# PRE-FEASIBILITY STUDY
# ON
# THE SOLVENT REFINED COAL
# DEVELOPMENT PROJECT
# IN
# INDIA

MARCH 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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# Preface

In response to a request from the Government of India, the Government of Japan decided to conduct a pre-feasibility study on the Solvent Refined Coal Development Project in India and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to India a study team headed by Mr. Yoshiyasu Mikami of Unico International Corporation, three times between September 1990 and January 1992.

The team held discussions with the officials concerned of the Government of India, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

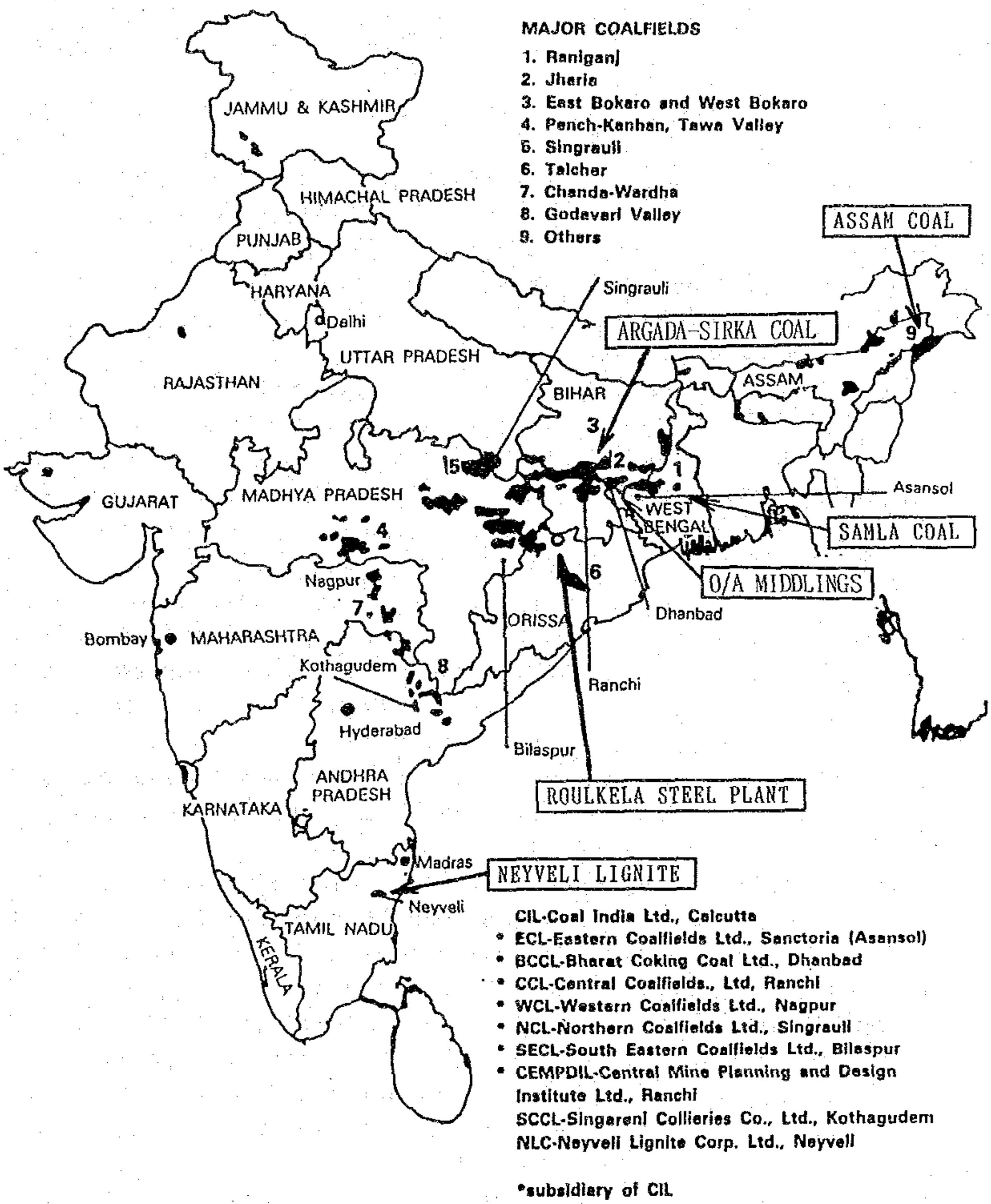
I wish to express my sincere appreciation to the officials concerned of the Government of India for their close cooperation extended to the team.

March 1992

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

PROJECT SITES AND MAJOR COALFIELDS OF INDIA




Ref: Report 1988-89, Government of India Ministry of Energy, Department of Coal

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## ABBREVIATION

| | |
|---|---|
| AC | alternating current |
| ACGIH | American Conference of Governmental Hygienists |
| AM | adherent moisture |
| ASTM | American Society for Testing and Materials |
| BCCL | Bharat Coking Coal Ltd. |
| BF | blast furnace |
| BOD5 | biological oxygen demand |
| BP | by-products |
| C | carbon |
| $C_5$ | pentanes |
| cal | calorie |
| CARD | Centre for Applied Research and Development |
| CCL | Central Coalfields Ltd. |
| CCSO | Central Coal Supply Organization |
| CFRI | Central Fuel Research Institute |
| CHP | coal handling plant |
| CIF | cost insurance and freight |
| CIL | Coal India Ltd. |
| CMPDIL | Central Mine Planning and Design Institute Ltd. |
| CNG | compressed natural gas |
| COD | chemical oxygen demand |
| COG | coke oven gas |
| cP | centipoise |
| CRI | Coke Reactivity Index |
| CSN | Crucible Swelling Number |
| CSR | Coke Strength after Reaction with Carbon dioxide |
| CWBD | cooling water blow down |
| d | day |
| d | dry |
| D&I | depreciation and interest |
| d.a.f. | dry ash free basis |
| dB | decibel |
| DC | direct current |
| $DI_{15}^{150}$ | Drum Index, 150 revolutions 15 mm index |
| dmf | dry |
| DOC | Department of Coal |
| DOE | Department of Environment |

| | |
|---|---|
| DOEA | Department of Economic Affairs |
| DOM | Department of Mines |
| DOS | Department of Steel |
| ECL | Eastern Coalfields Ltd. |
| EEC | East European Community |
| EIRR | economic internal rate of return |
| Ex Band | excluding band |
| F/FO | first in first out |
| F/S | feasibility study |
| fa | ratio of aromatic carbon to total carbon |
| FC | fixed carbon |
| FIRR | financial internal rate of return |
| FOB | free on board |
| FR | fuel ratio |
| FSI | Free Swelling Index |
| g | gram |
| $g/Nm^3$ | gram per normal cubic meter |
| GKLT | gray king low temperature carbonisation |
| GM | gross moisture |
| GPM | gallon per minute |
| GSI | Geological Survey of India |
| H | hydrogen |
| h | hour |
| H/C | hydrogen/carbon ratio |
| $H_2S$ | hydrogen sulfide |
| HGI | Hardgrove Grindability Index |
| HI | hexan insoluble material |
| HSCL | Hindustan Steelworks Construction Ltd. |
| HVC | high volatile coal |
| Hz | hertz |
| IBM | Indian Bureau of Mines |
| IBP | initial boiling point |
| IDC | interest during construction |
| IISCO | Indian Iron and Steel Company Ltd. |
| ILO | International Labor Organization |
| IM | inherent moisture |
| In Band | including band |
| IOM | insoluble organic matters |
| IPSS | Interplant Standards on Pollution Control of SAIL |
| IR | infra red spectroscopic analysis |

| | |
|---|---|
| ISO | International Organization for Standardization |
| JICA | Japan International Cooperation Agency |
| JIS | Japanese Industrial Standard |
| kcal | kilocalorie |
| kcal/h | kilocalorie per hour |
| kcal/kg | kilocalorie per kilogram |
| kg | kilogram |
| $Kg/cm^3G$ | kilogram per square centimeter gauge |
| kg/h | kilogram per hour |
| kl | kiloliter |
| km | kilometer |
| kV | kilovolt |
| kVA | kilovolt ampere |
| kW | kilowatt |
| l | litter |
| LVMCC | low volatile medium coking coal |
| M | thousand |
| m | month |
| m | meter |
| m/s | meter per second |
| M10 | Micum 10 mm Index |
| $m^2$ | square meter |
| $m^3$ | cubic meter |
| $m^3/h$ | cubic meter per hour |
| $M_{40}$ | Micum 40 mm Index |
| max | maximum |
| MCC | medium coking coal |
| MEC | Mineral Exploration Co.,Ltd. |
| MECON | Metallogical and Engineering Consultants Ltd. |
| mg/l | milligram per litter |
| $mg/Nm^3$ | milligram per normal cubic meter |
| MGR | Merry-Go-Round |
| min | minimum |
| min | minute |
| MINAS | Minimum National Standards |
| ml | milliliter |
| MM | million |
| mmHg | millimeter mercury column |
| MMkcal | million kilocalorie |
| MMkcal/h | million kilocalorie per hour |

| | |
|---|---|
| mmWC | millimeter water column |
| MOE | Ministry of Energy |
| MOF | Ministry of Finance |
| MOU | Memoranda of Understandings |
| MRTR | Monopoly and Restriction Acts |
| MSI | Micro Strength Index |
| MSL | mean sea level |
| MW | megawatt |
| N | nitrogen |
| $N_2$ | nitrogen molecule |
| NCC | non-coking coal |
| NCEPC | National Committee on Environmental Planning and Coordination |
| NCL | Northern Coalfields Ltd. |
| NH3 | ammonia |
| NIEs | Newly Industrialized Economics |
| NLC | Neyveli Lignite Co.,Ltd. |
| $Nm^3$ | normal cubic meter |
| $Nm^3/h$ | normal cubic meter per hour |
| $Nm^3/t$ | normal cubic meter per metric ton |
| NMR | nuclear magnetic resonance |
| NOx | nitrogen oxides |
| O | oxygen |
| OA | oil agglomerated |
| OC | open cast mining |
| OMS | output per Manshift |
| OVHD | over head |
| PCC | prime coking coal |
| ppm | part per million |
| PSA | pressure swing adsorption |
| QI | quinoline insoluble material |
| QS | quinoline soluble material |
| R&D | research and development |
| RBI | Reserve Bank of India |
| RDCIS | Research and Development Centre for Iron and Steel |
| RH | relative humidity |
| Ro | Mean Maximum Reflectance in Oil |
| ROI | return on investment |
| ROM | run of mine coal |
| Rs | Indian Rupees |

| | |
|---|---|
| RSP | Rourkela Steel Plant |
| S | sulphur |
| s | second |
| S.P.M. | suspended particulate matter |
| S.S. | suspended solid |
| SAIL | Steel Authority of India Ltd. |
| SCCL | Singaleni Coalfields Co.,Ltd. |
| SCF | standard conversion factor |
| SCO | Simulated Coke Oven |
| SECL | South Eastern Coalfields Ltd. |
| SG | steel grade |
| Sp.Gr. | specific gravity |
| SRC | Solvent Refined Coal |
| SW | scope of work |
| t | metric ton |
| t/d | metric ton per day |
| t/h | metric ton per hour |
| t/y | metric ton per year |
| THF | tetra-hydrofuran |
| TI | total inert |
| TISCO | Tata Iron and Steel Co.,Ltd. |
| TLV | Threshold Limited Value |
| TM | total moisture |
| TS | total sulphur |
| TWA | Time Weighted Average Concentration |
| UC | underground mining |
| UHV | useful heat value |
| US$ | US Dollar |
| V | volt |
| V | volume |
| VISL | Visvesvaraya Iron and Steel Ltd. |
| VM | volatile matter |
| vol% | volume percent |
| WCL | Western Coalfields Ltd. |
| WG | washery grade |
| wt% | weight percent |
| y | year |
| Yen | Japanese Yen |
| °C | degree centigrade |
| $\mu g/Nm^3$ | microgram per normal cubic meter |

# Chapter 1 BACKGROUND STUDY

# Chapter 1 BACKGROUND STUDY

## 1.1 Social and Economic Situation in India

### 1.1.1 Social Situation in India

India gained independence in 1947, embracing 3,288,000 square kilometers with a total population of 844 million which is expected to reach thousand million by 2000 AD.

India is a multi ethnic, linguistic and religious country. Besides Hinduism and Islam, the other religions include Christianity, Sikhism, Budhism, Jainism and Zoroastrianism.
The caste system which is an exclusive feature of Indian society is gradually weakening with gradual modernization of the country.

Administratively, India is divided into 25 states and 7 centrally administered territories.
India being a subcontinent, there exists a great deal of variations in terms of climate, geography, agricultural and industrial products. On the past, however, despite such variations and issues, the Indian social system is stable. India, since its independence, has maintained a parliamentary form of government based on a universal adult enfranchisement.
India is one of the few developing countries which has maintained a democratic government.

As the term Indian mixed economy implies India possesses a number of huge public industries under powerful governmental control (the element of public control in the coal and steel industries concerned herein is extremely great) and the government has pursued policies protecting domestic industry including the private sector in order to further import substitution.

India had been practicising protectionist policies so far. However, since May 1991 a great deal of liberization of economic policies has been announced by the central government and industry has welcomed it.

### 1.1.2 Outline of Indian Economy

Annex 1.1.1 outlines the main features of the Indian economy.

(1) Population

The birthrate (per thousand of population) was 39.9 in 1950-51 and increased to 41.7 in 1960-61 but after dropped again to 36.9 in 1970-71, to 33.9 in 1980-81 and to 31.3 in 1988-89. However the death rate also dropped from 27.4 (per thousand of population) in 1950-51, 22.8 in 1960-61, 14.9 in 1970-71, 12.5 in 1980-81 and to 10.9 in 1988-89. The average life span for females was 31.66 years in 1950-51 and had become lengthened to 59.1 years in 1987-88. The total population also increased from 361.1 million in 1960-61, up to 442.4 million in 1960-61, to 551.3 million in 1970-71, to 675.2 million in 1980-81 and reached 827.1 million in 1990-91. The average annual increase in population over the years 1980-87 of 2.2% was low when compared to averages of Pakistan and Bangladesh but at this level of population increase by the year 2000 population will reach 1 billion. The structural shift towards an aging population also represents a serious employment problem.

(2) Economic Development (Annex 1.1.1)

The GNP for 1989-90 was 392,524 Rs. crores, and since the exchange rate of the Rupee against the US dollar was Rs.16.65 per US dollar for the same period and population totaled 811.0 million the per capita GNP was US$290.

As can be seen from Annex 1.1.3 there have been large fluctuations in the growth rate of the GDP. The highest growth rate was 10.4%, achieved in 1988-89 (on basis of 1980-81 prices) while the lowest rate was -5.2% for 1979-80. The variations in the growth of the agricultural industry are mainly responsible for these fluctuations, as can be seen from Annex 1.1.3. While the growth in the agricultural sector in 1988-89 was 16.9% in 1988-89 a minus growth of -12.3% was registered for 1979-80. From 1980-81 to 1988-89 the average annual growth was 5.5%. This is low when compared to East Asia but represents a high level among the low income countries.

(3) Industrial Structure

The share of total GDP accounted for by agriculture was 56.5% in 1950-51 which decreased to 39.6% in 1980-81 and further decreased to 34.8% in 1988-89 (refer to Annex 1.1.4). On the other hand, the share of industry increased from 15% in 1950-51 to 24.1% in 1980-81 and 26.9% in 1988-89. The share of other industries in 1988-89 shows that transport and communications accounted for 17.6%, the financial sector 9.5%, and public expenditure including military expenditure accounted for 11.2%. It is anticipated that as economic development continues the share of agriculture will continue to decrease while that of industry increases.

In terms of employment, the agricultural sector maintained the importance of its share accounting for 51.5% in 1984-85, and 50.2% in 1989-90. The population in the industrial sector rose from 14.3% to 14.9% over the same period. The annual growth rate was 3.49% for agriculture and 4.55% for industry with an overall average of 3.99% (refer to Annex 1.1.5).

(4) Capital Formation and Savings

The domestic savings rate and capital formation against the GDP in the 1980s was around the 20% level with capital formation slightly surpassing the savings rate. This is an average level in South-West Asia but is low when compared to the 30% plus of East Asia.

(5) Price Index (Annex 1.1.2)

On a 1981-82 basis the retail price index for 1980-81 was 93.1 and 182.7 for 1990-91, giving an average annual rate of increase of 7.0% in the 1980s. On a 1960 basis the consumer price index for 1980-81 was 401 and for 1990-91 947 giving an average annual increase of 9.0% in the 1980s.

(6) Foreign Exchange Rates (Annex 1.1.1)

The exchange rate against the US dollar was 7.91 Rupees in 1980-81, the average for 1990-91 was 17.94 Rupees, and at the September, 1991 it was 25.50 Rupees.

(7) International Balance of Payments (Annex 1.1.6)

Exports fell in 1985-86 but have increased since. On the other hand, imports have continued to increase since resulting in an annual deficit in the trade balance and taking 1988-89 as an example, the deficit in the trade balance registered for this year amounted to Rs. 6,308.9 crores or the equivalent of about 1.8% of GDP. The foreign currency holdings, were reducing every year from Rs.7645.2 crores in 1986-87 and for 1990-91 were Rs.4,388 crores. As shown in Annex 1.1.7 the main import items cost a total of Rs.200,957.6 million in 1986-87 of which 31.2% was for machinery, 21.7% for industrial materials (of which 7.7% was for steel materials), 15.1% for petroleum related items, 13.1% for chemical goods and 8.1% for raw materials.

## 1.2 Review of National Development Plans and Energy Policy in India

### 1.2.1 National Development Plans in India

India adopted new industrial policies in May 1991. Major points of the policies are mentioned below with historical background information. Relating to this project, investments and developments in the field of coal mining still need licenses requirement, but the iron and steel industries are exempted from this requirement. Therefore, private companies can invest in the field of iron and steel industries freely, and national steel companies will be pressed to promote modernization programmes. Further, Government abolished steel administration except certain sector including defense on 16 January, 1992. At the same time, uniform price policy was abolished. India will take more flexible policies to introduce foreign technology, while the government will take responsibility for the promotion of domestic technology which is judged to be important for the national economy and which private companies are not able to carry out.

(1) Major Highlights of the New Industrial Policy, 1991

1) Private sector to enter all industrial and manufacturing activities; industrial licensing has been done away with for all industries except a few strategically sensitive areas such as defense, atomic energy, etc., irrespective of the level of investment.

2) Compulsory licensing to continue in areas like coal, petroleum, sugar, cigarette, motor cars, hazardous chemicals, drugs and pharmaceuticals and some luxury items.

3) Reservation of items for the small scale to continue so as to promote the industrial and agro industrial employment base.

4) Public sector to retain its monopoly existence in the 8 core areas like defense, atomic energy, mineral oils, rail transport and mining.

5) Import of capital goods shall be automatically cleared where the foreign exchange requirement is ensured through foreign equity.

6) Import of capital goods w.e.f. 1.4.92 shall be automatically approved if the c.i.f. value of the import is less than 25% of the total value of the plant and machinery and subject to a maximum limit of Rs. 2 cores.

7) All existing and new industrial units to be broad-banded, so as to enable them to produce any article without requiring any additional investment in plant and machinery.

8) All substantial expansions of existing units exempted from licensing.

9) Term loans to be granted by financial institutions for new projects shall no longer be convertible into equity.

10) The limit for foreign investment in equity has been raised to 51% from the existing 40% in high priority industries. Consequential amendments to the Foreign Exchange Regulation Act, 1973, to follow.

11) Dividends to be expatriated by companies with foreign equity to be met through export earnings over a period of time.

12) Foreign equity proposals delinked from foreign technology agreements.

13) Companies with foreign equity upto 51% to act as trading houses primarily engaged in export.

14) Automatic clearance for foreign technology agreements in high priority industries upto a lump sum payment of Rs. 1 crore, 5% royalty for domestic sales and 8% for exports, subject to a total payment of 8% of sales over a 10 year period from the date of agreement or 7 years from the commencement of production.

15) Government's shareholding in the public sector units to be offered to mutual funds, financial institutions, general public and workers, in consonance with the partial disinvestment policy to be implemented in a phased manner.

16) Workers participation in management and revival of sick units, to be encouraged.

17) MRTP Act to be amended to remove the threshold assest limits in respect of prior approval of Central Government for establishment of new undertakings, expansions, mergers, amalgamations and takeovers and appointment of Directors under certain circumstance.

(2) To present the relation between Indian policies taken by the Indian Government to date and new industrial policies, chapter 2 of Industrial Policy & Procedure 1991 is described below. (This part is omitted from the English version). New industrial policies together with devaluation of the exchange rate (18 Rs./US$ in Oct. 1990 was devaluated to 25.5 Rs./US$ in Sep. 1991) will have a positive effect on exports and foreign companies investment, however, compared with ASEAN countries, new industrial policies are still

conservative and the privatalization of national companies taken by some countries is not included in new policies. Political stability and infrastructure consolidation will also be required.

### 1.2.2 Indian Energy Policies

There is a great diversity of energy sources in India ranging from cow dung fuels to nuclear energy, while various energy resources such as water power, coal, oil and natural gas are found in India's vast territories. On a domestic level there is wide use of non-commercialized fuels such as cow dung and charcoal while the main forms of commercial energy are coal, oil and electricity.

The energy consumption per capita including the non-commercial types is 260 kg when converted to oil terms, which is low when compared to China.

The output of primary energy producers in 1985 converted to oil terms was 133 million tonnes of which 56% came from coal, 22% from oil and 15% from water power. However, consumption for the same year amounted to 144 million tonnes, with the larger part of imported energy taking the form of oil. The breakdown of consumption shows that 53% was in the form of coal, 29.8% oil, and 14% water power. In January, 1987 the proved and pumpable oil reserves were accounted 581 million tonnes with 19 years of pumping but prospecting efforts have resulted in annual increases in the pumpable reserves. In January, 1987 the proved and exploitable reserves of natural gas were 541 (American) billion cubic metres converting to 480 million tonnes of oil. The crude oil output for 1986 was 30.48 million tonnes (or 630,000 barrels per day), and natural gas output was 9.84 billion cubic metres which converted to oil terms represents 8.8 million tonnes (180,000 barrels per day). A particular characteristic of the oil consumption pattern is the high share (close to 60%) accounted for by medium distillates such as kerosene or light oil. Of the 8.1 billion cubic metres of natural gas produced in 1985, 5 billion cubic metres was used in electric power generation and fertilizer production. The price of petroleum products is cheap in the case of domestic products such as kerosene, but with the exception of those for fertilizer production prices are high for industrial use.

Coal reserves in formations with a seam thickness above 50 cm and up to a depth of 1,200 metres are accounted 159.3 (American) billion tonnes with 302 minable years while the total reserves are vast being evaluated as more than 1,000 years stock. However, there are only 30 years stock of prime coking coal and there is a large ash content to Indian reserves. Imports are therefore required to adjust ash content. The coal output in 1985-86 was 154.2 million tonnes while consumption was 157 million tonnes, and imports almost all of prime coking coal.

The generating capacity for electricity in 1985 was approximately 52 million kW made up of 32 million kW from thermal generation, 16.2 million kW from hydroelectric and 13.3 million kW from nuclear power facilities.

On average an annual increase of facilities close to 10% is recorded but the increase of demand is high and there is a constant shortage of electric power and since domestic and agricultural consumption is given priority many factories suffer power shortages.

In view of the above background the Indian government has introduced a compulsory recovery system to increase oil production and the recovery rate has increased. Moreover the government plans to actively pursue prospecting to identify new oil fields while at the same time endeavouring to restrain the expansion of energy consumption. The development of substitute fuels will also be promoted. The suitable use of natural gas whether for electricity generation or for fertilizer production is also under consideration (for example introduction of LPG to automobiles, the use of CNG or methanol as car fuel, etc).

Besides the continuous punctual development of new collieries, efforts in the coal sector need to be directed to reducing coal production costs, and improving the quality of coal through measures such as installation of coal washeries. As the ash content of Indian raw material coal is high, ash content adjustments must be made using imported coal. Also India's prime coking coal reserves are small. Therefore, if India can introduce the technology for producing coke from non-coking coal of which it has plentiful reserves, then imports can be reduced and the service life of prime coking coal deposits be lengthened.

Measures to be taken with regard to electricity include the reinforcement of generating facilities improvements in the operating rates of generating facilities, the reduction of loss during transmission and the promotion of energy saving. So that supply can keep up with the rapid increases in demand.

## 1.3 Present Situation and Development Programmes of Indian Coal Industry

Before nationalisation in the early 1970s the Indian coal industry produced around 70 million tonnes annually but after the nationalisation which was effected between 1971 and 1973 production reached 100 million tonnes in 1975-76 due to efforts to increase production in order to meet domestic demand and provide an oil substitute. For several years after this production stagnated but in the 1980s with the expansion of open cast mining, production had reached 147.41 million tonnes by the final year of the sixth five year plan, 211.2 million tonnes in 1989-90 and is projected to reach 417 million tonnes in the year 2000. Annex 1.3.15 indicates production records to date and future forecasts.

Tables 1.3.1 and 1.3.2 indicate the companywise output for coal and show that Coal India Limited (CIL) produced 170.08 million tonnes in 1988-89, representing 88% of the total output of 193.87 million tonnes.

Annex 1.3.16 shows records of the evolution of opencast and underground mining output. Output by underground mining and opencast mining in 1973-74 was 51.79 million tonnes and 18.01 million tonnes respectively which increased to 63.86 million tonnes and 106.24 million tonnes in 1988-89. Whereas underground mining stayed level there was a marked and rapid increase in the output from opencast mining.

Annex 1.3.3 indicates the production by category of coal. In 1987-88 the output of coking coal was 41.08 million tonnes, and 138.67 million tonnes for non-coking coal, 11.16 million tonnes for lignite and 11.15 million tonnes of clean coal after washing. 64% of the coking coal was used as metallurgical coal.

Coal productivity as shown in Annex 1.3.4 increased at CIL from 0.87 tonnes per man shift in 1984-85 to 1.11 tonnes in 1988-89. The OMS figures for underground and opencast mining are shown in Annex 1.3.17 and illustrate the extremely high productivity of the opencast method compared to the underground system. This underlines the fact that the increased productivity for coal is due to the increase in opencast mining.

Annex 1.3.5 shows the production capacity and actual production of each company together with operating rates. Operating rates differ by year and by colliery but the average operating rate rose from 81.83% in 1985-86 to 91.81% in 1988-89.

The production capacity in 1989-90, the final year of the Seventh Five Year Plan, was 254.29 million tonnes, but whereas production was 210 million tonnes the demand was for 222 million tonnes resulting in a shortage of 12 million tonnes which is scheduled to meet with imports and freed stock. Further, as shown in Annex 1.3.6 the total demand for coal in 1989-90 by all users was 222 million tonnes of which 33 million tonnes demand was for coking coal for metallurgical use and 189 million tonnes for non-coking coal. The largest share of the non-coking coal demand was the 118 million tonnes for thermal generation fuel followed by demand from the cement sector of 11.5 million tonnes.

The main source of imports, as can be seen from Annex 1.3.7 indicating coal imports and exports, is Australia, which accounted for 95% of imports in 1985-86. Further, the amount imported has increased rapidly from the 191,781 tonnes in 1983-84 to 2,449,853 tonnes in 1985-86. Exports are small compared to imports reaching a level of 196,007 tonnes in 1985-86 with the main markets being Bangladesh and Nepal.

Indian coal production in 1988 was 188 million tonnes accounting for 8.3% of the total world production of 2,255 million tonnes and ranking fifth in importance after China, the USA, the Soviet Union and Poland. (refer to Annex 1.3.8)

### 1.3.1 Coal Price

The pit head price of coal is decided by the Central Government in accordance with the Colliery Control Order of 1945. As can be seen from Annex 1.3.18 the coal price increased rapidly from Rs.44.73 per tonne in 1974-75 to

Rs.183 per tonne in 1984-85. After this the price rose to Rs.219 per tonne in 1988-89. Calculated on a dollar base prices have remained stable since 1980-81, as is shown in the table below. Prices have not kept up with the increase in production costs and with the exception of 1980-81 costs have outstripped prices. In 1988-89 while costs were Rs.248.15 per tonne the price was Rs.219 per tonne. 44% of the Rs.248.15 costs in 1988-89 were for salaries and wages, 14% for stores, 10% for depreciation, 8% for interest, 7% for electricity, 4% for administration, 3% for transport and 10% for other costs (refer to Annex 1.3.19).

CIL Coal Price and Costs (avg. pit-head price)

| | 74-75 | 78-79 | 79-80 | 80-81 | 84-85 | 85-86 | 86-87 | 87-88 | 88-89 |
|---|---|---|---|---|---|---|---|---|---|
| Production Cost (Rs./t) | 58.82 | 95.09 | 110.04 | 123.12 | 190.63 | 213.63 | 221.54 | 236.07 | 248.15 |
| Price (Rs./t) | 44.73 | 62.23 | 101.18 | 128.02 | 183 | 210 | 210 | 219 | 219 |
| Exchange Rate ($) | - | 8.28 | 8.02 | 7.91 | 11.89 | 12.24 | 12.78 | 12.97 | 14.47 |
| Price ($/t) | - | 7.52 | 12.62 | 16.18 | 15.39 | 17.16 | 16.43 | 16.89 | 15.13 |

Further, the figure of Rs.219 has been corrected to Rs.249 since Jan. 1989.

The price of prime coking coal (ash content under 8%) imported to Japan from Australia is shown below:

| | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
|---|---|---|---|---|---|---|---|
| CIF (yen/t) | 16,863 | 15,306 | 14,934 | 14,215 | 9,791 | 7,546 | 6,524 |
| Exchange ($) | | | 238 | 238 | 169.49 | 144.93 | 128.21 |
| CIF ($) | | | 62.7 | 59.7 | 57.8 | 52.1 | 50.9 |

The customs price of crude oil in Japan during the same period dropped from US$36.03 per barrel in Jan. 1982 to US$33.94 per barrel in Jan. 1983, then to US$29.49 per barrel in Jan. 1984, US$29.10 per barrel in Jan. 1985, US$27.77 per barrel in Jan. 1986, US$14.99 per barrel in Jan. 1987, US$18.20 per barrel in Jan. 1988 and US$13.28 per barrel in Jan. 1989.

The sales price for coal includes royalties, cesses and tax. Annex 1.3.9 shows a categorywise breakdown of the price components for Jan. 1, 1989 showing that the various surcharges amount to 50% of the basic price. Moreover, purchases of coal by steel plants must add on the cost of transport to the above.

### 1.3.2 Coal Reserves

According to Annex 1.3.10 from the appendixed documents published in the 'Statistics for Iron and Steel Industry in India' (1990) reserves for non-coking coal are 130,178.50 million tonnes and 99.35% of these are in the Gondwana formation coalfield. In turn, 90.58% of this Gondwana coalfield is distributed through the coalfields of West Bengal, Bihar, Madhya Pradesh and Orissa. The coal samples selected for testing as SRC production feedstock are the Samla coal taken from the Raniganj coalfield (the largest coalfield with reserves of 25,428.15 million tonnes) and Argada-Sirka coal from the South Karanpura coalfield (reserves of 5,610 million tonnes). Coking coal reserves amount to 19,645.19 million tonnes as shown in Annex 1.3.11 of which 30.87% are prime coking coal found in the state of Bihar. The semi-coking coal reserves amount to 4,637.88 million tonnes. The main coalfields are shown in Annex 1.3.20 showing the distribution of the major coalfields in India and shows that these are concentrated in the east of India. Up to the present, steel plants were concentrated in this area but the VISAG Plant which recently began production is a coastally located plant.

Finally, figures for reserves given by the Department of Coal are 170 billion tonnes of coal and 6 billion tonnes of lignite.

### 1.3.3 Washeries

The ash content of Indian coal is high and so coking coal must be treated in washeries. There are also plans for the construction of washeries for non-coking coal but as prices would increase consumers are oppose and the plans remain unrealized. The output of clean coal in 1988-89 was 8,662.2 thousand tonnes at Coal India Limited, 1,964.0 thousand tonnes at TISCO, 1,060.1 thousand tonnes at SAIL giving a total output of 11,686.3 thousand tonnes (refer to Annex 1.3.12). Coal India washeries output comprises the output of 4,502.4 thousand tonnes from Bharat Coking Coal (BCCL), the 3,841.8 of Central Coalfield Limited (CCL) and the 318 thousand tonnes of Western Coalfield. The oil agglomerated middlings used as a test sample coal for the present study are middlings supplied from the Lodna Washery of BCCL.

The recovery rates of clean coal from individual washeries differ but is generally around 56.8%. About 29% of the middlings are used as steam coal. About 14% of the remains are rejected. The details of the washery facilities are shown in the attached Annex 1.3.13. This shows that all of the facilities are old having been constructed before 1970, and operating rates are low compared to the 1988-89 output and production capacity indicated above.

### 1.3.4 Metallurgical Coal

The scheduled production of hot metal for 1990-91 is 15.65 million tonnes so that with a 17% ash content and a coal-hot metal ratio of 1.284 the coal requirement is taken to be 20 million tonnes. However, since the ash content of domestic coal is approximately 18.5% it is necessary to import 3.6 million tonnes of low ash coal to adjust this to a 17% level. Subtracting the imported coal requirement from 20 million tonnes of the domestic coal requirement gives a figure of 16.49 million tonnes for the domestic requirement which actually represents a supply of 14.06 million tonnes. There is a 2.43 million tonne shortage (or 1.6 million tonnes in terms of imported coal) which will also have to be met by imported coal. The total import requirement is therefore forecast to be 5.2 million tonnes.

Annex 1.3.14 indicates coking coal requirement of steel sector including the hot metal production, coking coal requirement, imported coal requirement, etc.

## 1.4 Review of the Present Situation and Development Plan of Steel Industry in India

### 1.4.1 Present Situation of Steel Industry in India

The domestic supply of finished steel in the period 1988-89 was for 13,661.4 thousand tonnes. Of which 1,543.5 thousand tonnes imported and 118.7 thousand tonnes exported. Thus 90% of the above total was domestically produced. (Refer to Annex 1.4.1)

The figures below show production of hot metal, ingots and finished metal respectively. These indicate the rapid increase in production which was achieved after Independence. (Annex 1.4.2/1.4.3)

(unit : thousand tonnes)

| | 1950 | 1960-61 | 1970-71 | 1980-81 | 1988-89 | 1989-90 | 1990-91 |
|---|---|---|---|---|---|---|---|
| Hot Metal | 1,687 | 4,405 | 7,030 | 8,554 | 11,997 | 11,935 | 12,175 |
| Ingots | 1,437 | 3,418 | 6,302 | 9,385 | 13,938 | | |
| Finished Steel | 1,019 | 2,337 | 4,793 | 7,903 | 13,297 | | |

The main producers of hot metal in 1990-91 were the Steel Authority India Ltd. (SAIL) which produced 9,815 thousand tonnes (representing 79.2% of the total domestic production) and Tata Iron & Steel Co. (TISCO) produced 2,314 thousand tonnes (19.0% of total production). The production of these two main producers taken together accounted for 12,175 thousand tonnes (or 99% of the total) to which the 115.4 thousand tonnes in 1988-89 of production of the secondary producers is there. (Annex 1.4.3)

Production of Main Producers in 1990-91 are shown below: (Tables 1.4.3)

(unit : thousand tonnes)

| | Bhilai | Bokaro | Durgapur | Rourkela | Iisco | Sail Total | Tisco | Total |
|---|---|---|---|---|---|---|---|---|
| Output | 3,549 | 3,257 | 972 | 1,326 | 711 | 9,815 | 2,314 | 12,175 |

Annex 1.4.5 shows the operating rates of hot metal production in the period 1976-87. In 1985-86 the operating rate of SAIL was at 72.2% while the operating rate of the private sector firm TISCO is reported to be superior to 97.3%.

## 1.4.2 Particularities of the Indian Steel Industry

(1) Hot metal production was begun by the private firm TISCO quite some time before Indian Independence. This firm has a very long history since 37,000 tonnes were produced in 1911-12 and 1,092,000 tonnes were produced in 1947, the year of Independence. (Annex 1.4.6)

(2) In line with its general policy for heavy industries since Independence the Indian government has followed a vigorous policy of nurturing the steel industry through government investment. Steel production was begun at steel plants set up in Bhilai, Durgapur and Rourkela in 1958-59 and 1959-60. Investment was temporarily cut down because of slumps in agricultural production but in 1972-73 steel production was commenced at the two plants of Bokaro and IISCO. Later an expansion of the scale of the Bokaro steel plant to increase capacity was carried out. (Annex 1.4.7) In general much of the equipment used is outdated and on a small scale and a number of improvement programs are currently in progress (these are treated in detail in another section). The national steel plants are under the control of SAIL (Steel Authority of India Ltd.), which achieved a

production of 8.4 million tonnes of crude steel in 1988 putting this in thirteenth place in terms of scale worldwide. (Annex 1.4.8) The national steel plants were constructed with cooperation from the Soviet Union, Germany, Great Britain, etc. and so the Indian government is in a position to be able to compare and evaluate the technology of these countries. Further, the VISAG steel plant which commenced operations recently is a national enterprise but not under the control of SAIL.
Since May 1991, a great deal of liberization of economic policies has been announced by the central government, and private companies can invest in the field of iron and steel industries. Further, January 1992, the government control on price, product structure and etc. was abolished.

(3) Indian production of crude steel in 1988 was 14.3 million tonnes ranking this as number 15 worldwide. South Korea, which had no steel plants before World War II, achieved a production of 19.1 million tonnes by 1988 and ranked as number eight in terms of output worldwide. (Annex 1.4.9) In Korean case the coastal steel plants have competing power and so exports are considerable. The demand for crude steel in India in 1988 was 16.3 million tonnes representing a per capita demand of 20.5 kg which is lower than the 39.8 kg average for the Asian region (excluding Japan). However the corresponding figures for Pakistan of 17.9 kg and for Bangladesh of 4.4 kg reveal that India has a relatively high per capita demand in the Southwest Asian region. The reason for the high level of the average Asian per capita demand is due to the NIEs (Newly Industrialized Economies) of Singapore (811 kg), Taiwan (572 kg), Hong Kong (393.1 kg) and South Korea (369 kg). (Annex 1.4.10).

(4) The iron ore and coal which constitute the raw materials for iron and steel production are produced domestically in India. Production of iron ore in 1988

was for 52,322 thousand tonnes which nearly compares to the output of Asia, and follows after the output of the Soviet Union (249,700 thousand tonnes), the People's Republic of China (164,000 thousand tonnes), Brazil (145,000 thousand tonnes) and of Australia (99,450 thousand tonnes). The output of coal is also considerable amounting to 176,976 thousand tonnes in 1987 which followed the output of China, the USA, the Soviet Union and Poland. However the quality of some of the domestic coking coal output is inferior and so part of Indian coking coal supply is imported. The greater part of Indian coking coal reserves are found in Bihar state while medium and semi-coking coal deposits are concentrated in Bihar and West Bengal. Indian steel plants were originally located near raw material sites and so are concentrated in the coal-field areas but the VISAG steel plant which began operations this year is located on the coast. Almost all steel plants possess mines of iron ore, limestone quarries, etc. while the IISCO and Tata plants also own coal mines.

(5) Non coking coal reserves amount to 130 billion tonnes while the reserves of coking coal are 19.6 billion tonnes and 4.6 billion tonnes for medium and semi-coking coal deposits. In order to reduce the ash content of the coking coal the raw coal is treated in washeries. Coal India Ltd. owns 14 washeries, TISCO has two, SAIL also has two washeries which have a combined capacity for 20.6 million tonnes of intake producing 11.7 million tonnes of clean coal (representing a 57% recovery rate). The clean coal is used for production of coke but the other coal is sold to Thermal Power Stations, etc at non coking coal price. The coal samples collected for the present study include Lignite samples obtained from Samla (Ranigunj), Argada-Sirka (South Karanpura), Assam (Makum) and Neyveli while the Middlings sample for Oil Agglomerated Middlings use was obtained from the Lodna washery of Bharat Coking Coal (B.C.C.L.) of Coal India

Ltd. This middling had been treated with the O/A testing equipment of CFRI. The amount treated in the same washery in 1988-89 was 261.3 thousand tonnes from which 163.0 thousand tonnes of clean coal was obtained. The ash content of the clean coal continues to be high and in order to reduce this ash content imported coal with a low ash content is mixed with this.

(6) As can be seen from the above, most of Indian raw materials are of domestic origin and so it is relatively easy to employ the cheap labor resources available to assure their supply. However, international competitive power is poor because of the outdated nature of the facilities and equipment. As expressed in the Modernization Plan, 700 kg of coking coal (or 1,025 in the case of IISCO) are required for production of one tonne of Hot Metal. The ratio of productivity to volume capacity of the blast furnace in Bokaro is relatively high at 1.32 tonnes per cubic metres per day, but other blast furnaces are around 1 tonne per cubic metres per day. Since conditions for obtaining raw materials differ it is difficult to make a comparison but in the Japanese case in 1989 on average 463 kg of coking coal were used for one tonne of hot metal production and the comparative performance of blast furnaces would be 1.93 $t/m^3/d$.

(7) In India so far the pricing of steel is under government control and so steel can be purchased at the same price anywhere domestically. The price includes a number of various elements. For example for Flats over 5 mm on June 2nd, 1989 the Basic Selling Price was Rs. 6,700 per tonne. Included in this Price was Rs. 525 for Excise Duty, Rs. 805 for Freight Element, Rs. 3 for J.P.C.C., Rs. 100 for S.D.F., Rs. 200 for EGEAF, and a total deduction of Rs. 1,633. The actual factory price was Rs. 5,067 so that close to 30% in terms of various costs had been added to the net factory price to obtain the Basic

Selling Price. In addition to this Basic Selling Price there is a Stockyard Price and a Market Price. (Annex 1.4.12)
However, since January 1992, the price control on steel has been abolished.

1.4.3 Modernization Plan for Steel Plants (as shown in the Corporate Plan Up to 2000 AD)

Annex 1.4.4 shows the capacity of hot metal production in 1994-95 and the projected in 2000 made by the working group of iron and steel for Ministry of Steel and Mining in 1989, so that new industrial policies were not reflected in these figures. As shown in this table, the capacity and production output of hot metal in 1994-95 will be 19.82 million tonnes in total, consisting of 13.82 million tonnes of SAIL, 3.4 million tonnes of VSP and 2.6 million tonnes of TISCO and the projected total production in 1999-2000 is 26.4 million tonnes. Besides this table, a corporate plan up to 2000 was published in 1987. A new version of the plan has not yet been published. This plan indicates a modernization programme for Indian iron and steel industries and policies for coke production and sections relating to this study are motioned bellow.

(1) Predictions for the increase in demand for Steel Products (1) are set at 14 to 15 million tonnes for 1989-90, for 18-19 million tonnes for 1994-95 and for 25 million tonnes in 2000 so that a 10 million tonne increase over the decade is assumed. The following considers the expansion in capacity of SAIL over the same period in response to such demand increases. The SAIL Plan forecasts a production of 19.7 million tonnes (18.2 million tonnes according to the working group for iron and steel) of hot metal by the year 2000. (Annex 1.4.13)

A large part of the planned increase in capacity is to be achieved through improving operating rates of existing facilities or by increasing efficiency (the table below shows how the productivity of blast furnaces will increase and the coke ratio be reduced). In addition the new installation of a 2000 cubic metre blast furnace is planned for the period 1999-2000. (Tables 1.4.14, 1.4.15 and 1.4.16)

COKING COAL REQUIREMENT PROJECTION

| | Bhilai | Bokaro | Rourkela | Durgapur | IISCO | Total | Total Actual |
|---|---|---|---|---|---|---|---|
| Hot Metal (thousand tonnes) | | | | | | | |
| 1989-90 | 4,080 | 4,620 | 1,350 | 1,200 | 950 | 12,200 | 11,997 |
| 1994-95 | 4,410 | 4,725 | 2,000 | 1,885 | 1,600 | 14,620 | |
| 1999-2000 | 5,500 | 5,600 | 3,430 | 2,600 | 2,520 | 19,650 | |
| Crude Steel (thousand tonnes) | | | | | | | |
| 1989-90 | 4,000 | 4,000 | 1,400 | 1,150 | 680 | 11,230 | |
| 1994-95 | 4,400 | 4,500 | 1,900 | 1,599 | 1,550 | 13,949 | |
| 1999-2000 | 5,035 | 4,850 | 2,565 | 2,470 | 2,150 | 17,070 | |
| Saleable Steel (thousand tonnes) | | | | | | | |
| 1989-90 | 3,153 | 3,156 | 1,200 | 991 | 600 | 9,100 | |
| 1994-95 | 3,745 | 4,175 | 1,612 | 1,383 | 1,425 | 12,340 | |
| 1999-2000 | 4,566 | 4,525 | 2,160 | 2,210 | 2,039 | 15,200 | |
| Coke Yield (%) | | | | | | | |
| 1989-90 | 66 | 66 | 66 | 66 | 66 | | |
| 1994-95 | 68 | 68 | 68 | 68 | 68 | | |
| 1999-2000 | 70 | 70 | 70 | 70 | 70 | | |
| Coke Ash (%) | | | | | | | |
| 1989-90 | 22.5 | 22.5 | 22.5 | 22.5 | 22.5 | | |
| 1994-95 | 22.5 | 22.5 | 22.5 | 22.5 | 22.5 | | |
| 1999-2000 | 20 | 20 | 20 | 20 | 20 | | |
| M10 Index of Coke | | | | | | | |
| 1989-90 | 10 | 10 | 10 | 10 | 10 | | |
| 1994-95 | 9 | 9 | 9 | 9 | 9 | | |
| 1999-2000 | 8 | 8 | 8 | 8 | 8 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| SP. Productivity (T/M$^3$/Day) | | | | | | |
| 1989-90 | 1.136 | 1.32 | 1.0 | 0.8 | 0.8 | |
| 1994-95 | 1.23 | 1.35 | 1.1(1.3) | 1.15(0.958) | 1.346 | |
| 1999-2000 | 1.3/1.6 | 1.60 | 1.3/1.6 | 1.3 | 1.6(1.346) | |
| Coke Rate (kg/THM) | | | | | | |
| 1989-90 | 700 | 680 | 750 | 800 | 1,025 | |
| 1994-95 | 650 | 650 | 680/700 | 700(730) | 750(640) | |
| 1999-2000 | 600/550 | 600/550 | 625/575 | 625/575 | 625(589) | |
| Coal Iron Ratio (12-p117) | | | | | | |
| 1989-90 | 1.33 | 1.29 | 1.80 | 1.52 | 1.94 | |
| 1994-95 | 1.17 | 1.17 | 1.295 | 1.265 | 1.353 | |
| 1999-2000 | 1.04 | 1.04 | 1.08 | 1.08 | 1.08 | |
| Coking Coal Requirement (thousand tonnes) | | | | | | |
| 1989-90 | 5,430 | 5,972 | 2,430 | 1,828 | 1,840 | 17,500 |
| 1994-95 | 5,180 | 5,550 | 2,590 | 2,385 | 2,195 | 17,900 |
| 1999-2000 | 5,720 | 5,824 | 3,704 | 2,808 | 2,721.6 | 20,777.6 |
| Average Ash Content in Coal Blend (%) | | | | | | |
| 1989-90 | 17 | 17 | 17 | 17 | 17 | |
| 1994-95 | 17 | 17 | 17 | 17 | 17 | |
| 1999-2000 | 15 | 15 | 15 | 15 | 15 | |

### 1.4.4 SAIL Plans for Individual Plants (as statistics in the Progress Reports)

Present and Future Production Facilities
(data source; corporate plan and statistics for iron and steel)

Rourkela

| | 1989-90 | 1990-91 | 1994-95 | 1999-2000 |
|---|---|---|---|---|
| hot metal prod. 1,000t/y | 1,350 | - | 2,000 | 3,430 |
| hot metal prod. 1,000t/y W.G | - | 1,410 | 1,840 | 3,180 |
| blast furnace. cbm | 2*1,139@1<br>1*1,658 | | | 1*2,000 |
| S.P Productivity $t/m^3/d$ | 1.0 | | 1.1(1.30) | 1.3 |
| coke oven no.of b.oven | 3 210<br>1 80@2 | | | @3 |
| coke rate kg/thm | 750 | | 680(700) | 625/575 |
| coal carbonised 1,000t/y | 2,100 | | 2,242 | 2,990 |
| COG million $Nm^3/y$ | 822 | | | |
| crude tar 1,000t/y | 59 | | 62.7 | 26.1 |
| ammonium sulphate 1,000t/y | 18.9 | | 20.2 | 26.9 |
| crude benzol | 10.5 | | 11.2 | 15.0 |
| coal preparation | | coal blending<br>PBCC@4<br>uniform levelling<br>facilities | | |

@1 3*1139

@2 2* 160

@3 new oven with 7 meter height

@4 PBCC capacity 80t/h blending ratio 30%

Present and Future Production Facilities
(data source; corporate plan and statistics for iron and steel)

Durgapur

| | 1989-90 | 1990-91 | 1994-95 | 1999-2000 |
|---|---|---|---|---|
| hot metal prod. 1,000t/y | 1,200 | - | 1,885 | 2,600 |
| hot metal prod. 1,000t/yW.G | - | 1,200 | 1,880 | 2,400 |
| blast furnace. cbm | 3*1,323<br>1*1,754 | | | |
| S.P Productivity $t/m^3/d$ | 0.8 | | 1.15(0.958) | 1.3 |

| | | | | |
|---|---|---|---|---|
| coke oven no. of b.oven | 4 312 | | 2*39 | |
| | 1/2 39 | | | |
| coke rate kg/thm | 860 | | 700(730) | 625/575 |
| coal carbonaised 1,000t/y | 1,583 | | 2,060 | 2,260 |
| COG million $Nm^3/y$ | 436 | | 565.7 | 626 |
| crude tar 1,000t/y | 39.5 | | 51.7 | 56.5 |
| ammonium sulphate 1,000t/y | 11.1 | | 14.4 | 15.8 |
| crude benzol | 7.1 | | 9.2 | 10.2 |
| coal preparation | | modernisation of coal washery | | |
| coal washery feed coal t/h | 360 1 | | | |

Present and Future Production Facilities
(data source; corporate plan and statistics for iron and steel)

Bhilai

| | 1989-90 | 1990-91 | 1994-95 | 1999-2000 |
|---|---|---|---|---|
| hot metal prod. 1,000t/y | 4,080 | - | 4,410 | 5,500 |
| hot metal prod. 1,000t/yW.G | - | 4,080 | 4,410 | 5,120 |
| blast furnace. cbm | 3*1,033 | | 1*1,033 to | |
| | 3*1,719 | | | |
| | 1*2,000 | | | |
| S.P Productivity $t/m^3/d$ | 1.136 | | 1.23 | 1.3/1.6 |

| | | | | | |
|---|---|---|---|---|---|
| coke oven no. of b. oven | 7 | 455 | | | |
| | 1 | 65 | | | |
| | 1 | 67 | | | |
| | 1 | | | | |
| coke rate kg/thm | | 700 | | 650 | 600/550 |
| coal carbonaised 1,000t/y | | 4,700 | | 4,480 | 4,620 |
| COG million $Nm^3/y$ | | 1,363 | | 1,298 | 1,339 |
| crude tar 1,000t/y | | 132 | | 134.2 | 138 |
| ammonium sulphate 1,000t/y | | 45 | | 42.7 | 44.0 |
| crude benzol | | 31.0 | | 29.3 | 30.0 |
| coal preparation | | | PBCC in<br>2 batteries<br>selective<br>crushing | | |

Present and Future Production Facilities
(data source; corporate plan and statistics for iron and steel)

Bokaro

| | | 1989-90 | 1990-91 | 1994-95 | 1999-2000 |
|---|---|---|---|---|---|
| hot metal prod. 1,000t/y | | 4,620 | - | 4,724 | 5,600 |
| hot metal prod. 1,000t/yW.G | | - | 4.580 | 4,720 | 5,250 |
| blast furnace. cbm | | 3*2,000<br>2*1,700mt | | | 1*1,033 to |
| S.P Productivity $t/m^3/d$ | | 1.32 | | 1.35 | 1.6 |
| coke oven no. of b.oven | 4 | 276 | | | |
| | 3 | 207 | | | |
| coke rate kg/thm | | 680 | | 650 | 600/550 |
| coal carbonaised 1,000t/y | | 5,170 | | 4,800 | 4,740 |
| COG million $Nm^3/y$ | | 1,463 | | 1,382 | 1,341 |
| crude tar 1,000t/y | | 134 | | 124.7 | 123 |
| ammonium sulphate 1,000t/y | | 46.5 | | 43.1 | 42.7 |
| crude benzol | | 33.6 | | 31.2 | 30.8 |

| | |
|---|---|
| coal preparation | coal blending selective crushing |

Present and Future Production Facilities
(data source; corporate plan and statistics for iron and steel)

IISCO

| | 1989-90 | 1990-91 | 1994-95 | 1999-2000 |
|---|---|---|---|---|
| hot metal prod. 1,000t/y | 950 | - | 1,600 | 2,520 |
| hot metal prod. 1,000t/yW.G | - | 670 | 950 | 2,200 |
| blast furnace. cbm | 2* 500 | | stage 1 | |
| | 3*1,170 | | stage 2 | |
| S.P Productivity $t/m^3/d$ | 0.8 | | 1.346 | 1.6(1.346) |
| coke oven no. of b. oven | 1 72 | | | |
| | 3 234 | | | |
| coke rate kg/thm | 1,025 | | 750(640) | 625(589) |
| coal carbonised 1,000t/y | 1,593 | | 1,640 | 1,900 |
| COG million $Nm^3/y$ | 469 | | 450 | 523 |
| crude tar 1,000t/y | 44.6 | | 45.8 | 53.2 |
| ammonium sulphate 1,000t/y | 9.6 | | 9.8 | 11.4 |
| crude benzol | 3.2 | | 9.8 | 11.4 |
| coal preparation | | augmentation of coal preparation facilities | | |

### 1.4.5 Coking Coal Requirement

As shown above, according to the corporate plan up to 2000 AD, the coking coal requirement of SAIL is projected to be 17,500 thousand tonnes in 1989-90, 17,900 thousand tonnes in 1994-95 and 20,777.6 thousand tonnes in 1999-2000 as a consequence of the increased output of hot metal together with the reduction in the coal iron ratio over that period. It is also expected that the average ash content in the coal blend will decrease from the 17% level of 1989-90 and 1994-95 to 15% by 1999-2000.

The availability, ash content, blend proportions and requirements of the various types of coal are shown below:

| | Availability | | Requirement | |
|---|---|---|---|---|
| | Ash Content (%) | Clean Coal (mil.t) | Blend proportion (%) | Coal Requirement (mil. t) |
| Indigenous Prime Coking Coal | | | | |
| 1989-90 | 19.79 | 6.88 | 35 | 6.125 |
| 1994-95 | 18.35 | 8.96 | 35 | 6.265 |
| 1999-2000 | - | - | 25 | 4.825 |
| Medium | | | | |
| 1989-90 | 17.92 | 7.47 | 35 | 6.125 |
| 1994-95 | 17.78 | 10.33 | 35 | 6.265 |
| 1999-2000 | - | - | 35 | 6.755 |
| Blendable | | | | |
| 1989-90 | 17.04 | 1.05 | 10 | 1.750 |
| 1994-95 | 15.04 | 2.63 | 10 | 1.790 |
| 1999-2000 | - | - | 10 | 1,930 |
| Imported Coal | | | | |
| 1989-90 | - | - | 20 | 3,500 |
| 1994-95 | - | - | 20 | 3,580 |
| 1999-2000 | - | - | 30 | 5,790 |
| Total | | | | |
| 1989-90 | | | 100 | 17.500 |
| 1994-95 | | | 100 | 17.900 |
| 1999-2000 | | | 100 | 19.300 |

Source : Corporate Plan for SAIL up to 2000 AD (1987).

The Working Group reported in October 1989 on the required and obtainable amounts coking coals in India for iron production as shown in Annex 1.4.17. This shows that the required amount, the obtainable amount and the shortage amount in 1990-91 are 17.44 million tonnes, 13.9 million tonnes and 3.53 million tonnes respectively and in 1994-95 23.20 million tonnes, 19.39 million tonnes and 3.8 million tonnes respectively. In this report working group anticipated an increase of production of both prime and medium coking coal in India in future.

### 1.4.6 Relation of Steel Industry to SRC Project

The SAIL prediction for Hot metal production in 2000 is for 19,650 thousand tonnes of output according to the corporate plan up to 2000 AD(18,200 thousand tonnes according to W.G report), with a coal iron rate of 1.08 and a coal requirement of 20,777.6 thousand tonnes (19,656 thousand tonnes). Taking the blend proportion of SRC to be 10% then even if all coal is blended the requirement of SAIL for SRC in 2000 would be 2 million tonnes. As it is possible that SAIL will in fact introduce other equipment for coal treatment in addition to the existing Partial Briquetting machines and Stamping machines it is actually feasible that the maximum market for SRC in 2000 will in fact be about 1.5 million tonnes. This represents 5,000 tonnes per day. If blend proportion of SRC is lower, the market of SRC is lower.

Further, it is projected to lower the ash content of coal to 17% in 1995 and then to 15% in 2000 and to lower the ash content of coke produced from 22.5% to 20%. Further, it is expected to improve the coke on the M10 scale to an index of 10 in 1989-90, then to 9 in 1994-95 and to lower the index further to 8 in the year 2000.

## 1.5 SRC Related Organizations in India

Annex 1.5.1 shows the Indian organization relating to the production of SRC (Solvent Refined Coal). The contact body on the Japanese side is the Department of Economic Affairs (DOEA), the Ministry of Finance (MOF) Government of India which issue requests to the Japanese Embassy.

The coal which constitutes the raw material of the SRC is supplied from the subsidiary coal companies of Coal India Ltd. (CIL) which are under the control of the Department of Coal (DOC) of the Ministry of Energy (MOE) and the lignite is supplied from the Neyveli Lignite Corp. The coal samples which were tested in Japan for the present report came from local mines, the Samla sample came from the mine of ECL (Eastern Coalfield Ltd.) the Argada-Sirka sample from CCL (Central Coalfield Ltd.), and the Assam sample from NEC (Coal India Ltd., North Eastern Coalfield Division). The O/A middlings (Oil Agglomerated Middlings) forming the object of tests were middlings separated out by the washing facilities of BCCL (Bharat Coking Coal Ltd.) which were treated by the Oil Agglomeration testing equipment of the CFRI (Central Fuel Research Institute). In addition to the CIL there are other firms such as SCCL, TISCO, etc. which carry out coal production but the CIL has the lion's share of the market.

All of the steel plants under control of SAIL (Steel Authority of India) can use the SRC produced and the Rourkela Steel Plant chosen as the site for the proposed construction of a demonstration plant is no exception. In addition to the SAIL plants the coastal steel plant of VISAG has commenced operations. There is also the TISCO plant which has been in operation as a private sector plant since before independence.

Research on the production of SRC in India has been carried out for many years by the CFRI under the control of CSIR (Council of Scientific and Industrial Research) using financial support from SAIL. The SRC produced at the CFRI is used to carry out trial coke production experiments at the Research and Development Centre for Iron and Steel (RDCIS) placed under the control of SAIL.

The Indian counterpart for the present study is the Metallurgical and Engineering Consultants (India) Ltd. (MECON) which is under the control of the Department of Steel (DOS). Besides MECON the DOS, RDCIS and CFRI participate in the steering committee of this project.

The promotion of the SRC proposal hereafter will depend on SAIL's perception of national merits to be gained from the use of SRC, since SAIL is a major user. Even if an SRC Plant were to start operating and the by-products were exploited together with the SRC produced, without the participation of SAIL the project would not be able to make headway.

The three member research team specialising in the SRC field who were invited by JICA are experts attached to MECON, RDCIS and CFRI respectively.

## 1.6 Review of Relevant Laws and Regulations in India

The present Report on the plan for SRC production is to evaluate the technical and economic aspects of the demonstration plant which is to produce SRC to serve as a feed for coke production thus using the general coal available in plentiful supplies in India in place of imported coal. The future benefits and effects of the introduction of SRC technology in India are to be studied. In this regard the legal regulations which are concerned are taken to include those for the Coal Mining and Steel sectors relating to the technical development and manufacture of facilities required to the construction of the SRC plant as well those regarding the environmental aspects of SRC production. Since regulations relating to environmental aspects are treated in detail in Chapter 5 dealing with environmental measures they are omitted here. Further, the main aim of providing a substitute for imported coal is the improvement of the foreign currency balance by reducing imports so that this aspect of the plan relates to import policies. The following is therefore an outline of Indian laws and ordinances concerning domestic heavy industry, technical regulations and trade controls.

(1) Hitherto, the state was responsible for the development of the heavy industries (encompassing the coal and steel sectors). According to the 1956 Industrial Policy Resolution Acts, industry is classified into three categories with category 1 designated as heavy industry in which the coal and steel sectors are included. It is also stipulated that the state shall be responsible for investment in and production of these industries. In line with this policy a large number of steel plants were constructed by the state during the second and third five year plans. Recently the construction of a coastally located steel plant and the renovation and modernization of existing steel plants have been carried out by the state. In addition to the nationalization of almost all mining companies expansion of their production was programmed through investments. The share of total state investment accounted for by investments to heavy industry has been very large. Moreover, the Monopoly and Restriction Acts were passed in 1969 in order to control the activities of

monopoly practices in the private sector. The Industry (Development and Regulation) Acts of 1951 and Foreign Exchange Regulation Acts of 1973 control foreign investment activities. In may 1991, the Indian Central Government announced the deregulation policies mentioned in chapter 1.2.1. Based on these policies, the industries listed under category 1 have been rescreened and the iron and steel industry has now been excluded from the list.

(2) The prices of major manufactured products were administered by the Essential Commodities Acts of 1956. However, January 1992, the price control on steel was abolished. In principle, in the case of the coal and steel sectors after a Joint Committee adds a 10 to 14% margin of reasonable profit to the average production cost, the price was decided by the addition of a large number of surcharges including taxes. In order to assure a uniform price throughout India transport costs are added as one of these surcharges. Depending on the aim envisaged the pricing is adjusted in line with policy. For example, although petroleum product prices are generally high those destined for fertiliser production are kept low.

In the present project the price evaluation of the raw material coal (including substituted imported coal price), of the produced SRC and accompanying by-products will effect the estimates for plant cost and so these represent factors having considerable influence on the general economic evaluation of the project.

(3) Hitherto, import restrictions were imposed by the Imports and Exports Acts of 1947 in order to protect domestic industry and it was not possible in principle to import any manufactured products which could be produced domestically. In addition, the 1962 Customs Acts placed considerable duties on imported articles. On the other hand, the government agenda policies of import substitution and export promotion were implemented through tax measures and financial support. To increase competitiveness of Indian industries in both domestic and foreign markets, regulations and protection policies have been considerably relaxed. Import of equipment

can be passed custom free if the amount of equipment is less than the foreign capital expenditure, and also it will be automatically approved if the amount of imported goods is small.

(4) Hitherto, the import of technology was restricted in order to promote the development of national technology. Imports of equipment relating to national technology development received support in the form of import permits, tax exemption measures and financial assistance. A large amount of experiment on SRC technology has already been conducted in India using coal domestically produced. In line with the deregulation policies announced in May 1991, the introduction of foreign technology in highly important industries will be accelerated under certain conditions. Technology which is important for the Indian economy and which cannot be developed by private companies will be developed by the government. The object of this study, the solvent refined coal process, may be promoted by government if the government recognizes this as important.

(5) It is very important to increase employment opportunities in India. The government also gives priority to reserving certain manufacturing fields to the small and cottage industries while also enforcing a policy to encourage employment of certain specified ethnic minorities and the lower caste groups.

## 1.7 Importance of SRC Project to Socio-economic Development in India

The output of manufactured steel materials in India in 1988-89 was 13,297 thousand tonnes, representing 90% of the required amount. Hot metal production for the same year was 11,997 thousand tonnes. The present per capita consumption of crude steel is 20.5 kg in India which is high among the nations of Southwest Asia but is lower than the average for the Asian region which is 39.8 kg (excluding Japan). Since the population is expected to become a thousand million by the year 2000 at its present rate of growth, the production schedule for manufactured steel materials for 1994-95 has been set at 18-19 million tonnes taking account of an increase in per capita consumption while an expansion to 25 million tonnes is planned for 2000.

India produces and exports metallurgical coal used as a raw material in steel production. The coal and raw material coal for coke production is also produced but coke is made by blending imported low ash coal with the high ash domestic coal. At present, the ash content of coke is 22.5% and the ash content of coal is 17% but it is aimed to bring these down to 20% and 15% respectively by 2000. The realization of these targets is desirable to improve the productivity of blast furnaces. Further, the supply of prime coking coal necessary to production of metallurgical coke is limited to the 5 (American) billion tonnes of reserves which will only last for about 30 years, so that the ratio of imported coal will inevitably increase given present conditions. Coking coal imported in 1985-86 amounted to about 2.5 million tonnes costing Rs. 2.2 (American) billion. Although coal imports are small in terms of overall imports the present deficit in the international balance of payments is an obstacle to economic development and a reduction in imports would produce considerable benefit.

In comparison to raw material coal India's reserves of non coking coal are extremely large and so this is the main fuel at present.

The SRC process would employ the plentifully available supplies of non coking coal to manufacture SRC which is a supplement with caking property used to produce coke. The SRC could therefore be blended in coke with general coal to produce a high quality prime coke.

If SRC can be used together with the economically produced non coking coal of India for the production of metallurgical coke then present imports could be reduced while at the same time cutting down on consumption of domestic prime coking coal. This would achieve the double benefit of saving on the foreign currency needed for imports of raw coal and prolonging the service life of domestic prime coking coal supplies.

Further, the construction and operation of the SRC plant would assure an expansion of employment opportunities and increased use of non coking coal which in turn would mean more employment because of the expansion in production of non coking coal itself and transport of this.

Introduction of SRC is concluded to be meaningful in realising the above objectives and moreover would serve to support the furthering of the SRC technology needed for future development of liquid fuels. At present, despite the production of oil and natural gas in India supply can not keep up with the increase in demand and considerable quantities of oil are imported. In the event of a future increase in oil prices SRC would provide a possible substitute fuel to oil.

Finally, the extension of the SRC process to manufacture products with coalchemical applications such as in carbon fibres or electrode binder can be envisaged.

# Chapter 2 MARKET STUDY (PAST TRENDS AND FORECAST)

# Chapter 2 MARKET STUDY (PAST TRENDS AND FORECAST)

## 2.1 Production of Hot Metal

### 2.1.1 General Situation

The first large scale iron manufacture in India was begun in 1907 by the private firm Tata Iron and Steel Co. (TISCO). The history of the Indian iron and steel industry can be roughly divided into two periods, that is the initial developmental period before WWII and the period of governmentally guided development after WWII.

In the post war period development of India's iron and steel industry was controlled by the government. Steel plants run as national enterprises were constructed at Bhilai, Durgapur, Rourkela and Bokaro, and facilities of these plants were expanded successively over the years. At the same time IISCO (Indian Iron and Steel Co. Ltd.) was nationalized and an expansion of the TISCO Steel Plant carried out. Further, the Vizag Steel Plant was recently constructed and has begun operations further expanding the hot metal production capacity. As a result of the above development the hot metal production capacity of the Indian iron and steel industry in 1990 had reached 18,915 thousand ton per year and the hot metal output in 1990-91 achieved 15,640 thousand tons.

In the postwar period the history of the Indian iron and steel industry can be divided into four periods. These are the first development period (the construction of new steel plants at Bhilai, Durgapur and Rourkela together with expansion of the Bhilai plant facilities), the second development period (new construction of Bokaro plant, expansion of the plant facilities at the Durgapur, Bhilai, Rourkela and TISCO sites), a period of stagnation (productive stagnation as a result of a slump in iron and steel demand), followed by a third period of development (expansion of plant facilities at Bhilai, Bokaro and TISCO sites together with construction of a new Vizag plant).

The following traces the history of the development of the iron and steel industry in India.

(1) Period of Initial Development (1907-1945)

Annual output of hot metal is lower than 1,480 thousand tons in this period during which the privately run TISCO plant is built and expanded, and construction carried out for the nationally run VISL (Visvesvaraya Iron and Steel Ltd.) plant and the IISCO (Indian Iron & Steel Co. Ltd.) plant (which is initially private but is subsequently nationalized).

(2) Post War Development under Government Control

1) First Development Period (1945 to 1965-66)

In this period the annual output of hot metal increased from 1.48 million tons to 7.21 million tons. During this period the national steel plant of Bhilai was constructed and then expanded, and construction of the national steel plants of Durgapur and Rourkela was also carried out.

2) Second Development Period (1966-67 to 1975-76)

In this period the annual output of hot metal increased from 7.09 million tons to 8.56 million tons. A new national steel mill was constructed at Bokaro and the expansion of facilities at Durgapur, Rourkela and TISCO plants was carried out.

3) Period of Stagnation (1976-77 to 1984-85)

This period saw a stagnation in the production of hot metal and the expansion of facilities at Bokaro Steel Plant was the only expansion in hot metal production facilities which was undertaken. Hot metal output fell from a peak in 1976-77 of 10.07 million tons to 8.55 million tons in 1980-81. After this output began to increase again and by 1984-85 it had recovered to a level of 9.69 million tons.

4) Third Development Period (1985-86 to 1989-90)

In the year 1985-86 the annual output of hot metal reached a 10 million tons mark and had increased to 12 million tons in 1988-89. Following this, further strides in production followed and in 1990-91 the annual production had reached an annual output of 15.64 million tons. Expansion work was undertaken at the Bhilai, Bokaro and TISCO plants and a new plant was constructed at Vizag.

At present the main framework of the Indian iron and steel industry is on a national enterprise basis. The production capacity of this national enterprise sector in 1990 was 16.315 million tons per year which accounts for 86.3% of India's total productive capacity. The public enterprises are SAIL (State Authority of India) and VSP (Vizag Steel Plant). SAIL owns the Bhilai, Bokaro, Durgapur, Rourkela and IISCO plants and had a total productive capacity of 12.915 million tons per year in 1990. The productive capacity of the Vizag Steel Plant in 1990 was 3.4 million tons per year. TISCO is the sole private sector company and in 1990 had a productive capacity of 2.6 million tons per year.

In India the production of finished steel normally falls short of demand and imports in excess of 10% of the annual production of finished steel have to be imported every year.

The supply and demand balance for finished steel in India is shown in the table below:

Achievements of the Supply and Demand Balance for Finished Steel in India

(Unit: 1,000 ton)

| Year | Output | Imports | Exports | Apparent Consump-tion | Demand/ Supply Balance | Import Dependency (%) |
|---|---|---|---|---|---|---|
| 1977-78 | 6,970 | 424 | 650 | 6,744 | 226 | 6.3 |
| 1978-79 | 7,653 | 1,048 | 425 | 8,276 | -623 | 12.7 |
| 1979-80 | 7,642 | 2,199 | 81 | 9,760 | -2,118 | 22.5 |
| 1980-81 | 7,903 | 1,748 | 25 | 9,626 | -1,723 | 18.2 |
| 1981-82 | 9,364 | 2,443 | 9 | 11,798 | -2,434 | 20.7 |
| 1982-83 | 9,128 | 2,092 | 4 | 11,216 | -2,088 | 18.7 |
| 1983-84 | 8,497 | 1,935 | 14 | 10,418 | -1,921 | 19.6 |
| 1984-85 | 8,782 | 1,621 | 102 | 10,301 | -1,519 | 15.7 |
| 1985-86 | 10,025 | 1,753 | 19 | 11,759 | -1,734 | 14.9 |
| 1986-87 | 10,541 | 1,559 | 27 | 12,073 | -1,532 | 12.9 |
| 1987-88 | 11,882 | 1,594 | 50 | 13,011 | -1,544 | 12.3 |

Source: SAIL; Statistics for Iron and Steel Industry in India, 1990.

The rate of import dependency (imports/apparent consumption) for finished steel in India soared from the 6.3% in 1977-78 to 22.5% in 1979-80 because of the rapid increase in imports.

In response to the above situation the Indian government proceeded with a rigorous import substitution policy for finished steel in order to reduce imports and meet domestic demand by expanding the domestic production of finished steel. As a result of this policy import dependency decreased and had been reduced to 18.2% in 1980-81. However the dependency increased again to 20.7% in 1981-82, and thereafter decreased successively to 18.7% in 1982-83, to 19.6% in 1983-84, to 15.7% in 1984-85, to 12.9% in 1985-86 and to 12.3% in 1987-88.

In order to meet the increase in hot metal demand which accompanied the application of policies for expansion of domestic demand and for finished steel import substitution the Indian government undertook an expansion in the hot metal productive capacity and hot metal output. Facility expansion was carried out after 1985 at the Bhilai, Bokaro and TISCO plants and also a new plant was constructed at Vizag in order to achieve the increase in productive capacity for hot metal.

As a future increase in demand for hot metal is anticipated to result from the projected expansion in demand for finished steel, the Indian steel industry in the 1990s plans to achieve a considerable increase in its hot metal productive capacity and output by improvements and expansion of blast furnaces, by rationalizing facilities, and through new production technology.

The production capacity of India's main manufacturers is estimated to reach 19.82 million tons per year in 1994-95 and 28.75 million tons per year in 1999-2000 while the hot metal production is forecast to be 19.8 million tons in 1994-95 and 26.45 million tons in 1999-2000.

The productive capacity, production achievement and forecasts for the main Indian manufacturers are given in the following table.

Achievements and Forecasts of Hot Metal Capacity and Output of India's Main Manufacturers

(Unit: 1,000 t/y)

| | Achievements | | Forecasts | | |
|---|---|---|---|---|---|
| | 1976-77 | 1988-89 | 1990-91 | 1994-95 | 1999-2000 |
| Productive Capacity | 12,465 | 15,425 | 18,915 | 19,820 | 28,750 |
| Output | 9,909 | 11,882 | 15,640 | 19,800 | 26,450 |

### 2.1.2 India's Hot Metal Productive Capacity

(1) History of Productive Capacity

TISCO (Tata Iron and Steel Co.) is India's main private sector steel manufacturer (integrated manufacturer) and has a history of production dating from 1907 when it started operations using its first blast furnace. Productive capacity has been successively increased through new installations and expansions and the hot metal production capacity had reached 18.915 million tons per year in 1990.

The history of new steel plant installations and expansions in India is given below:

1) Initial Development Period (1907 to 1944)

Expansion of No. 1 Blast furnace at TISCO plant (operations commenced in 1907), new private sector plant installation of India Iron and Steel Co. (IISCO) (operations begun; blast furnace No. 1 in 1922, blast furnace No. 2 in 1924), expansion of the TISCO plant (operations begun; blast furnace No. 2 in 1923, blast furnace No. 3 in 1931), new national plant of VISL (Visvesvaraya Iron and Steel Ltd.) constructed (operations begun in 1923).

2) Post War Period of Government Controlled Development (from 1945 to 1990-91)

a) First Development Period (from 1945 to 1965-66)

Expansion of TISCO Steel Plant facilities with Blast Furnace No. 4 (began operating in 1959), construction of new national steel plant at Bhilai (blast furnaces No. 1 and No. 2 began operating in 1959, furnace No. 3 in 1960), construction of new national steel plant at Durgapur (blast furnace No. 1 began operating in 1959, furnace No. 2 in 1961 and furnace No. 3 in 1962), construction of new national steel plant at Rourkela (blast furnace No. 1 began operating in 1959, blast furnace No. 2 in 1960 and furnace No. 3 in 1962). Expansion of the Steel Plant at Bhilai (blast furnace No. 4 began operating in 1964 and furnace No. 5 in 1966.

b) Second Development Period (from 1966-67 to 1975-76)

Expansion of Durgapur Steel Plant with addition of blast furnace No. 4 (began operating in 1967), expansion of Rourkela steel works with blast furnace No. 4 (began operating in 1967). Expansion of Bhilai Steel Plant with blast furnace No. 6 (began operating in 1971), construction of new national steel Plant at Bokaro (blast furnace No. 1 began operating in 1972 and furnace No. 2 in 1974), expansion of TISCO Steel Plant with addition of blast furnace No. 5 (began operating in 1976).

c) Period of Stagnation (from 1976-77 to 1984-85)

Expansion of Bokaro Steel Plant (furnace No. 3 began operating in 1978 and furnace No. 4 in 1981)

d) Third Development Period (from 1985-86 to 1989-90)

Expansion of the Bokaro Steel Plant (blast furnace No. 5 began operating in 1985). Expansion of Bhilai Steel Plant with blast furnace No. 7 (began operating in 1987), expansion of TISCO Steel Plant with blast furnace No. 6 (began operating in 1988), construction of new steel Plant at Vizag (began operating in 1990).

The hot metal output of India's integrated steel plants, as shown in Table 2.1.1, increased from 12.465 million tons per year in 1976-77 to 13.398 million tons per year in 1983-84, then to 13.607 million tons per year in 1985-86, 14.495 million tons per year in 1986-87, 15.425 million tons per year in 1988-89 and 16.015 million tons per year in 1989-90.

The useful volume of the blast furnaces and hot metal productive capacity of India's individual integrated steel plants are shown in Table 2.1.2.

(2) Forecast for Production Capacity

1) Forecast Method

The forecasts for hot metal production capacity of India's integrated steel plants employed the forecasts for hot metal production capacity in 1994-95 projected by MECON, and applied the method outlined below to get estimates for 1999-2000.

a) Forecasts of Production Capacity for Individual SAIL Steel Plants

a. Forecasts of the Blast Furnace Useful Volume by Steel Plant

On the basis of the blast furnace improvement and expansion plans together with the plans for expansion of useful volume of the individual steel plants published in SAIL's Corporate Plan up to 2000 AD (1987 issue) a forecast by plant for the projected blast furnace useful volume was given.

b. Forecasts of Blast Furnace Productivity by Plant

The improvement target for blast furnace productivity (Hot Metal t/d/BF Volume in cubic m) by plant indicated in SAIL's Corporate Plan up to 2000 AD (1987 issue) was used as the forecast base data.

Improvement targets for blast furnace productivity of the individual SAIL plants is as follows:

| Plant | 1989-90 | 1994-95 | 1999-2000 |
|---|---|---|---|
| Bhilai | 1.136 | 1.230 | 1.300 |
| Bokaro | 1.320 | 1.350 | 1.600 |
| Durgapur | 0.800 | 1.150 | 1.300 |
| Rourkela | 1.000 | 1.130 | 1.300 |
| IISCO | 0.800 | 1.346 | 1.346 |

c. Forecast of Blast Furnace Productivity by Plant

The plantwise hot metal productive capacity was forecasted using the following method.

| Plant daily hot metal productive capacity (t/d) | = | Blast furnace useful volume (cubic m) | x | BF productivity ($t/d/m^3$) |
|---|---|---|---|---|

| Plant annual hot metal productive capacity (t/y) | = | Plant daily hot metal productive capacity (t/d) | x | Scheduled number of working days in one year (d/y) |
|---|---|---|---|---|

b) Forecast of Hot Metal Productive Capacity of TISCO Plant

| Plant daily hot metal productive capacity (t/d) | = | Blast furnace useful volume (cubic m) | x | BF productivity ($T/D/m^3$) |
|---|---|---|---|---|

| Plant annual hot metal productive capacity (t/y) | = | Plant daily hot metal productive capacity (t/d) | x | Number of working days in one year (d/y) |
|---|---|---|---|---|

c) Forecast of Hot Metal Productive Capacity of Vizag Plant

This was estimated by dividing the forecasted 5.7 million tons hot metal output for 1999-2000 by the projected operating rate (0.95).

2) Forecast Results

As shown in Table 2.1.3 the total annual productive capacity of India's integrated steel manufacturers was forecast to increase to 18.915 million tons in the year of 1990-91, to 19.82 million tons in the year of 1994-95, and to 28.75 million tons in the year of 1999-2000.

The forecasts for the effective capacity of blast furnaces, the daily hot metal productive capacity, annual hot metal productive capacity, working days per year and blast furnace productivity of the SAIL plants, TISCO plant in 1999-2000 are as shown in Table 2.1.4.

### 2.1.3 Hot Metal Production in India

#### (1) Production History

Table 2.1.5 gives a summary of hot metal production in India from 1950 to 1988-89. From a hot metal output of 1.687 million tons in 1950 production grew at an annual growth rate of 10.07% to reach 4.405 million tons in 1960-61. In the 1960s production grew at an annual growth of 4.79% to increase to 7.03 million tons in 1970-71. Growth was sustained in the early 1970s and production had reached 10.071 million tons in 1976-77 but after this there was a slight dropping off and output decreased to 8.554 million tons in 1980-81. However production picked up again in the 1980s and the ten million mark was passed in 1985-86 with an output of 10.159 million tons for that year and in 1988-89 11.997 million tons output was achieved.

In Indian statistics for hot metal output achievement figures are recorded separately for main producer and secondary producers. The plants under SAIL control and TISCO constitute the main producer category (integrated steel producers) while secondary producers consist of VISL, IDCOL and SANDUR.
Table 2.1.6 indicates the production history for the main producers and secondary producers from the year of 1976-77 to 1990-91.

The production history of the secondary hot metal producers from 1984-85 to 1988-89 is shown below:

(Unit: 1,000 ton)

| Producer | 1984-85 | 1985-86 | 1986-87 | 1987-88 | 1988-89 |
|---|---|---|---|---|---|
| VISL | 57.0 | 33.0 | 4.0 | - | 12.0 |
| IDCOL | 61.2 | 87.0 | 95.6 | 102.2 | 103.4 |
| SANDUR | 3.0 | 3.1 | - | - | - |
| Total | 121.2 | 123.1 | 99.6 | 102.2 | 115.4 |

(2) Production Forecasts

Forecasts for the future total hot metal output of the integrated plants of SAIL, TISCO and VSP were projected to be 19.8 million tons in 1994-95 and 26.45 million tons in 1999-2000. Plantwise forecasts for hot metal production in the years from 1991-92 to 1994-95 and of 1999-2000 are as shown in Table 2.1.7.

### 2.1.4 Sales of Pig Iron in India

(1) Productive Capacity

The productive capacity of the main producers of Saleable Pig Iron in India in the year of 1989-90 was 630,000 tons per year at the Bhilai steel plant, 714,000 tons per year at Bokaro steel plant, 300,000 tons per year at Durgapur steel plant and 250,000 tons per year at the IISCO steel plant giving a total output of 1.894 million tons per year.

(2) Sales History

Sales statistics for pig iron in India record the sales achievements of the main producers (integrated plants) and secondary producers separately. The main producers are the plants under SAIL control and TISCO, IDCOL and SANDUR constitute the secondary producers.

The history of pig iron sales of the main producers by plant and the history of sales of the secondary producers from 1976-77 to 1989-90 are as shown in Table 2.1.8.

Sales of pig iron in India decreased from 2.041 million tons achieved in 1976-77 to reach a bottom of 1.092 million tons in 1979-80. After this sales were achieved in a range between 1.112 and 1.483 million tons and in the year of 1988-89 sales of 1.348 million tons were achieved.

The history of sales of pig iron by secondary producers in the period 1984-5 to 1988-89 are as shown below:

(Unit: 1,000 tons)

| Producer | 1984-85 | 1985-86 | 1986-87 | 1987-88 | 1988-89 |
|---|---|---|---|---|---|
| IDCOL | 61.2 | 87.0 | 95.6 | 102.2 | 103.4 |
| SANDUR | 3.0 | 3.1 | - | - | - |
| Total | 64.2 | 90.1 | 95.6 | 102.2 | 103.4 |

(3) Sales Forecasts

Sales of pig iron in India are forecast to increase from 1.348 million tons in 1989-90 to 1.789 million tons in 1990-91, to 2.8 million tons in 1994-95 and to 4 million tons in 1999-2000.

Forecasts for Indian pig iron sales are as shown in Table 2.1.9.

## 2.2 Production of Coke and Its By-products in India

### 2.2.1 Coke Production

(1) Present Situation and Future of Coke Ovens

Coke production in India is carried out at the SAIL plants of Bhilai, Bokaro, Durgapur and Rourkela, and in addition to these there are coke oven facilities at IISCO and TISCO producing coke.

The total number of coke batteries in India was 34.5 (representing 2,367 ovens) in 1989-90 projected to increase to 36.5 batteries in 1994-95 (2,445 ovens) and then to 37.5 batteries in 1999-2000 (2,525 ovens). The present figures and forecasts for the coke batteries and ovens by individual plant are shown in Table 2.2.1.

(2) Coke Production

1) Production History

Indian coke production fell from 10.186 million tons in 1982-83 to 8.559 million tons in 1984-85 after which it increased to reach a level of 10.061 million tons in 1988-89.

Coke produced in India is divided into categories of Hard Coke, Nut Coke and Mixed Coke.

The coke production history of SAIL, TISCO and the overall industry are given below:

(Unit: 1,000 ton)

| Firm | 1982 -83 | 1983 -84 | 1984 -85 | 1985 -86 | 1986 -87 | 1987 -88 | 1988 -89 |
|---|---|---|---|---|---|---|---|
| SAIL | 8,835 | 8,531 | 7,149 | 7,934 | 7,772 | 8,063 | 8,458 |
| TISCO | 1,351 | 1,363 | 1,410 | 1,390 | 1,469 | 1,502 | 1,603 |
| Total | 10,186 | 9,894 | 8,559 | 9,324 | 9,241 | 9,565 | 10,061 |

2) Production Forecasts

It is forecast that coke production in India (except IISCO) will be 11.097 million tons in 1994-95 and 16.472 million tons in 1999-2000. The breakdown of this production reveals that SAIL (except IISCO) is forecast to produce 9.235 million tons in 1994-95 and 14.61 million tons in 1999-2000, while TISCO will produce 1.862 million tons in 1994-95 and 1.862 million tons in 1999-2000.

The figures for the total input of coal for coke production and the percentage of coke used for steel production which are indicated in the SAIL Corporate Plan up to 2000 AD were used as the base data for forecasting the production output of SAIL (except IISCO). The forecast for TISCO production output was based on the projected production of hot metal (Table 2.1.7) and the estimated coke rate.

Table 2.2.2 indicates the history of plantwise production of coke in India for the period from 1982-83 to 1990-91 together with forecasts for plantwise production from 1994-95 to 1999-2000.

### (3) Coke Demand

#### 1) Demand History

In India coke used for steel production (i.e. Blast Furnace Coke) is mainly of the hard coke although nut coke is also used for a part of steel production.

The Indian blast furnace coke demand in 1982-83 was 8.001 million tons which fell slightly to 7.491 million tons in 1984-85 and after increased to become 8.887 million tons in 1988-89.

The history of coke demand for SAIL and TISCO is shown below:

(Unit: 1,000 ton)

| Firm | 1982 -83 | 1983 -84 | 1984 -85 | 1985 -86 | 1986 -87 | 1987 -88 | 1988 -89 |
|---|---|---|---|---|---|---|---|
| SAIL | 6,567 | 6,217 | 6,081 | 6,552 | 6,546 | 6,714 | 7,376 |
| TISCO | 1,434 | 1,388 | 1,410 | 1,390 | 1,469 | 1,502 | 1,511 |
| Total | 8,001 | 7,605 | 7,491 | 7,942 | 8,015 | 8,216 | 8,887 |

#### 2) Demand Forecast

In the 1990s the demand for blast furnace coke increased with the commencement of production by VSP and it is estimated that demand will reach 12.944 million tons in 1994-95 and increase to reach 15.988 million tons in 1999-2000.

Forecasts demand for blast furnace coke by plant have been made by multiplying the projected hot metal production output by the projected coke rate in each plant.
Forecasts for coke demand in the case of SAIL, TISCO and VSP are as follows:

(Unit: 1,000 ton)

| Year | SAIL | TISCO | VSP | Total |
|---|---|---|---|---|
| 1994-95 | 9,214 | 1,690 | 2,040 | 12,944 |
| 1999-2000 | 11,085 | 1,625 | 3,278 | 15,988 |

Table 2.2.3 indicates the history of plantwise coke demand in India between 1982-83 and 1988-89 and gives forecasts for the same from 1994-95 to 1999-2000.

Table 2.2.4 shows the plantwise coke rate (i.e. the coke consumption per ton of hot metal) for the period from 1982-83 to 1988-89 and gives forecasts for the period 1994-95 to 1999-2000.

### 2.2.2 Production of Coke By-products

(1) General Outline

The raw gas from the coke oven batteries (raw coke oven gas) has a calorific value of 4,000-5,000 Kcal/N cubic m and is an important in house fuel source. In addition to this it is a valuable raw material of chemical products since it contains coal tar, crude benzene, ammonia and sulphur, etc.

The raw coke oven gas is refined after treatment to various processes such as tar separation, desulphurization, ammonia sulphation (for the production of ammonium sulphate), and benzene separation and then used as fuel.

Figure 2.2.1 is the flowchart for the recovery and production of coke by-products in SAIL.

Production statistics indicate raw coke oven gas, crude tar, crude benzene and ammonium sulphate as the primary by-products of coke.

Crude tar is a mixture of several hundred different chemical compounds ranging from light oil to pitch. These compounds are separated and distilled to produce a variety of chemical products but the number of chemical compounds which separate on a commercial base is small. Further, besides a number of the compounds which can be used as crude finished products the majority of the compounds are employed in the form of creosote oil or pitch without having been separated out.

The main tar products of SAIL are pitch, naphthalene, anthracene oil, creosote oil, tar oil, phenol, cresol and cresylic acids. These are shown in statistics as secondary by-products of coke under the category of tar products.

Crude benzene is used for the production of the different aromatics by being separated and refined through processes of acid washing, pressure hydro-refining, desulphurization and B.T.X. distillation.

The main aromatic products of SAIL of the benzene group products are benzene, toluene, xylene, naphtha, solvent oil and still bottom oil.
They are shown in statistics as secondary by-products of coke under the category of benzene or aromatic products.

(2) The Characteristics and Use of the Coke By-products in SAIL

The specifications, characteristics, common uses and producing plant names for the benzene group products, pitch- H.P. naphthalene and carbon black feedstocks and other tar products are shown respectively in Tables 2.2.5, 2.2.6 and 2.2.7.

(3) Production of Coke By-products

1) Survey Method

Where information on the history and forecasts for primary by-products of coke in India were available this formed the base data for areas considered. For aspects for which data was not available a reasonable estimation method was employed. Data availability is as indicated below:

| Product | Aspects for which data were available | Aspects for which data were not available |
|---|---|---|
| Primary By-product | Production records and forecasts for by-products in SAIL by plant (except COG) | Actual production records of COG (except Rourkela) in SAIL by plant |
| | Records of each product's recovery amount in SAIL by plant and in TISCO (per 1 ton of coal intake) | Forecasts of each product's recovery amount in TISCO (per 1 ton coal intake) |
| | | Production forecasts for IISCO |
| | Production records of Rourkela Plant | Production records and forecasts for TISCO |
| | | Production forecasts for VSP |

The following estimation methods were used for those aspects for which data was not available.

a) Production of Coke Oven Gas

The production achievements for coke oven gas of the Bhilai, Bokaro and Durgapur plants was estimated using the following method.

coal input to coke oven (t) =
  crude tar output (t) / crude tar yield

production of coke oven gas (N cubic m) =
  coal input to coke oven (t) x
  the coke oven gas yield (N cubic m/t)

The production achievements for coke oven gas of IISCO was estimated using the following method.

coal input to coke oven (t) =
  coke output (t) / coke yield

production of coke oven gas (N cubic m) =
  coal input to coke oven (t) x
  the coke oven gas yield rate (N cubic m/t)

The production achievements and forecasts for coke oven gas of TISCO were estimated using the following method.

coal input to coke oven (t) =
  coke output (t) / coke yield

production of coke oven gas (N cubic m) =
  coal input to coke oven (t) x
  the coke oven gas yield (N cubic m/t)

The yield of crude tar (output of crude tar (t) for one ton of coal input to the coke oven) in the plants of Bhilai, Bokaro and Durgapur together with the yield of coke oven gas (COG) (output of coke oven gas (N cubic m) per one ton of coal input to the coke oven) are as shown below:

| Year | Crude Tar Yield | | | COG Yield | | |
|---|---|---|---|---|---|---|
| | Bhilai | Bokaro | Durgapur | Bhilai | Bokaro | Durgapur |
| 1984-85 | 0.00278 | 0.00252 | 0.00198 | 272 | 283.10 | 283.10 |
| 1985-86 | 0.00279 | 0.00245 | 0.00216 | 277 | 282.05 | 243.34 |
| 1986-87 | 0.00272 | 0.00257 | 0.00229 | 276 | 283.30 | 255.33 |
| 1987-88 | 0.00280 | 0.00258 | 0.00235 | 284 | 290.40 | 255.40 |
| 1988-89 | 0.00309 | 0.00246 | 0.00239 | 279 | 289.60 | 241.11 |
| 1989-90 | 0.00309 | 0.00246 | 0.00239 | 279 | 289.60 | 241.11 |

The yield of coke (output of coke (ton) for one ton of coal input to the coke oven) in the plants of IISCO and TISCO together with the yield of coke oven gas (output of coke oven gas (N cubic m) per one ton of coal input to the coke oven) are as shown below:

| Year | Coke Yield | | COG Yield | |
|---|---|---|---|---|
| | IISCO | TISCO | IISCO | TISCO |
| 1984-85 | 0.5916 | 0.6128 | 258 | 281 |
| 1985-86 | 0.6190 | 0.6073 | 262 | 279 |
| 1986-87 | 0.6280 | 0.6176 | 261 | 278 |
| 1987-88 | 0.6660 | 0.6236 | 269 | 279 |
| 1988-89 | 0.6640 | 0.6477 | 275 | 281 |
| 1989-90 | 0.6640 | 0.6477 | 275 | 281 |
| 1994-95 | 0.6640 | 0.6477 | 275 | 281 |
| 1999-2000 | 0.6640 | 0.6477 | 275 | 281 |