Coal Supply and Demand Trends in India ♦

- Role of Coal and its Future -

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Introduction

The Website of the Embassy of India in Japan introduces the economy of India as follows [1] : "India- the fourth largest economy in terms of purchasing power parity and the tenth most industrialized country in the world- is one of the fastest growing developing economies today, a result of wide ranging on-going economic reforms undertaken in the early nineties. It has attracted favourable international attention thanks to its recent remarkable growth, as well as its undoubted potential to sustain this performance for years to come. Thus, the Goldman Sachs famous BRICs report lists India as the only country with the prospect of registering at least 5% growth in GDP for the next fifty years."

This report is about the role coal plays in the energy supply, which is the basis of such economic growth in India, and will provide information including the current domestic supply capacity (reserves, production technology and related infrastructure) and demand trend in electric power and industrial sectors.

1. Coal in the Primary Energy Supply

Change in primary energy supply (domestic production) by fiscal years in India [2] is shown in Table 1-1. Total primary energy supply in FY2004 was 13,160PJ. Coal and lignite accounted for 6,855PJ, 52.1% of the total, whereas crude oil was 1,423PJ (10.8% of the total). Natural gas was 1,224PJ (9.3% of the total), and the total of hydro and nuclear was 3,658PJ (27.8% of the total). Since 1987, share of coal in primary energy supply has maintained a level of around 50%, but after 2001, the share

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1 http://www.embassy-avenue.jp/india/index.html

2 The fiscal year in India starts in April and ends next March, as in Japan.

increased to more than 50%. Average growth rates for the ten-year period from FY1984 to FY1994 are as follows: 4.9% for coal and lignite, 1.1% for crude oil, 10.4% for natural gas, 4.3% for hydro and nuclear, and 4.4% for total primary energy supply. Similarly, for the ten-year period from FY1994 to FY2004, the growth rates were as follows: 3.3% for coal and lignite, 0.5% for crude oil, 5.0% for natural gas, 1.4% for hydro and nuclear, and 2.6% for the total primary energy supply. Therefore, looking at the ten-year period trends, growth of energy supply (domestic production) is slowing in comparison to the growth of the size of economy. However, for the last three years, primary energy supply (domestic production) grew steadily at an annual average of 6.0%, although still slightly behind growth of the economy. (The growth rate was notable for coal at 5.8%, and hydro and nuclear at 10.4%, while the growth of natural gas was 0.6%, showing stagnation.)

Table 1-1 Change in Primary Energy Supply (domestic production)

(Unit: PJ)

Fiscal year	Coal/Lignite	Crude oil	Natural gas	Hydro/Nuclear	Total
1984	3,047 (46.0%)	1,214 (18.3%)	279 (4.2%)	2,089 (31.5%)	6,629 (100.0%)
1985	3,185 (47.0%)	1,263 (18.6%)	313 (4.6%)	2,016 (29.7%)	6,777 (100.0%)
1986	3,439 (47.7%)	1,276 (17.7%)	380 (5.3%)	2,119 (29.4%)	7,214 (100.0%)
1987	3,778 (51.2%)	1,271 (17.2%)	442 (6.0%)	1,889 (25.6%)	7,380 (100.0%)
1988	4,097 (49.7%)	1,342 (16.3%)	509 (6.2%)	2,293 (27.8%)	8,241 (100.0%)
1989	4,233 (48.6%)	1,427 (16.4%)	654 (7.5%)	2,403 (27.6%)	8,717 (100.0%)
1990	4,063 (45.5%)	1,383 (15.5%)	693 (7.8%)	2,800 (31.3%)	8,939 (100.0%)
1991	4,431 (48.0%)	1,271 (13.8%)	718 (7.8%)	2,818 (30.5%)	9,238 (100.0%)
1992	4,606 (50.1%)	1,128 (12.3%)	696 (7.6%)	2,757 (30.0%)	9,187 (100.0%)
1993	4,751 (51.0%)	1,132 (12.1%)	706 (7.6%)	2,731 (29.3%)	9,320 (100.0%)
1994	4,935 (48.3%)	1,350 (13.2%)	750 (7.3%)	3,181 (31.1%)	10,216 (100.0%)
1995	5,264 (50.1%)	1,472 (14.0%)	872 (8.3%)	2,900 (27.6%)	10,508 (100.0%)
1996	5,498 (52.0%)	1,378 (13.0%)	896 (8.5%)	2,807 (26.5%)	10,579 (100.0%)
1997	5,469 (49.9%)	1,418 (12.9%)	1,017 (9.3%)	3,048 (27.8%)	10,952 (100.0%)
1998	5,392 (48.0%)	1,370 (12.2%)	1,057 (9.4%)	3,414 (30.4%)	11,233 (100.0%)
1999	5,454 (48.4%)	1,338 (11.9%)	1,096 (9.7%)	3,384 (30.0%)	11,272 (100.0%)
2000	5,683 (49.6%)	1,358 (11.8%)	1,135 (9.9%)	3,286 (28.7%)	11,462 (100.0%)
2001	5,948 (50.5%)	1,341 (11.4%)	1,145 (9.7%)	3,350 (28.4%)	11,784 (100.0%)
2002	6,126 (52.3%)	1,383 (11.8%)	1,209 (10.3%)	3,003 (25.6%)	11,721 (100.0%)
2003	6,496 (52.1%)	1,397 (11.2%)	1,231 (9.9%)	3,349 (26.8%)	12,473 (100.0%)
2004	6,855 (52.1%)	1,423 (10.8%)	1,224 (9.3%)	3,658 (27.8%)	13,160 (100.0%)
Average annual growth rate	Coal/Lignite	Crude oil	Natural gas	Hydro/Nuclear	Total
1984-1994	4.9%	1.1%	10.4%	4.3%	4.4% (5.5%)
1994-2004	3.3%	0.5%	5.0%	1.4%	2.6% (6.2%)
2002-2004	5.8%	1.4%	0.6%	10.4%	6.0% (7.7%)

Note: PJ = Peta Joule = 10^{15}Joule

Figures in parentheses for each fiscal year show the composition ratio of each energy source to the total primary energy supply (domestic production).

Figures in parentheses for the annual average growth rate show the annual average growth of real GDP.

Source: Central Statistical Organisation / Ministry of Statistics and Programme Implementation, “Energy Statistics 2004-05”

Forecast of primary energy supply for commercial use in India[3] is shown in Table 1-2. The forecast is based on two scenarios : GDP growth rate of 7% and 8%. However, forecasts for hydro and nuclear are the same regardless of GDP growth rate. With a GDP growth rate of 7%, it is forecast that the primary energy supply will increase from 327 million tons equivalent to oil (hereinafter indicated as toe) in FY2003 to 1,344 million toe in FY2031, with an average annual rate of 5.2%. Similarly, with a GDP growth rate of 8%, the average annual rate will be 5.9%, and it will increase to 1,633 million toe by FY2031. As for the composition of primary energy supply, it is forecast that coal will hold the largest share in both cases. Although increases in the supply of natural gas and nuclear are expected to reduce effects on the environment, coal will likely remain the leading part in energy supply in the future as well.

Table 1-2 Forecast of Primary Energy Supply

(Unit: million toe)

		Fiscal year							Average annual growth		
		2003	2006	2011	2016	2021	2026	2031	03-16	16-31	03-31
Case with GDP growth rate of 7%	Hydro	7	9	15	19	24	34	43	8.0%	5.6%	6.7%
		2.1%	2.4%	3.1%	3.0%	3.0%	3.2%	3.2%			
	Nuclear	5	7	15	29	54	79	115	14.5%	9.6%	11.8%
		1.5%	1.9%	3.1%	4.6%	6.8%	7.5%	8.6%			
	Coal	167	200	253	322	393	517	641	5.2%	4.7%	4.9%
		51.1%	53.3%	52.4%	51.5%	49.3%	49.2%	47.7%			
	Oil	119	124	151	188	234	294	370	3.6%	4.6%	4.1%
		36.4%	33.1%	31.3%	30.1%	29.4%	28.0%	27.5%			
	Natural gas	29	35	49	67	92	127	175	6.7%	6.6%	6.6%
		8.9%	9.3%	10.1%	10.7%	11.5%	12.1%	13.0%			
	Total	327	375	483	625	797	1,051	1,344	5.1%	5.2%	5.2%
Case with GDP growth rate of 8%	Hydro	7	9	15	19	24	34	43	8.0%	5.6%	6.7%
		2.1%	2.4%	3.0%	2.8%	2.7%	2.8%	2.6%			
	Nuclear	5	7	15	29	54	79	115	14.5%	9.6%	11.8%
		1.5%	1.8%	3.0%	4.2%	6.0%	6.4%	7.0%			
	Coal	167	204	269	360	456	632	816	6.1%	5.6%	5.8%
		51.1%	53.5%	53.0%	52.6%	50.6%	51.2%	50.0%			
	Oil	119	125	157	201	259	334	435	4.1%	5.3%	4.7%
		36.4%	32.8%	30.9%	29.4%	28.7%	27.1%	26.6%			
	Natural gas	29	36	52	75	108	155	224	7.6%	7.6%	7.6%
		8.9%	9.4%	10.2%	11.0%	12.0%	12.6%	13.7%			
	Total	327	381	508	684	901	1,234	1,633	5.8%	6.0%	5.9%

Note: The upper row shows the energy supply and the lower row shows the composition ratio for each fiscal year.

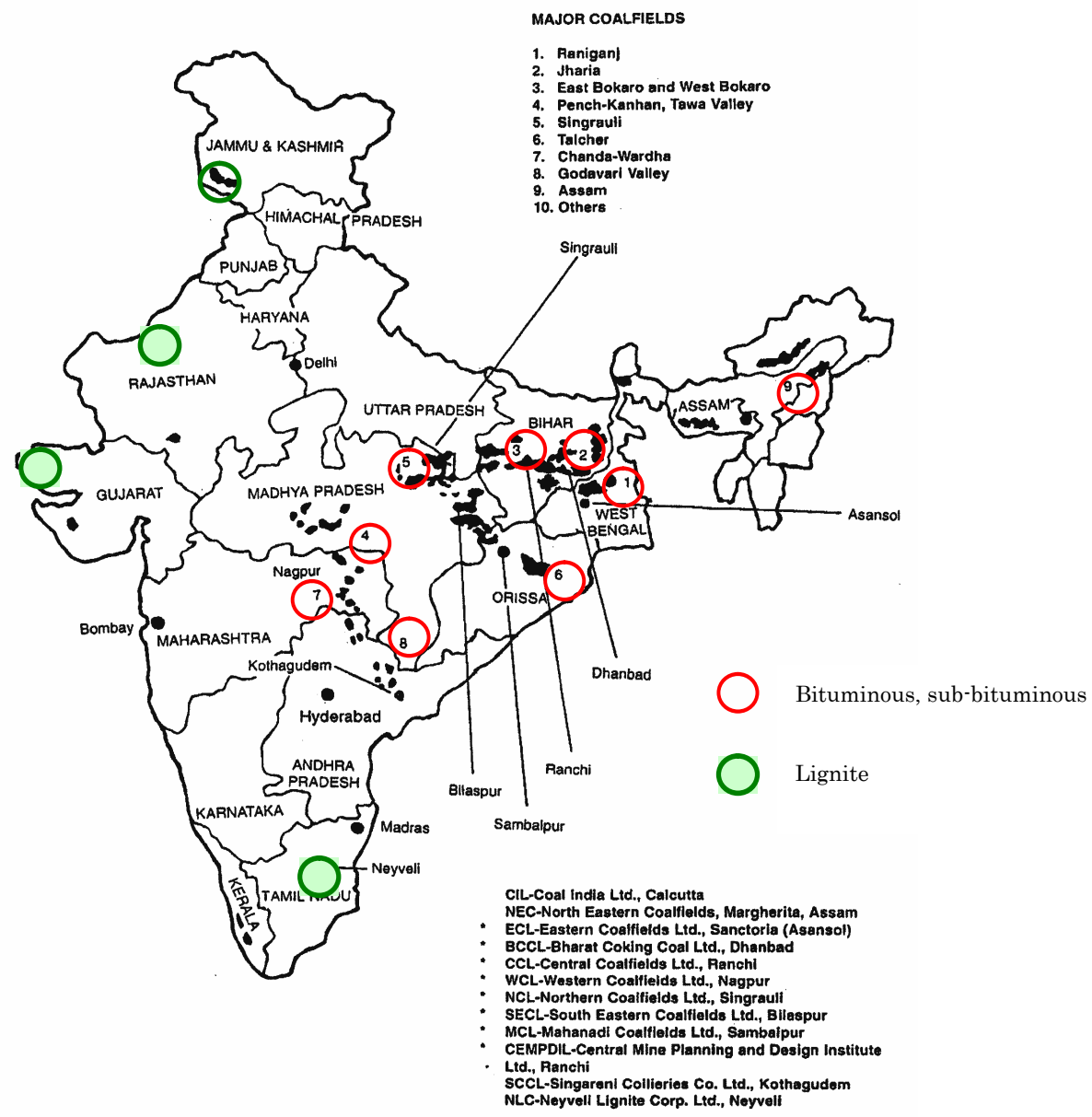
Source: The Planning Commission, “Draft Report of the Expert Committee on Integrated Energy Policy” (December 2005).

[3] The Planning Commission develops the forecast of primary energy supply. In this forecast, primary energy supply is divided into commercial use and non-commercial use. For commercial use, forecasts are made separately for the demands of coal, petroleum and natural gas for electric power, which consumes the most energy, and on the demands of coal, petroleum and natural gas for consumption other than electric power. Forecast on primary energy of non-commercial use covers wood fuel, electric power, manure, kerosene and LPG.

2. Coal Resources

Coal resources in India are divided into Gondwana coal, comprised of coal seams of the Permian Period in the Palaeozoic Era, coal of the Tertiary Period in the Cenozoic Era, and lignite. Gondwana coal (hard coal), which constitutes the large majority of coal resources, is concentrated in Central to Eastern India, as shown in Figure 2-1 [4].

Figure 2-1 Coal Distribution Map in India



Source: Central Mine Planning and Design Institute/Coal India Limited.

[4] Gondwana coal can be found mainly in the States of West Bengal, Jharkhand, Bihar, Orissa and Madhya Pradesh. Coal of the Tertiary Period is found in the Northeastern States, Assam State and Jammu Kashmir State. Most of lignite is found in Tamil Nadu, it is also found in the States of Jammu Kashmir, Rajasthan and Gujarat.

As shown in Table 2-1, the Central Government of India announced that the amount of coal reserves in the country is 283,500 million tons [5]. When the coal reserves are categorized by type of coal, coking coal (prime coking coal, medium coking coal, semi coking coal) accounts for 32.1 billion tons, and steaming coal (for electric power and industry in general) accounts for 215.8 billion tons, so the reserves of steaming coal [6] are overwhelmingly larger. Reserves of lignite are estimated at 35.6

Table 2-1 Coal Reserves

(Unit: million tons)

		Proved	Indicated	Inferred	Total	Major type of coal
Coking coal	Prime coking coal	4,614	699	-	5,313 (1.9%)	
	Medium coking coal	11,417	11,765	1,889	25,071 (8.8%)	
	Semi coking coal	482	1,003	222	1,707 (0.6%)	
	Total	16,513	13,467	2,111	32,091 (11.3%)	
Steaming coal		76,447	103,623	35,686	215,756 (76.1%)	
Total		92,960	117,090	37,797	247,847 (87.4%)	
Brown coal		-	-	-	35,636 (12.6%)	
Sum total		-	-	-	283,483 (100.0%)	
Jharkhand		35,417	30,439	6,348	72,204 (25.5%)	Steaming coal, Prime coking coal, Medium coking coal
Orissa		15,161	30,976	14,847	60,984 (21.5%)	Steaming coal
Chhattisgarh		9,373	26,191	4,411	39,975 (14.1%)	Steaming coal
West Bengal		11,383	11,876	4,554	27,813 (9.8%)	Medium coking coal
Madhya Pradesh		7,513	8,815	2,904	19,232 (6.8%)	Medium coking coal
Andhra Pradesh		8,263	6,079	2,584	16,926 (6.0%)	Steaming coal
Maharashtra		4,653	2,309	1,620	8,582 (3.0%)	Steaming coal
Uttar Pradesh		766	296	0	1,062 (0.4%)	Steaming coal
Meghalaya		117	41	301	459 (0.2%)	Steaming coal
Assam		279	27	34	340 (0.1%)	Steaming coal
Bihar		0	0	160	160 (0.1%)	Steaming coal
Arunachal Pradesh		31	40	19	90 (0.0%)	Steaming coal
Nagaland		4	1	15	20 (0.0%)	Steaming coal
Tami Nadu		-	-	-	30,523 (10.8%)	Lignite
Rajasthan		-	-	-	3,099 (1.1%)	Lignite
Gujarat		-	-	-	1,778 (0.6%)	Lignite
Jammu Kashmir		-	-	-	128 (0.0%)	Lignite
Kerala		-	-	-	108 (0.0%)	Lignite

Note: Figures show coal reserves as of January 1, 2005 at the depth of 1,200m or shallower.
Percentage of the total shows the composition ratio to the total coal reserves.
Refer to Attached Map 1 at the end for the location of each state.

Source: Hard coal: Ministry of Coal, "Annual Report 2004-05"
Lignite: Ministry of Mineral and Mines, "Indian Mineral Year-Book 2004"

[5] According to the figures of the World Energy Council (WEC) in 2004, recoverable reserves of coal in the world accounts for 909.1 billion tons. Reserves in India are estimated at 92.4 billion tons, or 10.2% of the total, and ranks fourth in the world following the U.S., Russia, and China.

[6] The calorific value of steaming coal based on Indian industrial standards is rather lower than that of steaming coal supplied by the international market, as shown in Table 4-3. Steaming coal in the international market is categorized under Grades A or B, according to India's coal categorization system. Coal in Grades F and E, which accounts for the largest amount produced in India, is internationally referred to as a low-quality product, and is barely handled in trade markets.

billion tons. By State, hard coal reserves are notable in Jharkhand, accounting for 72.2 billion tons, which includes not only steaming coal but also coking coal. It is followed by Orissa (61.0 billion tons), Chhattisgarh (40.0 billion tons), West Bengal (27.8 billion tons), Madhya Pradesh (19.2 billion tons) and Andhra Pradesh (16.9 billion tons). Lignite can be found in Southern and Northwestern India, with most of its endowment in Tamil Nadu (30.5 billion tons).

3. Current State and Forecast of Coal Demand

3-1 Current State of Coal Consumption

Table 3-1 shows the change in coal consumption (raw coal, excluding lignite) in India by sector. Major consuming sectors are electricity, iron and steel, and cement.

Table 3-1 Change in Coal Consumption by Sectors (excluding lignite)

(Unit: million tons)

Fiscal year	Electricity	Iron and steel	Cement	Other	Total
1984	57.7 (40.8%)	25.0 (17.7%)	7.3 (5.2%)	51.5 (36.4%)	141.5 (100.0%)
1985	68.6 (44.1%)	24.8 (16.0%)	8.0 (5.2%)	54.0 (34.7%)	155.5 (100.0%)
1986	78.6 (47.1%)	24.2 (14.5%)	8.9 (5.3%)	55.2 (33.1%)	166.8 (100.0%)
1987	91.8 (51.2%)	26.7 (14.9%)	8.8 (4.9%)	52.0 (29.0%)	179.2 (100.0%)
1988	97.2 (50.6%)	29.8 (15.5%)	9.3 (4.8%)	55.9 (29.1%)	192.1 (100.0%)
1989	108.3 (53.2%)	30.6 (15.0%)	9.5 (4.7%)	55.0 (27.0%)	203.4 (100.0%)
1990	113.7 (53.3%)	30.9 (14.5%)	10.4 (4.9%)	58.3 (27.3%)	213.4 (100.0%)
1991	126.8 (54.6%)	34.0 (14.6%)	10.8 (4.6%)	60.7 (26.1%)	232.3 (100.0%)
1992	138.6 (57.3%)	37.1 (15.4%)	11.7 (4.8%)	54.4 (22.5%)	241.8 (100.0%)
1993	154.4 (60.2%)	37.6 (14.7%)	11.1 (4.3%)	53.2 (20.8%)	256.3 (100.0%)
1994	160.9 (59.8%)	38.6 (14.3%)	12.4 (4.6%)	57.4 (21.3%)	269.2 (100.0%)
1995	184.5 (65.0%)	39.1 (13.8%)	11.1 (3.9%)	49.4 (17.4%)	284.0 (100.0%)
1996	199.6 (66.8%)	39.8 (13.3%)	10.1 (3.4%)	49.2 (16.5%)	298.6 (100.0%)
1997	205.5 (67.0%)	39.8 (13.0%)	10.1 (3.3%)	51.4 (16.8%)	306.8 (100.0%)
1998	216.3 (69.0%)	33.9 (10.8%)	14.1 (4.5%)	49.2 (15.7%)	313.5 (100.0%)
1999	236.3 (75.0%)	22.7 (7.2%)	9.5 (3.0%)	46.6 (14.8%)	315.0 (100.0%)
2000	252.9 (74.1%)	30.7 (9.0%)	15.3 (4.5%)	42.2 (12.4%)	341.2 (100.0%)
2001	265.2 (75.8%)	30.0 (8.6%)	14.8 (4.2%)	39.7 (11.3%)	349.7 (100.0%)
2002	267.9 (74.1%)	30.6 (8.5%)	16.4 (4.5%)	46.9 (13.0%)	361.7 (100.0%)
2003	280.0 (73.8%)	29.7 (7.8%)	16.6 (4.4%)	53.1 (14.0%)	379.4 (100.0%)
2004	305.3 (75.5%)	32.1 (7.9%)	18.1 (4.5%)	49.2 (12.1%)	404.7 (100.0%)
Average annual growth rate	Electricity	Iron and steel	Cement	Other	Total
1984-1994	10.8%	4.4%	5.4%	1.1%	6.6% (5.5%)
1994-2004	6.6%	-1.8%	3.9%	-1.5%	4.2% (6.2%)
2002-2004	6.8%	2.4%	5.2%	2.4%	5.8% (7.7%)

Note: Consumption is for raw coal excluding lignite.
Figures in parentheses for each fiscal year show the composition ratio of each sector to the coal demand in total.
Figures in parentheses for average annual growth rate show the average growth rate of real GDP.

Source: Central Statistical Organisation/Ministry of Statistics and Programme Implementation, “Energy Statistics 2004-05”

Coal consumption in the electricity sector in FY2004 was 305.3 million tons, or 75.5% of the total. It is followed by 32.1 million tons (7.9%) in the iron and steel sector, and 18.1 million tons (4.5%) in the cement sector, and these three sectors in total account for 88% of the total. Consumption in other sectors (fertilizer, ceramic industry other than cement, textile, chemicals, paper, etc.) was 49.2 million tons, or 12.1% of the total. When comparing coal consumption in FY1984 and FY2004, consumption decreased in other sectors only. This is largely because coal consumption by railway decreased to zero during this period. On the other hand, coal consumption for the electricity sector over the same period increased by 247.7 million tons, iron and steel sector by 7.1 million tons and cement sector by 10.8 million tons. In particular, coal consumption in the electricity is nearly five times larger than 20 years ago. Increase in coal consumption in India is largely due to increased consumption for electricity.

3-1-1 Coal Consumption in the Electricity

Table 3-2 shows the comparison of the change in electric power generation in India (excluding private power generation) and coal consumption in the electricity sector shown in Table 3-1 above. Electric power generation in FY2004 was 587.4 TWh. By power source, coal fired power generation was 424.1 TWh (composition ratio: 72.2%). Diesel fired power generation was 2.5 TWh (0.4%), and gas fired power generation was 59.5 TWh (composition ratio: 10.1%). Thermal power generation in total accounted for 486.1 TWh (composition ratio: 82.7%), while hydraulic power generation accounted for 84.5 TWh (composition ratio: 14.4%) and nuclear power generation for 16.8 TWh (composition ratio: 2.9%). Thermal power generation is the major source of power generation in India, and coal fired power generation holds the largest share among them. Therefore, the role of coal in India is quite important. The growth rate of electric power generation by power source for the ten-year period from FY1984 to FY1994 were as follows: 10.2% for thermal power, 4.4% for hydraulic power, 3.3% for nuclear power, and 8.4% for total electric power generation. Therefore, growth in thermal power is notable. Similarly, the growth rate for the ten-year period from FY1994 to FY2004 were: 6.4% for thermal power, 0.2% for hydraulic power, 11.5% for nuclear power, and 5.3% for electric power generation in total. While the growth of thermal power is still strong, nuclear power had the highest growth rate for the period.

Based on available materials, there is no breakdown of thermal power generation in FY2002 and before. In Table 3-2, coal fired power generation during this period is estimated. First, coal consumption per 1kWh (coal consumption rate) was calculated from electric power generation and coal consumption during FY2003-FY2004. Then, based on this rate, coal consumption rate [7] in 2002 and before is assumed at

[7] Based on the material by Central Electricity Authority, the coal consumption rate for FY1995 and after is 700-730g/kWh.

680g/kWh, and electric power generation is calculated from coal consumption for each fiscal year. This estimation is based on the premise that there are no changes in power generation efficiency and calorific value of coal. As a result, it was confirmed that the share of electric power generation by coal fired power generation was the largest in the past as well.

The coal consumption rate in Japan is at the level of 340g/kWh. Compared to this figure, coal consumption in India is extremely inefficient. The major reason for this is considered to be the calorific value of coal. While the calorific value of coal used in Japan for power generation is 6,000kcal/kg or more, in India, it is around 3,800kcal/kg, even for hard coal, and that of lignite remains at the level of around 2,700kcal/kg. In FY2004, 92% of coal consumption was hard coal, and the remaining 8% was lignite.

3-1-2 Coal Consumption in the Iron and Steel Sector

Table 3-3 compares the changes in pig iron production and coal consumption in the iron and steel sector shown in Table 3-1. Please note that the figure of coal imports here shows imports of coking coal for each fiscal year, and that domestic coal consumption was calculated by subtracting this import figure from coal consumption shown in table 3-1.

From FY1994 to FY2004, pig iron production expanded at an average annual growth rate of 3.5%, from 17.8 million tons to 25.1 million tons. On the other hand, coal consumption decreased from 38.6 million tons in FY1994 to 32.1 million tons in FY2004, a decrease by 6.5 million tons. In Table 3-3, coal consumption is divided by pig iron production to obtain coal consumption per 1 ton of pig iron (coal consumption rate). Up to FY1998, when domestic coal accounted for more than 70% of the total coal consumption, the coal consumption rate was more than 1.6tons/ton. On the other hand, in FY1999 and after, when the share of domestic coal decreased to less than 70%, the rate becomes less than 1.6 tons/ton. Ash content in domestic coal is high even for coking coal (see Table 4-3), and an increase in the use of domestic coal will lead to a jump in the amount of coal consumption necessary for pig iron production. In contrast, increase in the use of import coal can relatively reduce the coal consumption even if pig iron production is increased, as can be seen in FY2002-FY2004.

3-1-3 Coal Consumption in the Cement Sector

Table 3-4 compares the changes in cement production and coal consumption in the cement sector shown in Table 3-1. Cement production became 2.1 times larger from 62.3 million tons in FY1994 to 133.6 million tons in FY2004, showing a average annual growth rate of 7.9%. Compared to this, growth of calorific consumption is relatively small. The main reason for this is improvement in coal quality due to increases of imported coal, and this tendency can be found notably in FY1997-FY1999.

Table 3-2 Changes in Electric Power Generation and Coal Consumption for Electricity

Table 2 : Production of primary sources of conventional Energy in India

(Unit: TWh)

Fiscal year	Thermal power				Hydraulic power	Nuclear power	Total	Coal consumption		Estimation of electric power generation based on coal consumption	
	Coal	Diesel	Gas	Sub-total				(million tons)	(g/kWh)	Coal	Diesel + gas
1984	- -	- -	- -	98.8 (63.0%)	53.9 (34.4%)	4.1 (2.6%)	156.9 (100%)	57.7	(680)	84.8 (54.1%)	14.0 (9.0%)
1985	- -	- -	- -	114.3 (67.1%)	51.0 (30.0%)	5.0 (2.9%)	170.4 (100%)	68.6	(680)	100.9 (59.3%)	13.4 (7.9%)
1986	- -	- -	- -	128.9 (68.6%)	53.8 (28.7%)	5.0 (2.7%)	187.7 (100%)	78.6	(680)	115.6 (61.6%)	13.3 (7.1%)
1987	- -	- -	- -	149.6 (74.0%)	47.4 (23.5%)	5.0 (2.5%)	202.1 (100%)	91.8	(680)	135.0 (66.8%)	14.6 (7.2%)
1988	- -	- -	- -	157.7 (71.2%)	57.9 (26.1%)	5.8 (2.6%)	221.4 (100%)	97.2	(680)	143.0 (64.6%)	14.7 (6.6%)
1989	- -	- -	- -	178.7 (72.8%)	62.1 (25.3%)	4.6 (1.9%)	245.4 (100%)	108.3	(680)	159.3 (64.9%)	19.4 (7.9%)
1990	- -	- -	- -	186.5 (70.6%)	71.6 (27.1%)	6.1 (2.3%)	264.3 (100%)	113.7	(680)	167.2 (63.3%)	19.3 (7.3%)
1991	- -	- -	- -	208.7 (72.7%)	72.8 (25.3%)	5.5 (1.9%)	287.0 (100%)	126.8	(680)	186.5 (65.0%)	22.2 (7.7%)
1992	- -	- -	- -	224.8 (74.6%)	69.9 (23.2%)	6.7 (2.2%)	301.4 (100%)	138.6	(680)	203.8 (67.6%)	21.0 (7.0%)
1993	- -	- -	- -	248.2 (76.6%)	70.5 (21.7%)	5.4 (1.7%)	324.1 (100%)	154.4	(680)	227.1 (70.1%)	21.1 (6.5%)
1994	- -	- -	- -	262.1 (74.8%)	82.7 (23.6%)	5.6 (1.6%)	350.5 (100%)	160.9	(680)	236.5 (67.5%)	25.6 (7.3%)
1995	- -	- -	- -	299.3 (78.8%)	72.6 (19.1%)	8.0 (2.1%)	379.9 (100%)	184.5	(680)	271.3 (71.4%)	28.0 (7.4%)
1996	- -	- -	- -	317.9 (80.3%)	68.9 (17.4%)	9.1 (2.3%)	395.9 (100%)	199.6	(680)	293.6 (74.2%)	24.4 (6.2%)
1997	- -	- -	- -	337.1 (79.9%)	74.6 (17.7%)	10.1 (2.4%)	421.7 (100%)	205.5	(680)	302.3 (71.7%)	34.8 (8.3%)
1998	- -	- -	- -	353.7 (78.9%)	82.9 (18.5%)	11.9 (2.7%)	448.5 (100%)	216.3	(680)	318.1 (70.9%)	35.6 (7.9%)
1999	- -	- -	- -	387.1 (80.5%)	80.8 (16.8%)	13.2 (2.8%)	481.1 (100%)	236.3	(680)	347.5 (72.2%)	39.6 (8.2%)
2000	- -	- -	- -	409.9 (81.8%)	74.4 (14.8%)	16.9 (3.4%)	501.2 (100%)	252.9	(680)	372.0 (74.2%)	38.0 (7.6%)
2001	- -	- -	- -	424.4 (82.0%)	73.6 (14.2%)	19.5 (3.8%)	517.4 (100%)	265.2	(680)	390.0 (75.4%)	34.4 (6.6%)
2002	- -	- -	- -	449.3 (84.3%)	64.0 (12.0%)	19.4 (3.6%)	532.7 (100%)	267.9	(680)	394.0 (74.0%)	55.3 (10.4%)
2003	404.9 (72.5%)	3.2 (0.6%)	58.7 (10.5%)	466.8 (83.6%)	73.8 (13.2%)	17.7 (3.2%)	558.3 (100%)	280.0	691	404.9 (72.5%)	61.9 (11.1%)
2004	424.1 (72.2%)	2.5 (0.4%)	59.5 (10.1%)	486.1 (82.7%)	84.5 (14.4%)	16.8 (2.9%)	587.4 (100%)	305.3	720	424.1 (72.2%)	62.0 (10.6%)
Average annual growth rate 1984-1994	-	-	-	10.2%	4.4%	3.3%	8.4% (5.5%)	10.8%		10.8%	6.2%
Average annual growth rate 1994-2004	-	-	-	6.4%	0.2%	11.5%	5.3% (6.2%)	6.6%		6.0%	9.3%
Average annual growth rate 2002-2004	-	-	-	4.0%	14.9%	-6.8%	5.0% (7.7%)	6.8%		3.8%	5.9%

Note: Electric power generation does not include private power generation. Figures in parentheses for each fiscal year show the composition ratio of each power source to total electric power generation.

Figures in parentheses for average annual growth rate show the average growth rate of real GDP. Figures for total thermal power for FY1995 and after include wind power.

Source: FY1984-FY2002: Central Statistical Organisation / Ministry of Statistics & Programme Implementation, “Energy Statistics 2004-05”

FT2003-FY2004: Central Electricity Authority, “Thermal Performance Review 2004-05” and Table 3-1.

However, the share of imported coal of total coal consumption decreased in FY2000 and after, maintaining a level of around 20%.

Table 3-3 Changes in Pig Iron Production and Coal Consumption

(Unit: million tons)

Fiscal year	Pig iron production	Coal Consumption		
		(ton/ton)	Import coal	Domestic coal
1994	17.8	38.6 (2.16)	10.2 (26.3%)	28.4 (73.7%)
1995	19.0	39.1 (2.05)	9.4 (24.0%)	29.7 (76.0%)
1996	20.5	39.8 (1.94)	10.6 (26.7%)	29.1 (73.3%)
1997	21.1	39.8 (1.89)	11.7 (29.5%)	28.1 (70.5%)
1998	20.2	33.9 (1.68)	10.0 (29.6%)	23.9 (70.4%)
1999	20.1	22.7 (1.13)	11.0 (48.4%)	11.7 (51.6%)
2000	21.3	30.7 (1.44)	11.1 (36.0%)	19.7 (64.0%)
2001	21.9	30.0 (1.37)	11.1 (37.0%)	18.9 (63.0%)
2002	24.3	30.6 (1.26)	13.0 (42.3%)	17.7 (57.7%)
2003	26.6	29.7 (1.12)	13.0 (43.8%)	16.7 (56.2%)
2004	25.1	32.1 (1.28)	14.6 (45.4%)	17.5 (54.6%)
Average annual growth rate 1994-2004	3.5%	-1.8%	3.7%	-4.7%
Average annual growth rate 2002-2004	1.6%	2.4%	6.1%	-0.4%

Note: Domestic coal consumption was derived by subtracting imports from total coal consumption.
Figures in parentheses show the value of coal consumption divided by pig iron production (coal consumption rate).
Percentage shown in parentheses for import coal and domestic coal are composition ratios.

Source: Pig iron production: Japan Iron and Steel Federation, "Handbook for Iron and Steel Statistics" for each year
Coal consumption: Central Statistical Organisation / Ministry of Statistics and Programme, "Energy Statistics 2004-05"
Import coal consumption: Ministry of Commerce & Industry, "Export Import Data Bank"

Table 3-4 Changes in Cement Production and Coal Consumption

(Unit: million tons)

Fiscal year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Average annual growth rate '94-'04	Average annual growth rate '02-'04
Cement production	62.3	69.3	76.2	83.1	90.5	98.2	97.6	106.9	116.3	123.4	133.6	7.9%	7.2%
Coal consumption Specific consumption (ton/ton)	12.4	11.1	10.1	10.1	14.1	9.5	15.3	14.8	16.4	16.6	18.1	3.9%	5.2%
Coal consumption / Cement production	(0.198)	(0.160)	(0.132)	(0.121)	(0.156)	(0.097)	(0.157)	(0.139)	(0.141)	(0.135)	(0.135)		
Coal import	0.7	1.3	1.7	3.5	4.7	6.0	4.4	3.4	3.7	3.2	3.6	17.7%	-0.4%
Import/consumption	5.7%	11.8%	16.4%	34.9%	33.0%	63.5%	28.7%	22.7%	22.4%	19.1%	20.1%		

Note: Coal consumption and coal imports include coals used for private power generation.

Source: Cement production, coal imports: Cement Manufactures' Association, "Cement Statistics 2000&2005"
Coal consumption: Central Statistical Organisation/Ministry of Statistics and Programme Implementation, "Energy Statistics 2004-05"

3-2 Forecast on Coal Demand

3-2-1 Forecast on Coal Demand by the Planning Commission

According to the initial forecast announced by the Planning Commission of India in the Tenth Five-Year Plan, coal demand is estimated as follows: 460.5 million tons of hard coal and 57.8 million tons of lignite, and 518.3 million tons in total for FY2006; 620.0 million tons of hard coal and 81.5 million tons of lignite, and 701.5 million tons in total in FY2011. Afterwards, the working group on the Planning Commission upwardly revised the figures, and the forecast as of 2005 shows that the demand for hard coal in FY2006 will be 473.0 million tons and that in FY2011 will be 676.0 million tons. Also, in the draft of report by the Expert Committee on Integrated Energy Policy by the Planning Commission, forecast on coal demand shown in Table 3-5 is included, which is cited from "Coal Vision 2025" prepared by The Energy and Resources Institute (TERI).

This forecast on coal demand is based on two scenarios. One in which the GDP growth rate is 7%, and one in which it is 8%. With a GDP growth rate of 7%, it is forecast that coal demand will increase from 445.7 million tons in FY2005 and to 1,147.1 million tons by FY2024, and with a GDP growth rate of 8%, to 1,272.0 million tons by FY2024. Average annual growth rate of coal demand is 5.1% in the case of 7% GDP growth rate, and is 5.7% in the case of the 8% scenario. By sectors, the growth rate is the highest for cement, followed by power captive (IPP) and iron and steel. As for the share of each sector in total coal demand, cement will increase by 5 points in the said period, but the shares of all other sectors will slightly decline.

3-2-2 Forecast on Coal Demand by the Ministry of Coal

The "Annual Plan 2005-06" published annually by the Ministry of Coal shows the forecast for coal demand by FY2011. This shows that coal demand will increase from 445.7 million tons in FY2005 to 676.0 million tons by FY2011, an increase by 230.0 million tons. Most of the increase is due to the increase of demand in the power captive (IPP) sector. Coal demand in the power utilities sector will show an average annual growth of 9.1% from FY2005, and the share of the power sector of total coal demand will increase from 74.2% in FY2005 to 80.3% in FY2011. The average annual growth rates for iron and steel (coke) and cement during the same period will be around 3-4%, and it is forecast that shares for both sectors will decrease.

Table 3-5 Forecast on Coal Demand by the Planning Commission

(Unit: million tons)

	Fiscal year	2005	2006	2011	2016	2021	2024	Average annual growth		
								'05-'11	'11-'21	'05-'24
Case with GDP growth rate of 7%	Power utilities	303.6 (68.1%)	317.0 (67.0%)	412.7 (67.5%)	517.3 (66.2%)	635.5 (64.1%)	718.9 (62.7%)	5.3%	4.4%	4.6%
	Power captive	27.4 (6.1%)	28.3 (6.0%)	43.3 (7.1%)	59.9 (7.7%)	83.5 (8.4%)	101.9 (8.9%)	7.9%	6.8%	7.2%
	Iron and steel	42.1 (9.4%)	42.7 (9.0%)	53.1 (8.7%)	66.6 (8.5%)	83.9 (8.5%)	96.5 (8.4%)	4.0%	4.7%	4.5%
	Cement	20.2 (4.5%)	25.4 (5.4%)	38.4 (6.3%)	58.2 (7.4%)	88.2 (8.9%)	113.1 (9.9%)	11.3%	8.7%	9.5%
	Bricks and others	52.5 (11.8%)	59.8 (12.6%)	63.5 (10.4%)	79.6 (10.2%)	100.7 (10.2%)	116.5 (10.2%)	3.2%	4.7%	4.3%
	Total	445.7	473.2	611.1	781.5	991.7	1,147.1	5.4%	5.0%	5.1%
Case with GDP growth rate of 8%	Power utilities	303.6 (68.1%)	317.0 (67.0%)	427.2 (67.8%)	552.6 (66.7%)	698.5 (64.8%)	804.0 (63.2%)	5.9%	5.0%	5.3%
	Power captive	27.4 (6.1%)	28.3 (6.0%)	44.3 (7.0%)	63.0 (7.6%)	90.0 (8.3%)	116.6 (9.2%)	8.4%	7.3%	7.9%
	Iron and steel	42.1 (9.4%)	42.7 (9.0%)	54.2 (8.6%)	69.5 (8.4%)	89.5 (8.3%)	104.5 (8.2%)	4.3%	5.1%	4.9%
	Cement	20.2 (4.5%)	25.4 (5.4%)	39.4 (6.3%)	61.1 (7.4%)	94.8 (8.8%)	123.5 (9.7%)	11.8%	9.2%	10.0%
	Bricks and others	52.5 (11.8%)	59.8 (12.6%)	64.5 (10.2%)	82.1 (9.9%)	105.6 (9.8%)	123.4 (9.7%)	3.5%	5.1%	4.6%
	Total	445.7	473.2	629.6	828.2	1,078.5	1,272.0	5.9%	5.5%	5.7%

Note: Although the material shows that total demand in FY2024 with 8% GDP annual rate increase assumption is 1,267 million tons, aggregation by industry sector adds up to 1,272 million tons. Figure by aggregation is used here.
Figures shown in parentheses show the composition ratio of each sector to total coal demand.
Refer to “Annual Plan 2005-06” by the Ministry of Coal for FY2005 and FY2006.

Source: The Planning Commission, “Draft Report of the Expert Committee on Integrated Energy Policy” (December 2005)

Table 3-6 Forecast on Coal Demand by the Ministry of Coal

(Unit: million tons)

Fiscal year	Power utilities	Power captive	Iron and steel (coke)	Cement	Other	Total
2005	303.6 (68.1%)	27.4 (6.1%)	42.1 (9.4%)	20.2 (4.5%)	52.5 (11.8%)	445.7
2011	511.0 (75.6%)	32.0 (4.7%)	54.0 (8.0%)	24.0 (3.6%)	55.0 (8.1%)	676.0
Average annual growth 2005-2011	9.1%	2.6%	4.3%	2.9%	0.8%	7.2%

Note: Figures in parentheses show the composition rate of each sector in the total coal demand.

Source: Ministry of Coal, “Annual Plan 2005-06”

4. Current State and Forecast of Coal Supply

4-1 Current State of Coal Production

Table 4-1 shows the changes of coal production from FY1985 to FY2004. Coal production in FY2004 was 382.6 million tons of hard coal (30.2 million tons of coking coal and 352.4 million tons of steaming coal) and 29.3 million tons of lignite, which is 411.90 million tons in total. This is the third largest production figure in the world, following China and the U.S. [8] Hard coal production in India is expanded at an average annual growth rate of 4.0% from FY1994 to FY2004, and became 1.5 times larger in the ten most recent years. When limited to the latest period from FY2002 to FY2004, average growth rate was a further 1.9 points higher at 5.9%. When viewed by type of coal, the production of coking coal has been on a downward trend since peaking in FY1991 when production reached 45.9 million tons. Its share of total coal production decreased to 7.3% from 18.7% in FY1991. Production of steaming coal and lignite has maintained an upward trend. As for steaming coal, its share has also increased in a stable manner, continuously rising from a little more than 70% in the 1980s to 86% in FY2004. On the other hand, lignite's share has maintained a level of around 7% since the 1990s.

By States, coal production in the four States of Bihar, Jharkhand, Madhya Pradesh and Chhattisgarh account for about half of the entire coal production in India. When Orissa State, where coal production shows the largest growth rate, is added, the figure reaches as much as 64% of the total production in FY2004.

4-1-1 Coal Producer

The business organizations of coal producers in India are categorized into the following four groups:

① Government-managed coal producers under the administration of the Ministry of Coal

- Coal India Limited (CIL): Coking coal and steaming coal

CIL is comprised of eight subsidiary companies. One of them is engaged in coal resources exploration and development planning, so there are seven companies producing coal.

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[8] Based on "Coal Information 2005" by OECD/IEA, coal production in FY2004 (forecast) is as follows:

No.1: China Hard coal: 1,956 million tons
No.2: U.S. Hard coal: 933 million tons; Lignite: 76 million tons

Table 4-1 Changes in Coal Production

(Unit: million tons)

	Fiscal year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Average annual growth '85-'94	'94-'04	'02-'04
Hard coal	Coking coal	35.2 (22%)	38.3 (22%)	40.0 (21%)	42.1 (20%)	43.8 (21%)	44.5 (20%)	45.9 (19%)	45.2 (18%)	44.7 (17%)	42.0 (15%)	39.9 (14%)	40.5 (13%)	43.8 (14%)	39.2 (12%)	33.0 (10%)	30.9 (9%)	28.7 (8%)	30.2 (8%)	29.4 (8%)	30.2 (7%)	2.0%	-3.2%	0.0%
	Steaming coal	119.1 (73%)	127.4 (73%)	139.8 (73%)	152.3 (74%)	157.1 (74%)	166.8 (74%)	183.5 (75%)	193.3 (76%)	204.0 (76%)	215.8 (78%)	233.5 (79%)	245.5 (80%)	253.3 (79%)	257.3 (80%)	271.1 (83%)	282.8 (84%)	299.1 (85%)	311.1 (85%)	331.8 (85%)	352.4 (86%)	6.8%	5.0%	6.4%
	Sub-total	154.3 (95%)	165.7 (95%)	179.9 (94%)	194.4 (94%)	200.9 (94%)	211.3 (94%)	229.4 (93%)	238.5 (93%)	248.7 (93%)	257.8 (93%)	273.4 (93%)	286.1 (93%)	297.2 (93%)	296.5 (93%)	304.1 (93%)	313.7 (93%)	327.8 (93%)	341.3 (93%)	361.2 (93%)	382.6 (93%)	5.9%	4.0%	5.9%
Lignite		8.0 (5%)	9.6 (5%)	11.3 (6%)	12.6 (6%)	12.4 (6%)	14.1 (6%)	16.0 (7%)	16.6 (7%)	18.1 (7%)	19.3 (7%)	22.2 (7%)	22.6 (7%)	23.2 (7%)	23.4 (7%)	22.5 (7%)	24.3 (7%)	24.8 (7%)	26.0 (7%)	28.0 (7%)	29.3 (7%)	10.2%	4.3%	6.1%
Total		162.3	175.3	191.1	207.0	213.3	225.4	245.3	255.1	266.8	277.1	295.6	308.7	320.4	319.9	326.6	338.0	352.6	367.3	389.1	411.9	6.1%	4.0%	5.9%
	Fiscal year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	-	'94-'03	'02-'03
Hard coal	Andhra Pradesh	-	-	-	-	-	-	-	-	-	25.0 (9%)	26.8 (9%)	28.7 (9%)	28.9 (9%)	27.3 (9%)	29.6 (9%)	30.3 (9%)	30.8 (9%)	33.2 (9%)	33.9 (9%)	-	-	3.4%	2.1%
	Bihar+ Jharkhand	-	-	-	-	-	-	-	-	-	73.3 (26%)	74.6 (25%)	77.7 (25%)	81.3 (25%)	76.2 (24%)	77.0 (24%)	75.4 (22%)	76.8 (22%)	78.6 (21%)	79.5 (20%)	-	-	0.9%	1.1%
	Madhya Pradesh+ Chhattisgarh	-	-	-	-	-	-	-	-	-	74.9 (27%)	79.8 (27%)	83.3 (27%)	84.8 (26%)	84.9 (27%)	87.9 (27%)	92.7 (27%)	97.8 (28%)	102.5 (28%)	111.3 (29%)	-	-	4.5%	8.6%
	Maharashtra	-	-	-	-	-	-	-	-	-	21.1 (8%)	22.8 (8%)	24.9 (8%)	26.2 (8%)	25.3 (8%)	27.7 (8%)	28.8 (9%)	30.8 (9%)	31.3 (9%)	32.9 (8%)	-	-	5.1%	5.1%
	Orissa	-	-	-	-	-	-	-	-	-	27.3 (10%)	32.7 (11%)	37.4 (12%)	42.2 (13%)	43.5 (14%)	43.6 (13%)	44.8 (13%)	47.8 (14%)	52.2 (14%)	60.0 (15%)	-	-	9.1%	14.9%
	Uttar Pradesh	-	-	-	-	-	-	-	-	-	13.8 (5%)	14.8 (5%)	15.4 (5%)	15.8 (5%)	15.6 (5%)	16.2 (5%)	16.9 (5%)	16.5 (5%)	17.8 (5%)	15.8 (4%)	-	-	1.5%	-11.2%
	West Bengal	-	-	-	-	-	-	-	-	-	17.2 (6%)	17.9 (6%)	18.0 (6%)	17.4 (5%)	18.8 (6%)	17.6 (5%)	20.1 (6%)	21.3 (6%)	20.5 (6%)	21.5 (6%)	-	-	2.5%	4.9%
	Other	-	-	-	-	-	-	-	-	-	5.2 (2%)	4.0 (1%)	0.7 (0%)	0.6 (0%)	4.9 (2%)	4.5 (1%)	4.7 (1%)	6.0 (2%)	5.2 (1%)	6.3 (2%)	-	-	2.1%	20.8%
Lignite	Gujarat	-	-	-	-	-	-	-	-	-	3.8 (1%)	4.9 (2%)	5.2 (2%)	4.9 (2%)	5.0 (2%)	4.3 (1%)	5.4 (2%)	6.2 (2%)	6.9 (2%)	6.7 (2%)	-	-	6.5%	-2.9%
	Rajasthan	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2 (0%)	0.2 (0%)	0.2 (0%)	0.3 (0%)	0.5 (0%)	0.7 (0%)	-	-	-	40.0%
	Tamil Nadu	-	-	-	-	-	-	-	-	-	15.5 (6%)	17.2 (6%)	17.5 (6%)	18.1 (6%)	18.2 (6%)	17.6 (5%)	18.0 (5%)	18.4 (5%)	18.6 (5%)	20.6 (5%)	-	-	3.2%	10.8%

Note: Figures in parentheses for each fiscal year show the composition ratio of each type of coal and that of each State in total coal production.

Source: Coal Controller's Organization/Ministry of Coal, "Coal Directory of India", Ministry of Coal, "Annual Report 2004-05" and The Energy and Resources Institute, "Teri Energy Data Directory & Yearbook 2003-04"

② Government-managed coal producer under the administration of the Ministry of Power
- Neyveli Lignite Corporation Limited (NLC): Lignite

③ Public coal producer owned 49% by the Central Government of India and 51% by the State Government of Andhra Pradesh
- Singareni Collieries Company Limited (SCCL): Coking coal and steaming coal

④ Coal producers managed by steel corporations and electric power companies
- The Tata Iron & Steel Company Limited (TISCO/Tata Steel)
- The Indian Iron & Steel Company Limited (IISCO)
- Damodar Valley Corporation (DVC)
- Jammu and Kashmir Minerals Ltd. (JKML)
- Bengal Emya Coal Mines Ltd. (BECML)
- Bihar State Mineral Development Corporation (BSMDC), etc.

Table 4-2 shows coal production and the number of coal mines in FY2004 by the form of business organization. Production of coal is concentrated in CIL, a government-managed company, and it holds around 85% share of hard coal, which has remained generally unchanged in the last ten years. Among the rest of production, SCCL and private companies hold the shares of around 10% and 5% respectively. By production methods, the share of open-cut mining is overwhelmingly large compared to underground mining. When viewed by the scale of production per coal mine, the

Table 4-2 Coal Production and Number of Coal Mines
by Form of Business Organization in FY2004

		Coal production (million tons)						Number of coal quarries			
		Total		Underground		Open-cut		Total	Underground mining	Open-cut	Underground + Open-cut
Hard coal	Government CIL	323.5	(79%)	47.0	(15%)	276.5	(85%)	470 (84%)	295	144	31
	Public SCCL	35.3	(9%)	13.0	(37%)	22.3	(63%)	67 (12%)	55	12	0
	Private Total	23.8	(6%)	1.7	(7%)	22.1	(93%)	19 (3%)	9	8	2
	Sub-total	382.6	(93%)	61.7	(16%)	320.9	(84%)	556 (99%)	359	164	33
Lignite	Government NCL	-		-		-		2	0	2	0
	Private Total	-		-		-		4	0	4	0
	Sub-total	29.3	(7%)	0.0	(0%)	29.3	(100%)	6 (1%)	0	6	0
Total		411.9	(100%)	61.7	(15%)	350.2	(85%)	562 (100%)	359	170	33

Note: Figures in parentheses for total coal production and total number of coal mines show composition ratios to the total.
Figures in parentheses for coal production by production method show the composition ratio of each production method to the coal production by form of business organization.

Source: Ministry of Coal, "Annual Report 2004-05"

average annual production of an underground coal mine did not reach 500,000 tons. The average annual production of an open-cut coal mine is 2 million tons, and the figure rises to around 5 million tons when limited to lignite. When average scale of production is compared between government-managed/public companies and private companies, the figure of private open-cut coal mine is larger than that of government-managed/public companies. As for the production ratio of underground mining and open-cut mining, the share of open-cut mining was over 60% in late the 1980s, but its share increased steadily during 1990s to reach as high as 85% in FY2004.

4-1-2 Quality, Amount of Production and the Price of Coal

In India, coal quality is categorized into coking coal (hard coking coal, semi coking coal) and steaming coal (non-coking coal) based on ash content and useful heat value (UHV)[9]. Coking coal is categorized into Steel (for steel making), Washery (clean coal beneficiated for steel making) and Semi-Coking (for coke) based on ash content and moisture, while steaming coal is categorized in grades from A to G based on UHV. Among steaming coal, A, B and C are for chemical raw material, D is for cement manufacturing, and E to G are for thermal power plants. Table 4-3 shows the categorization grades of coal quality in India and production by categories from FY2001 to FY2003. When seen by categorization grades of coal quality, production of steaming coal categorized as E and F are dominant, accounting for more than 60% of steaming coal production.

Pithead price by CIL (Pithead price of coal by CIL from September 29, 2003 to June 15, 2004) is 1,050-1,870 Rs/ton for steaming coal A (22.83-40.65US$/ton at 1US$ = 46Rs), and 400-710 Rs/ton (8.70-15.43US$/ton for the same) for steaming coal F, which has the largest production. It is 2,960 Rs/ton (64.35US$/ton for the same) for coking coal Steel-I.

4-1-3 Coal Preparation

Coal in India contains high percentages of ash and is distributed evenly in mineral matters. Therefore, it is difficult to implement coal preparation, so only coking coal is beneficiated and sold to customers such as iron and steel companies. However, the Ministry of Environment and Forests (MOEF) notified publicly “Ash Content

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9 UHV is a figure calculated from ash content (A%) and moisture (M%) through the following formula, and is different from gross calorific value (GCV) provided in JIS.
UHV = 8,900 - 138 x (A+M)

Notification (1997)[10]" on September 17, 1997, which requires coal preparation for steaming coal as well from June 2002.

Table 4-3 Grades of Coal Quality and Production Thereof in India

	Grade	Ash content, moisture	Production (by fiscal year, million tons)			Usage
			2001	2002	2003	
Coking coal Hard coking coal	Steel-Ⅰ	Ash ＜ 15%	0.21	0.28	0.20	Steel making
	Steel-Ⅱ	15 ～ 18	0.54	0.28	0.11	
	Washery-Ⅰ	18 ～ 21	0.46	0.52	0.36	
	Washery-Ⅱ	21 ～ 24	3.55	3.87	4.39	
	Washery-Ⅲ	24 ～ 28	5.58	6.18	5.73	
	Washery-Ⅳ	28 ～ 35	17.97	18.86	18.41	
Coking coal Semi coking coal	Semi-Coking Ⅰ	Ash+Moisture ＜ 19%	0.36	0.21	0.21	Coke
	Semi-Coking Ⅱ	＞ 19	-	-	-	
Coking coal production			28.67	30.20	29.41	
	Grade	UHV	2001	2002	2003	Usage
Steaming coal Non-coking coal	A	＞ 6,200 kcal/kg	3.46	3.37	3.82	Chemical raw material
	B	5,200 ～ 6,200	22.12	21.87	21.97	
	C	4,940 ～ 5,600	48.29	47.16	51.94	
	D	4,200 ～ 4,940	39.70	39.31	41.54	Cement
	E	3,360 ～ 4,200	69.75	75.59	80.05	Thermal power generation
	F	2,400 ～ 3,360	107.95	115.54	123.20	
	G	1,300 ～ 2,400	2.29	3.38	3.31	
Steaming coal production			293.56	306.22	325.83	
Total production			322.23	336.42	355.24	

Note: Figures for total production of steaming coal and total production differ from those in Table 4-1.
Source: Grades of coal quality; Ministry of Coal, "Annual Report 2004-05"
Production by grades; CMIE, "Economic Intelligent Service 2005"

CIL established two new coal preparation plants for steaming coal, and transformed five coal preparation plants for coking coal to plants for steaming coal. However, coal preparation capacity obtained from the sum of this adds up to a mere 20.2 million tons per annum, accounting for only about 6% of the total production of steaming coal in FY2004, 352.4 million tons. CIL decided that it is financially impossible to create new coal preparation plants that can beneficiate all the coal it produces, so it is now developing a strategy to promote the construction of coal preparation plants for coal mines under the control of CIL thorough build-operate-own (BOO) programs utilizing private funds.

According to material from the Ministry of Coal (February 2006), processing capacity of private (BOO) preparation plants is only 11.27 million tons per annum for

10 Ash Content Notification: requires the use of beneficiated coal with ash content not exceeding 34% in effect from June 2001, (the actual date was June 2002). This applied to all thermal plants located beyond one thousand kilometers from the pithead and any thermal plant located in an urban area or, sensitive area irrespective of the distance from the pithead except any pithead power plant.

7 plants in total for coking coal and 59.75 million tons per annum for 24 plants in total for steaming coal, totaling only 71.02 million tons per annum for 31 plants. Even when combined with the steaming coal preparation capacity of CIL, it is 79.95 million tons per annum, only 23% of the total production of steaming coal in FY2004.

Table 4-4 Number and Processing Capacity of Coal Preparation Plants

Classification	CIL			Private			Total		
	Coking coal	Steaming coal	Total	Coking coal	Steaming coal	Total	Coking coal	Steaming coal	Total
Number of plants	12	7	19	7	24	31	19	31	50
Processing capacity (million tpa)	20.10	20.20	40.30	11.27	59.75	71.02	31.37	79.95	111.32

Source: Ministry of Coal, "A Presentation before APEC Seminar" (February 2006)

4-2 Current State of Coal Trade

As can be seen in Table 4-5, while coal export in India did not reach 1 million tons over the period from 1970s through 1990s, it has exceeded the 1 million tons mark since FY1999. On the other hand, import has steadily increased since the first coal import of 220,000 tons was recorded in FY1978, although there are slight increases and decreases each fiscal year. When the import and export of coal are compared, in FY1979, which is the year following the first import of coal, the amount of import exceeded that of export, a trend that was maintained until now. Coal import in FY2005 increased significantly to 41.67 million tons from 26.13 million tons in FY2004, and nearly doubled the figure in FY2003. The average growth rate for the past three years has exceeded 20%. On the other hand, export has maintained the level of over 1 million tons since FY1999, and the figure for FY2004 was 1.55 million tons.

After FY1991, data on import by type of coal are available. In FY1991, 5.27 million tons of coking coal and 660,000 tons of steaming coal were imported, and the share of coking coal in the total import was 89%. However, in FY2004, the share declines to 56% (14.57 million tons of coking coal and 11.56 million tons of steaming coal). The average annual growth rate of import during this period was 25.6% for steaming coal and 8.1% for coking coal, so it shows that the increase in the import of steaming coal was notable. “Ash Content Notification, 1997” issued by the MOEF had a significant impact as a cause of increase in the import of steaming coal, and coal fired power plants and cement plants in coastal areas, in particular, are shifting their coal procurement from domestic coal to import coal. In addition to these, India had imported about 2 million tons of coke since FY1999, but the amount diminished gradually to 1.5 million tons in FY2004.

Table 4-5 Changes in Import and Export of Coal

(Unit: million tons)

Fiscal year		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Import	Coking coal	-	-	-	-	-	-	-	-	-	-
	Steaming coal	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	0.22	0.94
Export		0.47	0.23	0.46	0.62	0.54	0.44	0.64	0.66	0.27	0.09
Fiscal year		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Import	Coking coal	-	-	-	-	-	-	-	-	-	-
	Steaming coal	-	-	-	-	-	-	-	-	-	-
		0.55	0.65	1.38	0.46	0.58	2.03	2.10	2.97	3.70	4.41
Export		0.11	0.16	0.15	0.08	0.13	0.21	0.16	0.17	0.20	0.16
Fiscal year		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Import	Coking coal	-	5.27	6.32	6.82	10.15	9.37	10.62	11.74	10.02	10.99
	Steaming coal	-	0.66	0.42	0.57	1.24	3.14	2.56	4.70	6.51	8.71
		6.05	5.93	6.74	7.39	11.39	12.51	13.18	16.44	16.54	19.70
Export		0.10	0.11	0.13	0.10	0.67	0.65	0.48	0.54	0.82	1.16
Fiscal year		2000	2001	2002	2003	2004	2005	Average annual growth rate			
								'80-'90	'90-'00	'91-'05	'02-'05
Import	Coking coal	11.06	11.11	12.95	12.99	14.57	23.89	-	-	11.4%	22.6%
	Steaming coal	9.87	9.44	10.08	8.69	11.56	17.78	-	-	26.5%	20.8%
		20.93	20.55	23.03	21.68	26.13	41.67	27.1%	13.2%	14.9%	21.9%
Export		1.29	1.90	1.52	1.63	1.55	-	-0.9%	29.1%	-	-

Source : Coal Controller's Organization / Ministry of Coal, "Coal Directory of India", Ministry of Coal, "Annual Report 2004-05" and The Energy and Resources Institute, "Teri Energy Data Directory & Yearbook 2003-04"

Table 4-6 shows the changes of coal import in India since FY1998 by country. In recent years, coal import from Australia has been the largest, with more than 10 million tons in volume, although its import volume and share in the total coal import increases and decreases each fiscal year. A similar trend can be seen in imports from China as well. Growth of import is the largest for Indonesia, and its share is 34.9%, second after Australia's 47.3%. The share increased to 37.2% by the first half of FY2005. Import from Indonesia is forecast to reach 10 million tons for the entire FY2005, and is now catching up with imports from Australia. By adding imports from China, which has the third largest share after Indonesia, total import from the three countries (Australia, Indonesia and China) account for as much as 91.1% of the total. Coal import from South Africa was 4.7 million tons in FY1999, and had maintained a level of over 3 million tons during FY2000-FY2002, holding the share of more than 15%. However, both the amount and share decreased significantly since FY2003. It is on an upward trend for FY2005, and it seems that India is seeking a way to diversify its suppliers. Coal import from the US is increasing, and this is considered to be because the US is a supplier for spot procurement, and also because of India's intention to diversify its procurement.

Table 4-6 Changes in Coal Import by Country

(Unit: million tons)

Fiscal year	1998	1999	2000	2001	2002	2003	2004	2005 First half	Average annual growth rate '98-'04	Average annual growth rate '02-'04
Australia	10.32 (62.4%)	10.81 (54.9%)	13.11 (62.6%)	10.85 (52.8%)	12.70 (55.1%)	13.31 (61.4%)	12.35 (47.3%)	5.79 (42.7%)	3.0%	-1.4%
Indonesia	2.38 (14.4%)	2.30 (11.7%)	2.55 (12.2%)	3.42 (16.6%)	3.97 (17.2%)	5.67 (26.2%)	9.13 (34.9%)	5.05 (37.2%)	25.1%	51.6%
China	0.80 (4.8%)	1.25 (6.4%)	1.73 (8.3%)	2.55 (12.4%)	1.96 (8.5%)	1.71 (7.9%)	2.32 (8.9%)	1.30 (9.6%)	19.5%	8.8%
US	0.01 (0.1%)	0.13 (0.7%)	0.06 (0.3%)	0.04 (0.2%)	0.03 (0.1%)	0.02 (0.1%)	0.71 (2.7%)	0.45 (3.3%)	103.5%	386.5%
South Africa	2.45 (14.8%)	4.68 (23.8%)	3.18 (15.2%)	3.11 (15.1%)	3.38 (14.7%)	0.64 (3.0%)	0.53 (2.0%)	0.75 (5.5%)	-22.5%	-60.4%
Other	0.58 (3.5%)	0.52 (2.6%)	0.30 (1.4%)	0.58 (2.8%)	0.99 (4.3%)	0.33 (1.5%)	1.09 (4.2%)	0.24 (1.8%)	11.1%	4.9%
Total	16.54	19.70	20.93	20.55	23.03	21.68	26.13	13.57	7.9%	6.5%

Note: Figures in parentheses show the composition ratio of each country to the total import.

Source : Directorate General of Foreign Trade / Department of Commerce/Ministry of Commerce & Industry, "Export Import Data Bank"

Increase in import from Indonesia is the result of favorable evaluation of factors such as high quality (low ash and low sulfur content), relatively low FOB price, and the short shipping distance of coal. It is expected that the import of steaming coal, including those used for power generation, will increase in the future, and it is almost certain that the share of Indonesian coal will hold the top share in the near future.

Furthermore, coke is mostly imported from China. Major destinations of coal export from India are neighboring countries, such as Bangladesh and Nepal.

4-3 Forecast on Coal Supply

The Ministry of Coal published forecast on domestic supply (production forecast) of coal (hard coal) in "A Presentation before APEC Seminar [11]" is shown in Table 4-7 herein. According to this forecast, domestic production of 382.6 million tons in FY2004 will grow with the average annual rate of 5.4% to 1,086 million tons by FY2024, which is an increase by 703 million tons. This figure includes some coal bed methane (CBM) and underground coal gasification (UCG), so coal production as a solid fuel is forecast at 1,061 million tons in FY2024. While the structure in which CIL is supplying most of the coal production is unchanged, the ratio will decrease by 7.3 points in 20 years to 77.3%. Production ratio of SCCL will also decrease by 4.9 points during the same period to 4.3%, so the share of both companies total will be 81.6%. It is forecast that this decrease will be supplemented by the increase in production by private coal

[11] APEC Clean Fossil Energy Technical & Policy Seminar, 22-25 February 2006, Lampang, Thailand

producers, which is predicted to grow with the average annual rate of 10.5% from 24 million tons in FY2004 to 175 million tons by FY2024, seven times larger than the figure of FY2004. The Central Government of India developed incentive measures for developing coal mines by private companies and introduction of foreign investments for private coal mines, and it is considered that this will promote expansion of production by private coal producing companies.

By comparing the coal production forecast and coal demand forecast by The Planning Commission shown in Table 3-5, it is clear, as shown in Table 4-7 and Figure 4-1, that the demand will exceed production and domestic production cannot cover the entire demand. Assuming that the figure obtained by subtracting production by demand as coal import, and based on the forecast of coal demand in the case with annual GDP growth rate of 8%, the amount of coal that must be imported in FY2024 will be 186 million tons, and the growth rate from FY2004 will exceed the growth rate of coal production.

Table 4-7 Comparison of Production Forecast and Demand Forecast on Coal (Hard Coal)

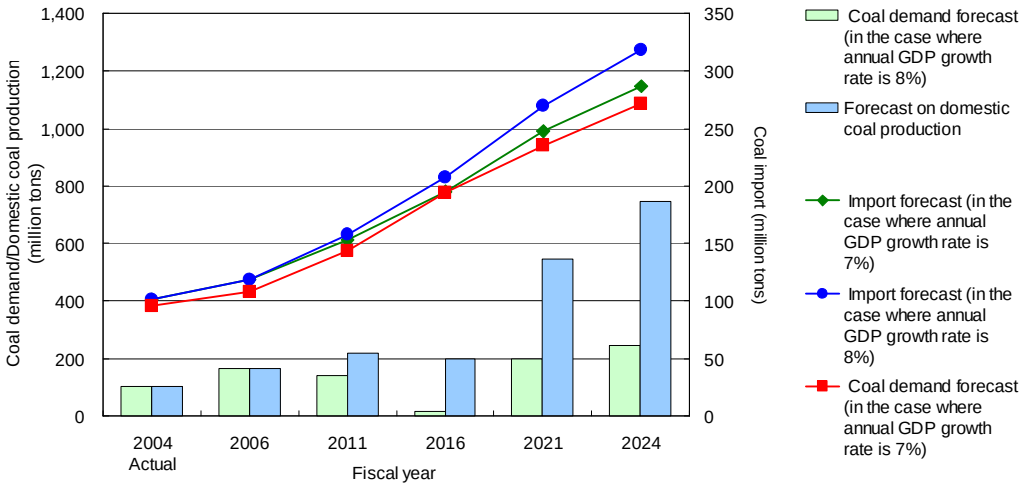
(Unit : million tons)

Fiscal year		2004 Actual	2006	2011	2016	2021	2024	Average annual growth rate		
								'04-'11	'11-'21	'04-'24
Production forecast	Government-managed CIL	323.6 (84.6%)	366.1 (84.7%)	504.1 (87.6%)	653.0 (83.9%)	755.0 (80.1%)	839.0 (77.3%)	6.5%	4.1%	4.9%
	Public SCCL	35.3 (9.2%)	37.5 (8.7%)	41.0 (7.1%)	45.0 (5.8%)	47.0 (5.0%)	47.0 (4.3%)	2.2%	1.4%	1.4%
	Private in total	23.7 (6.2%)	28.8 (6.7%)	30.5 (5.3%)	75.0 (9.6%)	125.0 (13.3%)	175.0 (16.1%)	3.6%	15.2%	10.5%
	Underground coal gasification	-	-	-	5.0 (0.6%)	15.0 (1.6%)	25.0 (2.3%)	-	-	-
A. Total		382.6	432.4	575.6	778.0	942.0	1,086.0	6.0%	5.0%	5.4%
Demand forecast		2004	2006	2011	2016	2021	2024	'04-'11	'11-'21	'05-'24
B. The Planning Commission (7% case)		404.2	473.2	611.1	781.5	991.7	1,147.1	6.1%	5.0%	5.1%
C. The Planning Commission (8% case)		404.2	473.2	629.6	828.2	1,078.5	1,272.0	6.5%	5.5%	5.7%
Ministry of Coal		-	-	676.0	-	-	-	-	-	-
Coal import forecast		2004	2006	2011	2016	2021	2024	'06-'11	'11-'21	'06-'24
Coal import (B-A)		26.1	40.8	35.5	3.5	49.7	61.1	-2.8%	3.4%	2.3%
Coal import (C-A)		26.1	40.8	54.1	50.2	136.5	186.0	5.8%	9.7%	8.8%

Note: Figures in parentheses for each fiscal year show the composition ratio of each form of business organization to the entire production.
Forecast on coal import is calculated by subtracting production forecast from demand forecast (The Planning Commission).
The figure for FY2006 and FY2011 reflects "Annual Plan 2005-06" by MOC and Revised Productin Planning by CIL respectively.
Actual production of FY2004 reflects "Annual Plan 2005-06" by MOC, and has a difference with the figures shown in Table 4-1. Refer to Table 4-5 for the actual import for FY2004.

Source: Ministry of Coal, "A Presentation before APEC Seminar" (February 2006), Table 3-5 and Table 3-6

Figure 4-1 Comparison of Production Forecast and Demand Forecast on Coal (Hard Coal)



Source: Prepared from Table 4-7

5. Challenges for the Coal Industry

In the draft report by the Expert Committee on Integrated Energy Policy by the Planning Commission, it is forecast that coal will occupy about half of the entire energy consumption in India until FY2031, and more than 70% of domestic coal production will be distributed for power generation. Here, we would like to point out some major challenges in terms of coal demand and supply in the future. These challenges are associated with one another, and countermeasures to achieve a comprehensive solution will be necessary in parallel with individual solutions.

5-1 Promotion of Coal Resources Exploration

There is a fear of a decrease in recoverable reserves in accordance with the significant increase of coal consumption that is expected in the future, which is a cause of concern for maintaining a long-term stable supply of domestic coal. Exploration of coal resources in India is conducted by the Central Mine Planning and Design Institute Limited (CMPDIL), which is an organization under the control of CIL. However, due to limitations in boring technology employed by CMPDIL, coal reserves are identified only within the depths of 300m. From now on, it is necessary to retain enough recoverable reserves to prepare for the future by promoting the exploration of coal reserves in deep underground actively, covering areas with the possibility of coal endowment. In order to achieve this, by strongly promoting the exploration business, it is considered to be effective to open up the coal reserves exploration business to domestic companies other than CMPDIL, just like the exploration of oil reserves was

opened up to companies other than the government-managed companies, and also to permit the entry of foreign investment.

5-2 Improvement of Operating Ratio and Productivity of Coal Mines

Temperature in major coal producing regions in India exceeds 40 Celsius during the summer season, causing a significant decline in the operating ratio of coal mines. Productivity will also drop by 5-15% on an annual average basis. On the other hand, demand for coal will also rise during the summer season due to increases in electricity demand for air conditioners, so a stable supply to customers cannot be ensured. In order not to lower the competitiveness of domestic coal against imported coal, it is important to maintain a production level that matches the demand. Therefore, coal mines should be managed with the intention of improving and maintaining their productivity.

5-3 Improvement, Expansion and Development of Coal Mines and Coal Preparation Plants by Private and Foreign Investment

Although the number of coal mines managed by private companies and not by CIL or SCCL is increasing and coal production is also on an upward trend, it is quite effective for an increase in coal production to encourage expanding the existing coal mines by fully utilizing the private capital in India as well as to promote developing a new coal mine. The same thing can be said about coal preparation plants, where further improvement in the coal preparation ratio is required when considering environmental measures and efficiency. There are no restrictions on the entry of foreign investment for these privately managed coal mines/coal preparation plants (it is even possible to acquire 100% equity), so it is considered that active introduction of foreign investment and employment of contractor systems will contribute largely to the expansion of coal production.

One must also consider improving the efficiency of management based on adequate competition by privatization coal mining companies under the control of CIL.

5-4 Improving the Efficiency of Coal Usage

In order to control coal demand, it is essential to improve the thermal efficiency of coal fired power plant where more than 70% of the total coal demand is consumed. The Planning Commission drew up a scenario of a comprehensive energy policy in which the average thermal efficiency of coal fired power plants is improved to 39% from the current 30.5%, and that of coal fired power plant using supercritical pressure

boiler of 500 MW to 42% from the current 36%. As a forecast for FY2031, if a thermal efficiency of 40% is achieved in every coal fired power plants, it estimates that it will be a saving of domestic coal consumption by 274 million tons, which will be roughly equivalent to the shortage of domestic supply in the same fiscal year.

On the other hand, based on a report from the Central Electricity Authority (CEA), loss factors in total power generation in FY2004 due to losses during transmission and distribution of electric power or due to power theft is more than 40% of the entire amount of electric power generated. Therefore, decreases in these power losses leads to a reduction in total electric power generation in India, and will in turn make it possible to reduce the coal consumption. Promotion of innovation in the power generation industry in India shall be an important key to keeping a good balance between the supply and demand of coal in India in the future.

5-5 Improvement and Expansion of Coal Infrastructure and Railway Innovation

According to the forecast of coal demand in India, it is expected that increases in production of domestic coal is not enough to cover the increased portion of demand. Even with countermeasures to increase supply and decrease consumption of coal in the country, it will be necessary to import coal from abroad. In particular, northern, western and southern States that are remote from coal production regions in India or that have coal fired power plants and cement plants, such as Panjab, Haryana, Rajasthan, Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamilnadu, Western Uttrapradesh, and the National Capital Territory of Delhi, it is expected to increase the import of foreign steaming coal with higher quality and lower price. However, ports of entry for coal in India do not equip port facilities to cope with such demand. With the existing plans for improving and expanding infrastructure that rely heavily on private investment, including foreign investments, future achievement of the plan remains unclear. Achievement of the plan to cover the expected shortage of domestic coal supply with imported coal is challenging, and if the plan is not achieved, it would greatly affect the economic growth of India. Therefore, active financial expenditure on port infrastructure by the Central Government of India or State Governments, ODA on the improvement of infrastructure, and utilization of loan programs by foreign organization should be required.

It is also necessary to transport the discharged imported coal from ports to the location of customers, via railway or road. It is crucial to carry out such improvement of infrastructure systematically for the whole coal chain. In particular, establishing an efficient railway transportation system is essential not only for import coal but also

for expanding domestic coal supply, so the restructuring of the entire railway system, including the revision of railway fare, and measures for breaking up and privatization will be required. Because the railway in India is under the monopoly of government railways, the principle of competition is not working, which is also an important issue.

Conclusion

The Planning Commission in India expects an average annual GDP growth of around 7-8% in the future, and coal demand of 1.1 billion tons by FY2024 (which was revised to 1.6 billion tons in the most recent information). The thermal efficiency amelioration in the coal fired power plant tries to be attempted. If this doesn't progress, increases in coal demand are expected to bring an increase in coal import, from 41.7 million tons in FY2005 to around 200 million tons. If this proves to be true, an effect on the international coal market will be inevitable, and the stable supply of coal in Japan would also be affected.

Also, it is reported that among the clean coal technologies (CCT) already developed or now being developed by Japan, such as coal preparation technology, coal reformulation technology and technologies for environmental measures have the potential to be used widely in India, so there is a possibility of providing technical assistance in a wide range of fields, such as coal mining, safety or management.

From now on, it is considered to be critical important for Japan to carefully observe, research and analyze the trends of India's coal industry.

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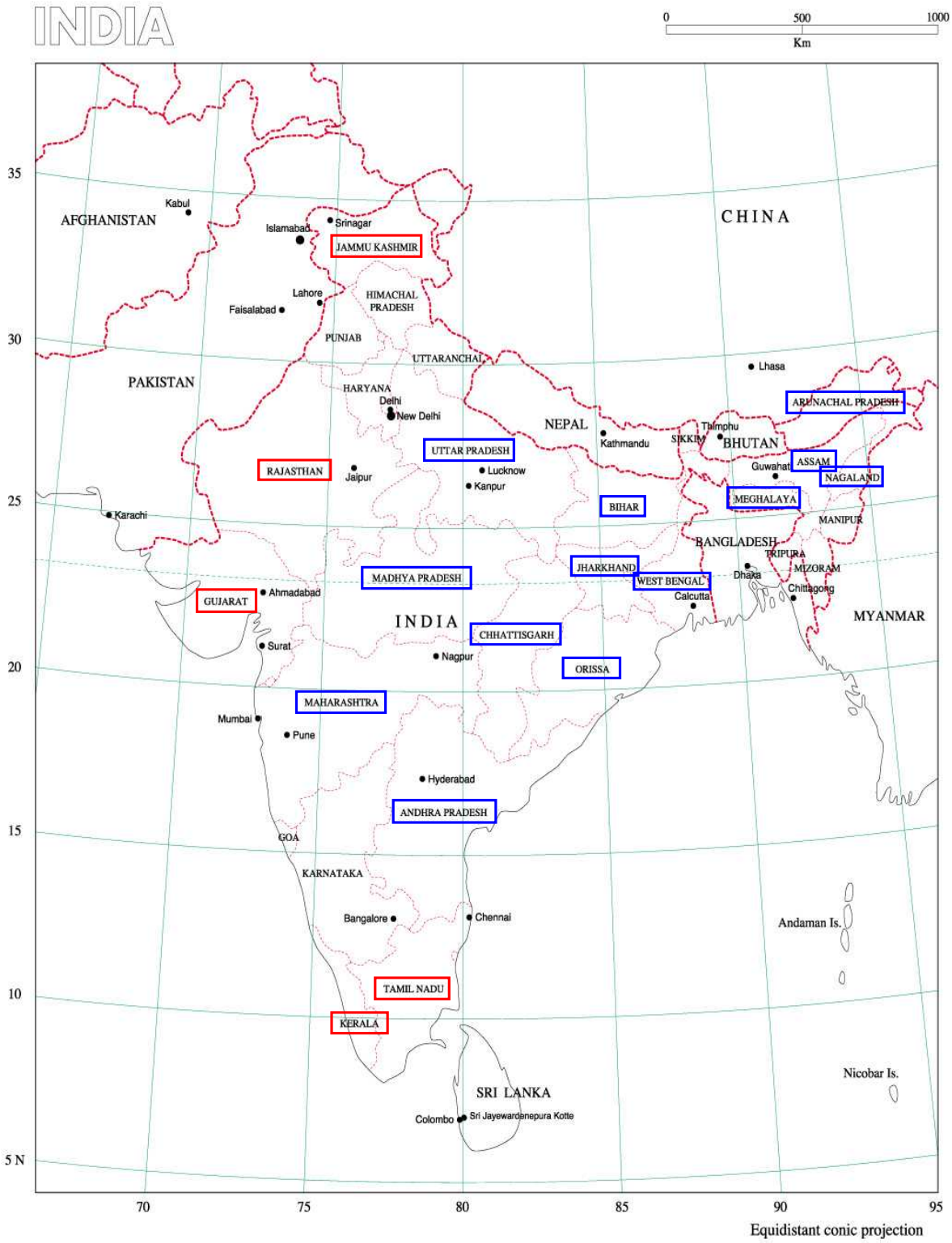
Attached Map 1 Province of India (by State)



Note: indicates States with hard coal endowment.
indicates States with lignite endowment.