industrial sector. The total consumption was 157.35 million tons in the first year of the plan while this reached 197.46 million tons in the final year, so that an increase of 40.11 million tons or over a 25% increase was attained.

At present in India the core sectors in this respect are the power, steel, loco (rail), cement and fertilizer sectors. For other consumers than the above mentioned transport is not normally effected in cases of a distance superior to 20 km. The increased consumption of the core sectors over the above period was 34.65 million tons accounting for the major part of increased consumption and the electric power sector showed a particularly sharp rise from 77.33 million tons to 115.12 million tons so that its share of the total was 58.3% in 1989-90.

The attached Table 3.1.5 shows the records for energy generated, pattern of electricity consumption and installed plant capacity over the Seventh Five Year Plan. Increases have occurred for each type of electric generation, plant capacity and energy generated but the increase has been especially marked in the case of the thermal sector. The thermal sector accounted for 43.1 billion kWh which represents 85% of the total increase of 50.7 billion kWh for power generation achieved between 1985-86 and 1988-89. The share of the thermal sector in total public power generation rose from 67% to 71% over the same period.

Table 3.1.6 indicates the quality grade specifications for coal used in thermal power plants showing that coal of Grade C or below is used. Indian coal often contains a large amount of mineral content such as abrasive silica so that the life use of mill facilities at power stations suffers a reduction. In order to tackle this problem it is planned to proceed with construction of washery together with the building of a Coal Handling Plant, though at present no washery for non-coking coal is in operation.

Demand from the steel sector has remained nearly level while the demand for imported coal has nearly doubled over the period (figures in the above Table 3.1.4 do not include imported coal statistics). The importance of imported coal has grown in order to assure that the necessary quantity and quality of coal for metallurgical coke is obtained.

(Unit: million tons)

Year	1985 -86	1986 -87	1987 -88	1988 -89	1989 -90
Imported Coal for Steel	2.40	2.56	3.47	4.20	4.45

Sources: For 1985-86 Explanatory Data from Indian Party to JICA Preliminary Mission.

For 1986-87 to 1988-89, 'Economic Survey 1989-90', Ministry of Finance

For 1989-90, 'Eighth Five Year Plan 1990-95 and Annual Plan 1991-92', Department of Coal

Demand from the railway (loco) sector has conversely continued to decrease in line with the ongoing electrification and switch to diesel of lines.

Demand of other sectors than that of the core sectors increased from 34.52 million tons to 39.98 million tons but this represented a decrease in overall share from 21.9% to 20.2%.