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INDIA

Asia-Pacific Energy Series Country Report

by

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EXECUTIVE SUMMARY

NATIONAL OVERVIEW

- India is the largest and most populous country on the South Asian subcontinent. Its population of 844 million is projected to rise to one billion by the year 2000, increasing the demand for food, energy, infrastructure and social services. Religious, cultural and regional differences have contributed to political and social unrest over the past few decades. Secessionist movements in the Punjab, Kashmir and Assam and communal violence throughout India have threatened to upset the political stability of the country.

- Political discontinuity, resulting from the fact that there were four prime ministers within eighteen months in 1989-1991, left many important socioeconomic and political decisions unresolved. Prime Minister Rao, who was elected to office in June 1991, faces tough political and economic challenges in the years ahead.

NATIONAL ECONOMY

- India's near-term economic development will be directed by the Eighth Five-Year Plan (1992-97). The Plan envisages a GDP growth rate of 5.6 percent per year, with government and private sector investments totalling Rs7,920 billion at 1991-92 prices (US$306 billion). The 1991-92 government budget for the energy sector is Rs135 billion (US$5.4 billion).

- In fiscal year 1990-91, the GDP was estimated to be Rs4.45 trillion, with a per capita income of US$350. The Finance Minister hopes for four percent GDP growth in 1991-92, down from five percent growth in 1990-91.

- Faced with serious trade, credit and fiscal imbalances, including a foreign debt exceeding US$76 billion, India was forced to pledge some of its gold as collateral for short-term loans in 1991. Public sector borrowing has averaged more than 10 percent of GDP for past several years. This, in turn, has fed money-supply growth averaging 17 percent a year and an annual inflation rate of nine percent by 1990, and 15 percent by December 1991.

- The administration of Prime Minister Rao has instituted tough structural reforms through the Export-Import (EXIM) Policy and the New Industrial Policy (NIP)

that were introduced in July 1991. The NIP liberalizes industrial licensing, foreign investment, foreign technology agreements, public sector policy, and the Monopolies and Restrictive Trade Practices (MRTP) Act. In addition, the economic reform program cuts subsidies for agriculture, exports and state-run enterprises, curbs defense spending, and partially privatizes various large government companies. Major market-oriented measures are designed towards meeting IMF and World Bank conditions for further loans. To support its economic reforms and to attract foreign capital, the Rao government devalued Indian rupee by 20 percent vis-a-vis five major currencies with two successive devaluations in July 1991.

- The government has raised the ceiling for automatic approval of foreign investment in joint ventures from 40 percent to 51 percent in many long-protected industries, particularly heavy manufacturing, high technology, food processing and tourism. The new policy also allows case-by-case exceptions for higher foreign equity in high-technology export-oriented ventures. Electricity generation, oil, natural gas, coal and most minerals industries will remain restricted to the public sector. However, there are now more opportunities for private and foreign firms in the upstream hydrocarbons sector.

- Despite reasonably successful export performance, India's trade deficit reached Rs106 billion (US$6 billion) in 1990-91. Crude oil and petroleum product imports, valued at US$5.5 billion, contributed significantly to the trade deficit.

- The Gulf Crisis (1990-91) and the trade embargo on Iraq have had a serious impact on the Indian economy with a loss of export markets, a drop in foreign remittances, and expenditures for the repatriation of 150,000 Indian workers. The estimated negative effect of the Gulf Crisis on India's current account balance is about US$1,390 million in 1990, US$2,160 million in 1991, and US$430 million in 1992.

- The deterioration of trade arrangements with the former Soviet Union has also affected the Indian economy. As India has a Rs20 billion trade surplus with the former Soviet Union, it is eager to become a major trade and industrial development partner of the newly emerging economies in the republics, particularly those in Central Asia.

ENERGY IN THE ECONOMY

- India's population of 844 million constitutes a huge market, and growth in energy production has not kept pace with demand. India produces 85 percent of its own energy needs; the remaining 15 percent is met by imported crude oil, petroleum products and coal. India's energy strategy is to raise its energy self-sufficiency by increasing domestic energy reserves and production levels, as well as employing

more efficient conservation measures and exploring options for alternative fuels and power sources.

- The Indian economy has become more oil-intensive in recent years. However, while the volume of oil consumed has risen and will further increase, its share of commercial energy is projected to decline. In 1990-91 oil and gas provided 40 percent of commercial energy; by 2009-2010 hydrocarbons will account for 34 percent of the energy supply. The share of coal and lignite in commercial energy will increase from 56 percent in 1990-91 to 64 percent in 2009-2010. Hydropower and nuclear power will constitute the remaining two percent. The supply of commercial energy is projected to rise to 555.5 million tonnes of oil equivalent (mmtoe) by 2009-2010.

OIL AND GAS

- India met 57 percent of its oil demand by domestic production in 1990-91. The country's reserves are estimated to be large enough to maintain self-sufficiency at 60 percent until 1995 and 45 percent until 2000. However, achieving these levels of self-sufficiency will require that oil discoveries of 239 million tonnes per year are made between 1990 and 2005.

- India's recoverable oil reserves are placed at about 775 million tonnes (mmt) (5,815 million bbl) and gas reserves at about 650 mmtoe (4.875 billion bbl). Another 300 mmt (2.25 billion bbl) of oil and 80 mmtoe (600 million bbl) of associated and non-associated natural gas are obtainable through secondary recovery methods.

- Domestic production of crude oil declined by about three percent to 33 mmt (247 mmb) in 1990-91, from the peak production in 1989-90 of 34 mmt (255 mmb). There was a shortfall in output of three mmt for a target of 36 mmt. Due to unrest in Assam and production difficulties in some oil fields, for 1991-92, the production target of 35 mmt (247 mmb) has been reduced to 32 mmt (240 mmb). The target crude production for 1994-95 is 50.3 mmt.

- Production of natural gas was 18 billion cubic meters (bcm) in 1990-91, an increase of 5.8 percent over 1989-90's output of 17 bcm. Gas production is to increase to 31 bcm by 1994-95.

- India's hydrocarbon future is far from certain. Petroleum development projects stalled for the past two years will result in at least three years of stagnant and/or declining output vis-a-vis demand. A 1991 report by Total-Compagnie Française de Pétroles (TCFP) suggests that over the next five years a total of 14 mmt (105

mmb) of crude oil will be lost as a result of production difficulties mainly associated with offshore areas.

- The most recent exploration round, India's fourth since 1980, comes five years after the third round, which did not result in any discoveries. The fourth round offers 124,300 km^2 of exploration areas in seventeen basins. Foreign and Indian companies will be allowed to bid for 72 on- and offshore exploration blocks.

- In the fourth round, the split ratio of the initial oil entitlement has been improved from the earlier 60:40 entitlement to 70:30 in a company's favor. Contracts for oil and associated gas finds are for 25 years, and in the case of free gas fields, contracts can extend to 35 years.

- Production of petroleum products by Indian refineries in fiscal year 1990-91 was 48.5 mmt, a 0.3 percent decline from the 1989-90 production of 48.6 mmt. India imported 27 mmt of crude and petroleum products in 1990-91.

- Consumption of petroleum products was 58.9 mmt in 1990-91 and is estimated to increase to 77.7 mmt in 1994-95. Product demand in 1994-95 is to be met by 50.3 mmt of indigenous crude production and 32.7 mmt of crude and product imports. Product demand is projected to reach about 102 mmt by 1999-2000 and 127 mmt by 2004-2005.

- The value of imports of crude oil and petroleum products during 1990-91 was US$5.5 billion, up 53 percent from 1989-90. Oil and petroleum product imports accounted for about one-third of the value of total merchandise imports in 1990-91. The import bill for oil is expected to average US$6 billion per year (in constant prices) or more through the end of the 1990s.

COAL

- In 1990-91, more than half of India's energy requirements were met by domestically produced coal and lignite and small quantities of coal imports. Coal production in 1990-91 was 212 mmt, while demand was 230 mmt. While coal production has been increasing, there have been problems in transportation and distribution of coal, contributing to growing stocks and imports.

- By 1994-95, annual coal and lignite production is to targeted to reach 310 mmt and demand is projected to be 321 mmt. It is feasible that annual coal production could reach 450 mmt by 1999-2000 and 600 mmt by 2009-2010. Despite growing concerns over the environmental impact of coal, its share in India's energy mix is likely to increase to 64 percent by 2009-2010.

ELECTRICITY GENERATION

- In 1991, India's installed electricity generation capacity was 72,020 MW. Of the 65,120 MW capacity held by utilities, over two-thirds was constituted by thermal power plant capacity, while hydropower accounted for 28 percent and nuclear power for only 2.5 percent. The Department of Power seeks to add 38,369 MW of capacity by 1994-95, most of which will be from thermal power plants based on coal and, increasingly, natural gas. The private sector will play a larger role in power generation as a result of the government's economic reform program.

- Power generation by utilities in 1990-91 was 264 billion kWh which was about 7.7 percent short of demand, resulting in load-shedding and power shortages throughout the country. Transmission losses are about 22 percent of total power generated. Industry consumes about 46 percent of the power generated, while agriculture accounts for 25 percent and the residential sector 22 percent.

NUCLEAR POWER

- Nuclear generating capacity in 1990-91 was 1,600 MW and is projected to increase to 8,000 MW by the year 2000. Three nuclear power stations produced six billion kWh of power in 1990-91. A fourth station was to be commissioned in 1991 and two more will become operational through the mid-1990s.

HYDROPOWER

- Installed hydropower generation capacity was 18,300 MW in 1990-91 and produced 71.5 billion kWh of power. Hydropower generation is to increase to 80 billion kWh in 1991-92. While India's hydropower potential has been estimated at 84,044 MW, generation capacity is unlikely to rise above 20,000 MW by the year 2000 due mainly to long construction lead-times and non-settlement of inter-State water disputes.

RENEWABLE AND NONCONVENTIONAL ENERGY SOURCES

- The Department of Nonconventional Energy Sources (DNES) envisages using nonconventional and renewable sources of energy to conserve conventional forms of energy and generate power equivalent to 250 mmt of coal annually by the year 2001. This includes the generation of 15,000 MW of electricity. Currently, traditional, non-commercial biomass fuels (firewood, bovine dung and crop residues) account for 48 percent of total primary energy in India. The use of solar thermal and photovoltaic systems and windmills has also increased in recent years.

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PREFACE

As part of our continuing assessment of Asia-Pacific energy markets, the Resources Programs has embarked on a series of country studies that discuss in detail the structure of the energy sector in each major country in the region. To date, our reports to the US Department of Energy, Assistant Secretary for International Affairs and Energy Emergencies, have covered Australia, China, India, Indonesia, Japan, Malaysia, New Zealand, Pakistan, the Philippines, Singapore, South Korea, Taiwan, and Thailand. The country studies also provide the reader with an overview of the economic and political situation in the various countries. We have particularly highlighted petroleum and gas issues in the country studies and have attempted to show the foreign trade implications of oil and gas trade. Finally, to the greatest extent possible, we have provided the latest available statistics—often from unpublished and disparate sources that are unavailable to most readers. Staff members have traveled extensively in—and at times have lived in—the countries under review and have held discussions with senior policymakers in government and industry. Thus, these reports provide not only information but also the latest thinking on energy issues in the various countries.

It is our hope that over the next few years these country studies can be updated and will provide a continuous, long-term source of energy sector analysis for the Asia-Pacific region.

The India Asia-Pacific Energy Series Country Report is the follow-on to a study by Victor Lobo, *Energy in India: The Oil Sector*, which was published by the East-West Center in December 1989. The study focused specifically on the petroleum industry, particularly refining, infrastructure, marketing and distribution, specifications of products, demand structure and pricing. The current study, therefore, must be seen as a supplement to our 1989 study and, as such, does not cover the petroleum sector in depth.

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The views expressed in this study are not necessarily those of the East-West Center Resources Programs. Responsibility for errors, omissions and inconsistencies remains with the author.

LIST OF MEASUREMENTS

ATKM	available tonnes per kilometer
b/d	barrels per day
bbl	barrel
bcm	billion cubic meters
bt	billion tonnes
°C	degrees Celsius
GW	gigawatts (1000 megawatts)
°F	degrees Fahrenheit
kcal/kg	kilocalorie per kilogram
kg/cm^2	kilograms per square centimeter
km	kilometer
kWh	kilowatt-hour
m	meter
md	millidarcies
mmb	million barrels
mmcm	million cubic meters
mmcm/d	million cubic meters per day
MMcf/d	million cubic feet per day
mmha	million hectares
mmkl	million kiloliters
mmscf/d	million standard cubic feet per day
mmt	million tonnes
mmtoe	million tonnes of oil equivalent
MW	megawatts
Rs	rupees*
RTKM	revenue tonnes per kilometer
tcf	trillion cubic feet
toe	tonnes of oil equivalent
tonne	1000 kilograms or one metric ton
US$	US dollars

*As of late 1991-early 1992, there were approximately Rs 25-26 to the US$1

One

NATIONAL OVERVIEW

GEOGRAPHY AND CLIMATE

The Republic of India is a member of the South Asian Association for Regional Cooperation (SAARC) whose other members include Bangladesh, Bhutan, Nepal, Pakistan and Sri Lanka. India is the largest country on the South Asian subcontinent and the seventh largest country in the world, with a land area of 3.28 million km^2.

To the north, India shares borders with Xizang (Tibet), the People's Republic of China, Nepal and Bhutan. It also borders on Pakistan in the northwest, Bangladesh in the east and Myanmar in the southeast. In the south, the Palk Strait separates India from Sri Lanka. The Andaman and Nicobar Islands in the Bay of Bengal and the Lakshadweep Islands in the Arabian Sea are also parts of India.

The Indian mainland lies between latitudes 8° and 33°15' North, and longitudes 68°5' and 97°25' East. The country's north-south length is 3,214 km, and its east-west width is 2,933 km, with international borders extending 15,200 km and a coastline of over 6,000 km in length.

India is separated from the rest of Asia by a 2,400 km long stretch of the Himalaya Mountains in the north, giving the country a distinct geographical identity. India stretches southward from the massive snow-capped peaks of the Himalaya Mountains to the tropical waters of the Indian Ocean. The country has coasts on the Bay of Bengal in the east and the Arabian Sea in the west.

Mainland India comprises three well-defined geographical regions: the Northern Mountain Belt, the Central Plains (Indo-Gangetic Plains), and the Southern Peninsula. The Northern Mountain Belt of the Himalayas lies between the Xizang (Tibetan) Plateau and the Indo-Gangetic Plains, and is made up of complex parallel ranges interspersed

with narrow basins and longitudinal valleys. The Himalayas contain some of the highest peaks in the world, some over 6,000 meters high, that are covered with glaciers and snow year-round.

Most of the northern Indian rivers and their tributaries emerge from the Himalayas and their secondary ranges. The southernmost range of the Himalayan System, the Siwaliks, are low-lying hills that merge with alluvial plains. In India's far northeast region, the Himalayan System curves across the Brahmaputra River and descends into the rainforest hills of Nagaland.

The Central Plains of the Ganges, Indus, and Brahmaputra Rivers and their numerous tributaries form the Indo-Gangetic Plains, among the largest alluvial flood plains in the world. These extensive plains sustain vast agricultural areas that are crucial to the life support of millions of people. Parts of the Indo-Gangetic Plains are irrigated, supporting densely populated areas in valleys, flood plains, and deltaic regions.

The Thar Desert, in the southwestern area of the Central Plains, extends northward into Rajasthan from the Rann of Kutch in the south. The Thar Desert is an ancient floodplain of rivers devoid of any stream drainage; some areas of this dry region are now being irrigated.

The Deccan, or Southern Peninsula of India, is a plateau region extending from the southern tip of the Indo-Gangetic Plains to Kanyakumari in the southernmost area of the country. The Peninsula is separated from the northern and central plains by hill ranges (including the Vindhyachal and Satoura Ranges) that vary in height from 460 to 1,220 meters. Large concentrations of population are found in the narrow western coastal strip along the Arabian Sea in Kerala and Maharashtra and on the Bay of Bengal, in the east.

India's climate is dominated by the southwestern monsoon in the summer and the northeastern monsoon in the winter. Occasional low depressions from Central Asia modify the temperature regime in northern India. The average temperature throughout the country ranges from 20°C (68°F) to 27°C (80°F). Tropical depressions and cyclones affect the climatic pattern in the eastern and southern parts of the country. Rainfall and temperature patterns exhibit a great deal of variability between different parts of India

due to the country's physiographic features. Annual rainfall ranges from an average of 100 millimeters (mm) in the Thar Desert in west to as high as 11,000 mm in northeast India. The summer monsoon rainfall is a critical environmental element in the Indian subcontinent, as it is crucial to the country's vast agriculture. The rainy season of the southwest monsoon in India lasts about four months from June to September. Generally, the summer monsoon sets in over Kerala in the south during the first week of June and then advances northeast, covering the entire country with rain by mid-July. The winter monsoon is a dry period that generally lasts from November to late April.

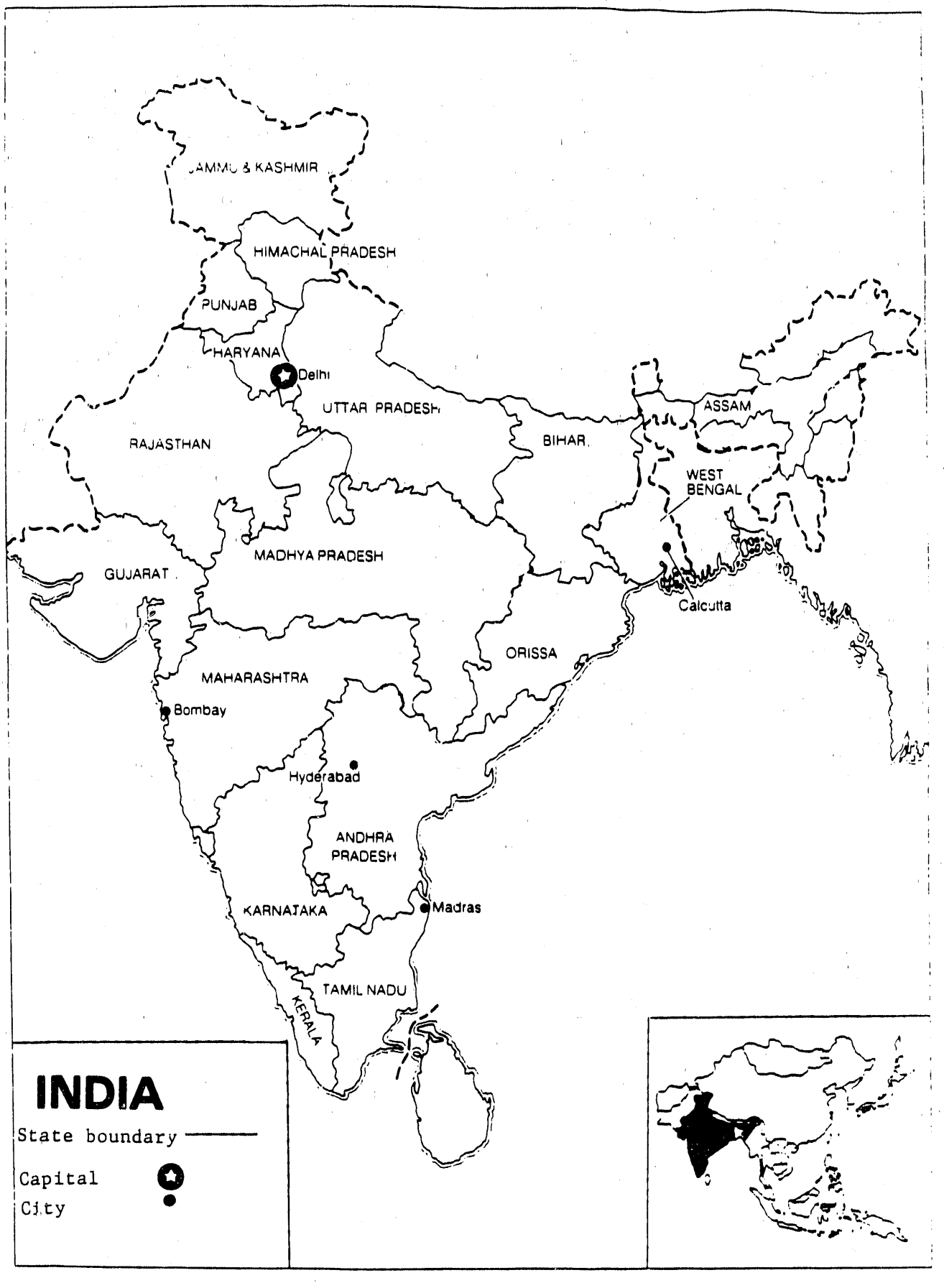
ADMINISTRATIVE REGIONS

The nation of India, in its present form, came into existence upon independence in 1947 and the subsequent partition of the Indian Dominion into India and Pakistan. Prior to independence, the Indian subcontinent was divided into British India (eleven provinces and six territories) and 570 principalities (princely states). Under the 1950 constitution, the nation was declared the Union of States of India, with the integration of former political entities into new administrative units termed States or Union Territories (Figure 1.1).

The States are governed by Councils of Ministers (Cabinets) responsible to elected legislative assemblies. Originally, the Union Territories were to be centrally administered, but over the years, the larger ones were granted their own Legislatures and Councils of Ministers, with the Central government retaining some responsibilities for them that it did not enjoy over the States. New Delhi, the capital of India, is an example of a Union Territory.

In response to popular demands to redraw State boundaries on broad linguistic lines, a new administrative organization of States and Union Territories under the States Reorganization Act (1956) resulted in the creation of fourteen States and six Union Territories. Sikkim was annexed as a State by India in 1975. Later, other regions were upgraded to States and there are now 25 States and seven Union Territories as follows:

Figure 1.1: **Administrative regions**



Indian States: Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnatak, Kerala, Madhya Pradesh, Maharashtra, Manipur, Mehgalaya, Mizoram, Nagaland, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh, and West Bengal.

Union Territories: Andaman and Nicobar, Chandigarh, Dadra and Nagar Haveli, New Delhi (Union Capital), Daman and Diu, Lakshadweep, and Pondicherry.

DEMOGRAPHICS

India is the world's second most populous country, with a population of about 843.9 million (437.6 million males and 406.3 million females) concentrated in approximately 600,000 villages and 4,689 cities and towns (March 1991 census). India has about 16 percent of the world's population of 5.4 billion, although it accounts for only 2.4 percent of the total world land area. By 2010, India is expected to surpass China as the world's largest population center.

Population growth during 1981-1991 was 2.1 percent a year, reflecting a general slowdown in population growth over previous decades. This slower rate is the result of a falling birth rate in many States, as well as a general decline in the fertility rate of women. While Indian governments have endorsed family planning as part of official development programs, it has proved difficult to disseminate the practice throughout the tradition-bound and still largely illiterate masses. Approximately 37 percent of India's population is under 14 years of age.

Demographic patterns tend to exhibit the strong cultural effect of the Hindu religion in India, with its socially stratified caste system. In terms of India's population growth — as well as its history, culture and economy — there is not just one India, but several different and distinct *Indias*.

Although the decennial population growth rate has declined from 24.7 percent to 23.5 percent during 1981-1991, India's population grows by 17 million people each year (see Table 1.1). India's population is projected to rise to over one billion by the year 2000, and to 1.3 billion by 2010. The mammoth task of providing food, shelter, jobs,

education and health care to an enormous population will bring about profound socio-economic and environmental changes in India.

Population density rose to 267 persons per km^2 in 1991 from 216 persons per km^2 in 1981. The highest population density is in the Union Territory of New Delhi followed by the Territories of Chandigarh, Lakshadweep, Pondicherry, Daman and Diu. The most densely populated States are West Bengal, Kerala, Bihar, Uttar Pradesh and Tamil Nadu.

There is a great variation in the sizes of the populations of various States and Territories. The six most populous States — Uttar Pradesh, Bihar, Maharashtra, West Bengal, Andhra Pradesh and Madhya Pradesh — account for 60 percent of the total population. Among the eleven States with populations exceeding 30 million, seven have populations of more than 50 million. The most populated State is Uttar Pradesh (138.8 million), followed by Bihar (86.7 million), Maharashtra (78.7 million), West Bengal (68 million), and Andhra Pradesh (66.3 million). There is disparity in the delivery of social and development services among the States and Union Territories. Differences in ethnic composition are also significant in the northern states.

The urbanization of the country's population has increased to 30 percent in 1991 from 17.1 percent in 1951. Population growth is higher in urban areas, reflecting, in part, the unprecedented upsurge in migration to cities from rural areas in the 1980s and early 1990s. One-third of India's population will be living in urban areas by the year 2000, if the present trend continues. Indian urbanization reveals several regional patterns. In the northern heartland, the west, where wheat is grown, is more urbanized than the east, where rice constitutes the staple crop.

In 1991, India had 21 metropolitan cities with populations of one million or more. Indian cities with populations greater than 100,000 are concentrated in three general regions: 1) the Indo-Gangetic Plains extending from the Punjab to the Ganges Delta, 2) the Bombay-Ahmadabad area, and 3) the southern part of the Peninsula, which includes Madras and Bangalore. The largest cities with populations over five million are Bombay, Calcutta, Delhi and Madras. Indian cities are places of staggering social and economic contrasts. As crowding intensifies, social stresses have multiplied, leading to sporadic rioting in recent years.

Table 1.1: **Population size and growth patterns**

Year	Population (million)	Decade Growth (percent)
1901	238.4	na
1911	252.0	5.7
1921	251.3	-0.3
1931	279.0	11.0
1941	318.7	14.2
1951	361.1	13.3
1961	439.2	21.5
1971	548.2	24.8
1981	683.3	24.7
1991	843.9	23.5

na: not available
Source: Census of India 1991

Unlike in other countries, in India male mortality at an early age is strikingly lower than female mortality in that the sex ratio is strongly male-biased. In 1991, for all ages, the ratio was 929 females per 1000 males, due to female infanticide, neglect of unwanted daughters and high maternal mortality.

The overall literacy rate in India was 52 percent in 1991, compared with 18 percent in 1953. There is a disparity in the literacy ratio for males (64 percent) and females (39 percent).

POLITICS

India is the world's most populous democracy with 550 million registered voters. The country has maintained its Central and State government administrative system through a system of checks and balances, and an independent judiciary, staffed by a well-developed bureaucracy.

The Union of India has a federal parliamentary form of government. Its 1950 constitution divided government responsibility between the Central Administration and the States. The Central Administration controls foreign affairs, defense, finance and currency, as well as most of the country's natural resources. The States are responsible for agriculture, irrigation, road transportation, education, health, local government and rural development.

In 1947, India emerged from British India as an independent nation. The democratic secular government was founded on the basis of a multi-lingual, multi-racial and multi-religious society, and was thus named the Union of India. Its founding party was the Indian National Congress Party. The current government party is the Congress-I Party.

In India's federal parliamentary system of government, the Central Administration has more authority than the other branches. The principal executive power resides in the office of the Prime Minister, the majority leader of the *Lok Sabha*, one of the houses of the national parliament. The members of the Lok Sabha are directly elected by the people, while in the other House of Parliament, the *Rajya Sabha*, members are indirectly elected through the State legislatures. The real legislative power resides in the Lok Sabha, including approval of budgets and passage of five-year development plans.

Elections have taken place at least once every five years since 1952, when the first elections were held after India was declared a republic on January 26, 1950. The most recent (mid-term) elections were held in June 1991.

Indian politics since 1947 have been dominated by the Congress Party, which has had ruled India for the past 41 of its 45 years since independence. And, for most of this period, the prime ministership has remained within the family of Pandit Nehru, the so-called "Nehru-Gandhi Dynasty" of modern India.

After independence on August 15, 1947, India began to emerge as a major regional political and industrial power. Under Pandit Jawahurlal Nehru's leadership for seventeen years, India followed socialistic centralized development policies with an emphasis on economic self-reliance. Nehru was a leading exponent of the Nonaligned Movement in the Third World. India, however, became involved in regional disputes in

1948 and in the 1960s with Pakistan over Kashmir, and in the 1960s with China over territory on India's northeastern border.

Following Nehru's death in 1964, Lal Bahredur Shastri was Prime Minister for two years. After Shastri's death, Nehru's daughter, Indira Nehru Gandhi, was elected as the Congress Party's parliamentary leader, and, thus, became the first female Prime Minister of India in 1966. Her administration provided stability and strong governmental authority in the Indian political arena and pursued rigorous social, economic and industrial programs. The ruling Congress Party, long the dominant power in India's politics, however, lost some of its near-monopoly in 1967. The party split into the New Congress Party, led by Indira Gandhi, and the Old Congress Party, headed by veteran leaders of India's independence movement.

In August 1971, India and the USSR signed a twenty-year Treaty of Peace and Friendship which included mutual defense guarantees. Hostilities broke out again with Pakistan in December 1971. A war was fought on both the East and West Pakistan fronts, resulting in the creation of a new nation, Bangladesh, from the former East Pakistan. A peace agreement was signed with Pakistan in 1972. In May 1974, India joined the ranks of the nuclear powers by detonating its first atomic bomb at Konkran, Rajasthan, in the Thar Desert near Pakistan. Tensions with Pakistan have been a chronic feature of India's foreign policy environment.

In June 1975, Mrs. Gandhi declared a "State of Emergency" which lasted until 1977. Opposition parties that were loosely united in the Janata (People's Party) coalition, led by Morarji Desai (Janata Dal), scored a massive victory in the 1977 elections, voting the New Congress Party out of power. However, Desai resigned in 1979 after his coalition partners split their loyalties.

Indira Gandhi's faction of the Congress Party, now known as the Congress-I Party, regained control of Parliament in the 1980 general elections. Following her reelection, Prime Minister Gandhi continued her previous administration's socialist programs. Indira Gandhi had groomed her son, Sanjay Gandhi, as her successor, but he was killed in a tragic airplane accident in 1983 while taking flying lessons.

Mrs. Gandhi's second term in power was characterized by continuing political crises, mainly concerning the Union government's authority vis-a-vis autonomy of the States. Economic, communal, and secessionist problems erupted in violent separatist movements based on regional and religious interests in the Punjab, Kashmir, and Assam.

Unrest in the Punjab resulted in the Indian Army's occupation of the Sikhs' holiest shrine, the Golden Temple of Amritsar, in 1983. The Sikhs viewed this as another example of Indira Gandhi's encroachment on their religious rights. Thus, Indira Gandhi was assassinated by her Sikh bodyguards at her official residence in New Delhi on October 31, 1984. Her son, Rajiv Gandhi, succeeded her as the Prime Minister of India. Rajiv Gandhi won a resounding election victory in December 1984, and his Congress-I Party won the largest majority in Indian history (415 out of 525 seats).

On December 3, 1984, methyl isocyanate, a deadly gas, escaped into the atmosphere from a pesticides factory in Bhopal owned by Union Carbide, a US company. Approximately 3,500 people were killed and 200,000 people became ill as a result of one of modern history's worst industrial accidents.

During his tenure (1984-89), Rajiv Gandhi followed up on many of the social programs pursued by his mother. His administration instituted economic reforms through liberalization of trade and commerce by opening up some sectors of the economy to private investment. These reforms brought profound changes to the Indian economy at the national and international level. The emphasis on technology-led growth spurred expansion of the economy and further development of the private sector. As India's regulations on foreign investment were relaxed, economic links with Western countries and Japan were strengthened, and new markets were established for Indian products.

Rajiv Gandhi's administration was not able to settle the mounting pressures of regional and communal disputes. In 1987, India sent its troops to Sri Lanka, where the Tamil guerrillas' secessionist movement had created an escalating crisis for the Sri Lankan central authority. The Indian troops were withdrawn from Sri Lanka in December 1989, after relatively heavy losses in the face of mounting hostility to the Indian military presence.

Serious floods in Bangladesh in October 1988 brought into the limelight the lingering water dispute between India and Bangladesh over control of the Ganges River waters and the building of the Farakka dam in India. In 1989, India also experienced serious strains in its relations with Nepal over the renewal of trade and transit treaties between the two countries. This resulted in India's closing of the frontier until a new agreement was signed in June 1990.

India's determination to be the dominant power in the region resulted in a successful military intervention to save the president of the Maldives from a coup mounted by mercenaries in 1990. In the early months of 1990, India and Pakistan again came close to war over the intensifying insurrection by Muslim secessionists in Indian-held Kashmir.

On the domestic front, Rajiv Gandhi's economic reforms were set back by the resignation of his finance minister, Vishwanath Pratap Singh, amidst accusations of corruption and misuse of power. Singh became a populist leader of the opposition to Rajiv Gandhi's Congress-I rule. The Janata Dal (People's Party), an offshoot of the Janata Party, with other parties in the National Front coalition, spearheaded the opposition campaign to the Congress-I government.

In the subsequent general election in November 1989, incumbent Prime Minister Rajiv Gandhi could not win a clear majority, although his Congress-I Party emerged as the largest single party in Parliament (with only 195 out of 525 seats). A loose coalition government of opposition parties, with the Janata Dal allied with the Hindu-revivalist Bharatiya Janata Party (BJP) and the Communists was formed under the leadership of Singh. Singh took charge as India's second non-Congress Party Prime Minister in December 1989.

The Singh government inherited the long-standing problems deep-rooted in Indian society, and was soon engulfed in another crisis. In 1990, Singh's coalition ally, the Bharatiya Janata Party (BJP), sponsored agitation on a 1947 dispute over a mosque in the northern town of Ayodhya, Uttar Pradesh, exacerbating communal tensions across India. Over 100,000 militant Hindus, led by the BJP and the Vishwa Hindu Parishad (VHP), were arrested following an assault on the mosque on October 30, 1990.

Hundreds of people were killed in communal clashes between Hindus and Muslims. As a consequence, curfews were instituted all over India. Road travel and rail services slowed to a crawl in many parts of northern India due to these riots and curfews.

During this crisis, Singh vacillated over economy policy, causing early plans for liberalization to be abandoned when they ran into opposition: economic growth slowed as a result of government inaction on many crucial policy matters. On November 7, 1990, India's Parliament voted Singh out of office by a margin of 346 to 142 votes. The authority of the Indian state had taken a terrible battering as a result of the worst unrest since the partition riots of 1947.

Chandra Shekhar took over as India's Prime Minister in November 1990. However, in March 1991, for the second time in five months, the minority government collapsed after its parliamentary backers withdrew their support. During this time, Rajiv Gandhi, whose Congress-I Party had the largest number of seats (195 with 25 Congress allies) in the Lower House, vacillated between inaction and plans to take over the government. Finally, Indian President Venkataraman announced on March 13, 1991 that the Lok Sabha (Lower House) was dissolved and, thus, set the stage for mid-term elections for a new Lower House in late May 1991. The announcement concluded one of the shortest tenures of government in Indian parliamentary history. The Shekhar government had been riven by bitter political wrangling and was not able to arrest domestic violence and corruption.

As the national elections were being held on May 20, 1991, in a campaign marred by political violence, former Prime Minister Rajiv Gandhi was assassinated by a bomb-blast at an election rally in rural Tamil Nadu. Sonia Gandhi, widow of the slain leader, declined the ensuing offer to lead the Congress-I Party; a veteran, P.V. Narasimha Rao, was chosen as the leader of the party.

The political scene was jolted by the assassination of Rajiv Gandhi, and national elections were postponed until mid-June 1991. This tragic event underscored the depth of turmoil threatening the world's largest democracy. Communalism and communal violence seemed to be the focal point of the 10th national elections. The Indian

President warned his nation in an extraordinary address on June 9, 1991, that India would cease to be a democracy if bloodshed and vote fraud continued through the crucial national elections.

For the second time in 18 months, no clear winner emerged in the national elections, although the Congress-I emerged as the largest party (on winning 220 out of 515 seats, it is short of a majority in the Parliament). The Congress-I Party reconciled itself to ruling as a minority government, with its leader, Narasimha Rao, becoming the fourth Prime Minister in eighteen months. Rao is also the first Indian Prime Minister who has hailed from South India.

Rao's coalition government faces formidable challenges. At stake is the future of India's foundations as a secular and democratic state. A rise in Hindu militancy now threatens to return the country to a Hindu *rashtra raj* (state/nation) and there are serious economic, communal and secessionist problems besetting the country. Rao's leadership has made difficult decisions as a matter of political expediency to resolve the current economic crisis with a new industrial policy (NIP), currency devaluations, budget cuts, deregulation and privatization.

The Indian-Soviet Treaty was renewed in July 1991, but it remains a mere ceremonial document. The former Soviet Union's special relationship with India is a thing of the past. The collapse of the Soviet Union has proved to be problematic for Indian trade and defense policies.

India's internally diverse States have been facing some of their most difficult challenges since the early 1980s. Besides the heightened confrontation between the Center and the States, many inter-State and intra-State conflicts have emerged. The internal social issues and the safeguarding of the Hindu caste-system are reaching the conflict stage. Serious cleavages have arisen in India, intensified by the sheer numbers of people and by the depth of their mutual distrusts and dislikes.

The pressure for greater regional autonomy also continues in several parts of India. At the same time, many of the State governments are occupied with insurgencies or ethnic and communal conflicts. Chief ministers in some States run their administrations with increasing latitude.

The debate over the distribution of power between the Center and the States in the Indian federal system has arisen from a reinterpretation of Article 356 relating to constitutional authority over the States, in particular, and emergency powers, in general. In light of their political, economic, financial, administrative and social experiences, States are demanding amendments and modifications to Article 356 to reinforce their authority over their own affairs.

Indian society has experienced turmoil in the machinations of state and polity. The States rich in oil, natural gas and other natural resources — Maharashtra, Andhra Pradesh, Tamil Nadu, Orissa, Assam, Nagaland, and Tripura — have clamored for independence in charting investment policies in their economies. They have been pressing the Union government for authority to utilize more of their energy resources for their own development and for the allocation of more funds to set up new industries based on the resources within their States.

Two

NATIONAL ECONOMY

ECONOMIC SYSTEM

Following independence in 1947, the Indian government adopted a centralized socialistic policy in its national economic and development planning. This policy, based on self-reliance through austerity, was pursued through target-oriented five-year development plans, regulation of private enterprise, state ownership of key industries, trade protectionism, and strict limits on foreign capital, equity, and technology. The Union government held a monopoly in key industries and controlled the export and import of certain commodities. Nationalization of the banking and energy sectors (including electricity generation, oil and gas production and marketing, and coal mines) was completed in the early 1950s. Public ownership of the railroads, airlines, shipping and major bus lines, communications, new steel mills, heavy industries, armament and other military equipment-making installations, the energy sector, and related activities was considered an important element of economic development. At present, the public sector in India is a vast domain which enjoys preferential access to many economic resources, imports and inputs.

India has always been heavily committed to autonomy in its development planning and decision-making. In the past, it has financed the greatest bulk of its development investments from its own resources — raised through heavy taxation and a high domestic savings rate — and could pay for any individual project at will. India has also been a recipient of a generous supply of multilateral foreign aid.

Nevertheless, a thriving private sector coexists with the public sector enterprises in this mixed economy: the bulk of the agricultural land, urban property, and most retail and wholesale businesses are privately owned. In addition, there are a large number of private industrial operations. The Rao administration is now promoting the transition from a mixed economy to a market-oriented economy.

India is among the ten largest industrialized countries in the world, and has reached a high level of indigenous accomplishment in industrial technology, textiles and fiber manufacturing, chemicals, nuclear energy, space and satellite communications, computers, shipbuilding and marine technology, armaments manufacture, and agriculture.

India's economic growth has been managed through development plans called Five-Year Plans (FYPs) that include heavy spending on government projects. The targets set by the Indian Planning Commission in the Five-Year Plans are key benchmarks for the progress of most sectors of the economy. The Five-Year Plans are managed by ministerial planning staffs and must be approved by Parliament.

The design of each FYP is the result of a political decision-making process that examines the allocation of domestic GNP between private and public sectors, determines the distribution of government resources between economic and social development, defense and other sectors, and estimates how much of overall national product needs to be taxed. The budget is allocated among various sectors and development programs: industry, rural development, agriculture, energy, communications, transportation, education, public health and associated sectors.

Since the 1980s, there has been a change in development planning, with a greater emphasis on private and foreign investments and joint ventures. With rapid growth and modernization as his aims, Prime Minister Rajiv Gandhi (1984-89) first introduced economic reforms and liberalized regulations for private sector investment. Deregulation and elimination of industrial licensing have been pursued for over a decade.

India's excellent credit rating in the 1980s allowed it to borrow easily and accelerate imports. With significant capital imports, India was able to modernize its industry and increase exports. However, the export surge did not completely finance debt repayment liabilities. Now, India can no longer borrow cheaply, since its credit rating has been downgraded to BBB minus — a rating just a bit higher than junk bonds. As a consequence, partial privatization of state-owned enterprises is being instituted and a public sector financial institution, ICICI, was allowed to sell 27 percent of its equity through a public share issue. About 20 percent of the shares of the Shipping Credit Corporation, the state-owned computer group (CMC), and the Indian Petrochemical

Corporation are also to be sold to the public. In his 1991-92 budget speech, the Finance Minister proposed a rapid disinvestment of government holdings by 20 percent.

Recent economic trends

India has exhibited impressive economic growth statistics over the past decade. During the 1980s, real GNP grew by nearly six percent per year, well up from the 3.5 percent average annual growth generated during the first three decades of independence. India exhibited a high savings rate of about 20 percent of GDP in the 1980s; the bulk of savings were invested in the economy. The gross capital formation rate was 22 percent of GDP in the 1980s. The percentage of Indians below the poverty line fell from 48.3 percent in 1977-78 to 29.2 percent in 1987-88. The portion of the population engaged in agriculture — which had remained at 70 percent for several decades — is now also decreasing.

The Seventh Five-Year Plan (1985-86 to 1989-90), under Rajiv Gandhi's administration (1984-89), promoted economic growth, modernization, self-reliance and greater social equity. The average annual growth rate during the Seventh Five-Year Plan was 5.3 percent.

India's gross domestic product in 1990-91 was estimated to be about Rs4.2 trillion (US$180 billion) and per capita income was US$350. The Finance Ministry is hoping for four percent GDP growth in the current fiscal year 1991-92, down from the five percent growth rate generated in 1990-91. Economic statistics based on 1980 factor costs are shown in Table 2.1.

The country's high growth rates in the late 1980s were accompanied by a widening fiscal deficit, which grew from six percent of GDP in the early 1980s to more than eight percent in the fiscal year that ended on March 31, 1990. During the same period, the current account deficit increased from an average of 1.3 percent of GDP to 3.3 percent, or US$8.6 billion. A budget deficit equal to nearly 6.5 percent of GDP is projected for the fiscal year 1991-92.

There has been a disquieting trend in the rate of domestic savings during the Seventh Five-Year Plan. The ratio of gross domestic savings as a percentage of GDP at

current market prices improved only marginally from 20.4 percent in 1985-86 to 21 percent in 1988-89, while the ratio of gross capital formation increased from 22.8 percent to 23.9 percent during the same period. On the other hand, public sector savings declined from 3.2 percent of GDP in 1985-86 to 1.6 percent in 1988-89 and private corporate sector savings decreased from 2.1 percent to 1.8 percent of GDP during the same period. However, household savings recorded an appreciable increase from 15.2 percent of the GDP in 1985-86 to 17.5 percent in 1988-89.

Despite some liberalization in the 1980s, Indian governments were unable to exert much discipline over public spending and a private sector shackled with high taxes and heavily dependent on imports. The result has been that in 1990-91 the economy slipped further out of control.

Inflation rose from an annual rate of about nine percent in mid-1990 to 13 percent at the end of October 1991. The Finance Ministry has estimated inflation at nine percent for the 1991-92 budget. Industrial output growth has fallen since the first quarter of the fiscal year 1991-92. However, with a good agricultural season, the economy is expected to grow about four percent.

The 1991-92 budget

A full budget was presented by the Rao government to the newly elected Parliament on July 24, 1991. The total outlay planned for the 1991-92 budget is Rs814 billion, compared to Rs750 billion in 1990-91. The new budget cuts the uncovered deficit to Rs77 billion, compared to Rs108 billion in 1990-91, and reduces the overall deficit to Rs377 billion vis-a-vis Rs433 billion in 1990-91. The budget initiates a process of fiscal reforms by reducing export subsidies, cutting market borrowing, and effecting selective disinvestment in public sector enterprises. The major categories of budget expenditure are interest payments on public borrowing (32 percent), defense (24 percent), and subsidies (17 percent). Subsidies, which peaked at 2.5 percent of the GDP in 1989-90, have been reduced to 1.8 percent of the GDP in 1991-92. While farm subsidies increased in previous budgets, this year's budgetary allocation has been reduced by Rs9.34 billion.

Table 2.1: **Major economic indicators**

	1988	1989	1990	1991	1992
		Percent annual change			
Gross Domestic Product*	10.4	5.2	4.5	4.2	4.8
Agricultural sector	15.4	2.5	2.2	2.0	2.0
Industrial sector	8.1	6.8	6.0	5.7	6.7
Service sector	8.1	6.3	5.3	4.8	5.5
Inflation rate-CPI	9.1	6.6	10.0	9.0	7.0
		Percent of GDP			
Gross domestic investment	23.9	24.1	23.5	23.3	23.6
Gross domestic savings	21.1	21.7	21.0	21.0	21.1
Resource gap	-2.8	-2.4	-2.5	-2.3	-2.5
Debt service ratio	28.9	26.3	26.4	24.1	26.1
		US$ billion			
Merchandise exports	14.2	16.8	19.3	21.9	25.1
Merchandise imports**	23.8	25.1	28.6	31.2	34.3
Trade balance	-9.7	-8.3	-9.3	-9.3	-9.2
Current account balance	-7.9	-7.3	-8.9	-8.9	-9.0
External debt	57.3	62.5	69.8	76.5	81.6

* Based on constant 1980 factor cost
** CIF
Sources: Ministry of Finance, Economic Survey 1989-90 (New Delhi, 1990); Reserve Bank of India, Annual Report 1989-90 (Bombay, 1990); World Bank, World Debt Tables, 1990-91, Vol. 2 (Washington, D.C., 1990); and staff estimates.

The government took a bold and innovative step with the announcement that it will disinvest up to 20 percent of its equity in selected public sector undertakings and sell this equity to mutual funds and financial and investment institutions. This is expected to yield

Rs2.5 billion to the Treasury in 1991-92. Besides enhancing resource availability, disinvestment should broaden the equity base and improve the management of these state undertakings. In another major step, the Rao government devalued the Indian rupee by 20 percent in two successive devaluations in early July 1991.

Budgetary deficits

Throughout the 1980s, the growth of expenditures in India has outstripped the increase in revenues. This has led to a widening of the budget deficits in the revenue account and a growing tendency to borrow from domestic and external sources to finance this deficit and the expenditures in the capital account.

This increasing recourse to borrowing has had several adverse affects. First, the deficit has been the principal factor fueling a high rate of monetary growth, which in turn, has increased inflationary pressures. Second, accelerated government borrowing from the commercial banking system, as well as from domestic savers, has claimed a high proportion of household savings, leaving a smaller portion for use in sectors such as industry and agriculture.

In addition, the mounting public debt has led to rising debt service obligations which have claimed an increasing share of government expenditures. The fiscal position in 1990-91 reached a critical stage with a Rs108 billion budget deficit. The previous Congress-I government had left an overall deficit of Rs106 billion, exceeding the budgeted estimate of Rs74 billion in 1989-90.

Eighth Five-Year Plan (1992-97) and beyond

The current five-year economic development plan is the Eighth Five-Year Plan, originally scheduled for 1990-91 to 1994-95; however, its framework was revised by the Rao Administration to cover the five years from 1992 to 1997. The revised Plan envisages a growth rate of 5.6 percent per year with investment totalling Rs7,920 billion (US$306 billion) at 1991-92 prices. Public sector investment is planned at Rs3,420 billion (US$131 billion), with major shares for the energy, transportation and communications sectors. The government will also spend Rs3,020 billion (US$116 billion) on infrastructure and

social programs, including housing, urban and rural development and public works. The planned private sector investments are Rs1,480 billion (US$57 billion). The domestic savings rate is expected to be 21.6 percent per year. Annual growth of 13.6 percent in exports and eight percent in imports is targeted.

The Rao government is presently finalizing the allocations for various sectors and streamlining the development process within the scope of its economic reforms. In mid-1990, the debate on economic policy came into sharp focus during the formulation of the "Approach to the Eighth Five-Year Plan (1990-95)." The Planning Commission charted out a new course emphasizing the democratization and the decentralization of the planning process, the devolution of responsibilities to State governments, the employment-oriented industrialization strategies and the protection of rural industries. The central thrust of the Eighth Five-Year Plan is to increase employment at the rate of three percent per year. The Plan seeks to guarantee the right to work to every Indian citizen.

The planned annual economic growth rate of 5.6 percent in the Eighth Five-Year Plan reflects underlying constraints on growth imposed by the fiscal crisis in the budgetary and external payments accounts. For this reason, the Plan places more emphasis on better utilization of existing resources rather than on a massive increase in net investment.

In an attempt to reduce its foreign debt of US$76 billion and increase minimal hard-currency reserves, the government announced measures to open up the economy, cut subsidies and curb defense spending in its annual budget for 1991-92. Many of the efforts focus on capital-intensive production using imported technologies, and liberalization of trade policies. While these policies may accelerate economic growth, they are also likely to exacerbate trade and debt problems.

The Rao government is focusing on stimulating greater private sector participation in the economy, which will allow competitive markets to play a critical role in fostering economic growth, development and alleviation of poverty. A New Industrial Policy (NIP), announced by the Rao government on 24 July 1991, has opened up the economy for foreign investment and joint ventures. The NIP discourages state-run monopolies and

frees potential manufacturers from bureaucratic licensing regulations. The NIP has raised the ceiling for automatic approval of foreign investment in joint ventures from 40 percent to 51 percent in many long-protected industries, particularly heavy manufacturing, high technology, food processing and tourism. The policy also allows case-by-case exceptions for higher foreign equity in high-technology export-oriented ventures.

Only those industries considered "strategic" or environmentally or socially sensitive will now require bureaucratic approval. In addition, the government still intends to protect its nascent, yet massive, market of potential consumers for its domestic product manufacturers. Control over power generation, oil and natural gas, coal and most minerals industries will remain restricted to the public sector. However, the Indian government has recently opened up opportunities for foreign and private companies in the upstream hydrocarbons sector.

Despite the resistance to change from the bureaucracy, bold steps in economic reform have already been taken, including currency devaluations, budget cuts, deregulation, and privatization. In October 1991, at the World Bank's annual meeting, the Rao government had stated that future government investment would be largely confined to improving infrastructure, social services and education. The main policy challenge for the Rao government is to ensure that economic growth and industrialization do not destabilize the delicate political and social balance in the country, as restructuring the Indian economy will involve some social costs in the transition period.

A major Indian export thrust faces obstacles such as the high cost of opening letters of credit, rising production costs due to higher prices for imported goods for export industries, and slumping overseas demand. The telecommunications and transport sectors, which constitute the essential infrastructure for accelerated exports, are in dire need of overhauling and expansion.

Presently, economic trends would indicate a slow-down, as the growing external debt service liabilities, the high debt-to-GNP ratio, inadequate new investments, and plummeting expatriate remittances from abroad are putting strains on the economy.

After increasing for 15 years, remittances from the Indian workers employed overseas declined in 1990-91, mainly as a result of the Gulf War.

Poverty and unemployment will continue to be major problems confronting India well into the 1990s. India will continue to project the contradictory image of an increasingly sophisticated and industrialized economy, competitive at a global level, but beset with serious problems of poverty, high unemployment, and social inequity. Unless the public distribution system is improved and public expenditure reaches the targeted populations, India will enter the 21st century as two nations, probably in conflict with each other — one modern and prosperous, the other backward and poor.

ECONOMIC SECTORS

Agriculture

Agriculture is the largest sector of India's economy and accounts for over one-third of GDP. About 68 percent of India's economically active population is engaged in agriculture. Agricultural development in the 1980s saw a combination of heavy investment in irrigation, the extensive planting of high-yielding crop varieties (HYVs), an increased capacity to store food grains, and an improved public distribution system.

The growth rate of overall agricultural production was 2.6 percent during 1967-1986, against a population growth rate of 2.3 percent over the same period. Intensification of agriculture, with better seeds, fertilizers, pesticides, mechanization and irrigation adopted since the 1960s, has amply rewarded Indian farmers with abundant harvests of food grains. Now hope is pinned on improving the drylands' farming output. Development plans project a four percent annual increase in crop production in the dryland regions.

Farming in India no longer depends heavily on the monsoon rains. Until the early 1980s, a monsoon failure would have a disastrous effect on agriculture, with consequent impacts on the economy. Since widespread use of the HYVs began, Indian agricultural production has grown at an average rate of 2.7 percent per year. During the later half of the 1980s, the rate of productivity rose to 3.6 percent. It is significant that increased output is almost entirely explained by growth in productivity.

The distribution of agricultural produce continues to be hampered by the lack of farm marketing roads. In 1990, only 40 percent of India's villages were accessible by motorable road, and animal-drawn carts still outnumber motor vehicles nationwide.

The Indian government has invested heavily in the agricultural sector. Government support ranges from the distribution of new seeds to extensive credits to farmers in rural development programs. The government allocated about Rs180 billion (US$11 billion) for agriculture in 1990-91, and provided subsidies for irrigation, fertilizers, petroleum products and electricity for farms. Agricultural loans worth Rs132 billion (US$8 billion) were extended in 1990-91. State governments finance about 60 percent of all public spending on agriculture.

India is a major producer of livestock and dairy products with a bovine population of 196 million cattle and 72 million dairy buffalo (1989-90). The dung produced by the bovine population, estimated to be 1,197 million tonnes (mmt) annually, is a major source of green manure and biomass fuel.

Foodgrains, which include rice, wheat, pulses, jowar, bajra and maize, account for about 70 percent of the country's crop area. Of the cash and plantation crops grown, oil seeds, cotton, jute, cashews and tea are the most important.

The value of agricultural commodity exports has risen by nearly 29 percent to Rs57.4 billion (US$3.6 billion) in 1990-91 from Rs44.6 billion (US$2.8 billion) in 1989-90. Exports include tea, coffee, tobacco, cotton, jute goods, cashews, spices, cereals, beef, poultry and eggs, processed food, marine and horticultural products.

In the 1980s, more than one quarter of India's cultivation area was still owned by less than five percent of the country's farming families. About one-half of all rural families own either as little as one-half hectare (an acre) or no land at all. Little land redistribution has taken place since the 1980s.

About 40 percent of India's land area is under cultivation. Out of India's 328.7 million hectares (mha) land area, about 175 mha are classified as arable land. India ranks third in the world in total arable land area, next only to the USSR and the United States, although the per capita arable land is only 0.22 hectares. About 33 percent of

foodgrain crops are irrigated. Land utilization encompasses many types of agricultural activities — from subsistence farming to mechanized farming in cropped lands, dairy farming, forestry, and livestock raising.

An interesting feature of Indian agriculture in recent years has been the widening of interregional disparities in agricultural productivity and standards of living. While regions served by assured irrigation have prospered, dry lands have not done so well. The inability to transfer the success of HYVs to dryland farming has widened the divide, in terms of living standards, between dry and wet regions. Consequently, food consumption levels are also uneven and the incidence of poverty and malnourishment varies widely across the country.

Outlook for agriculture

The expansion of Indian agriculture during the 1980s and early 1990s suggests that initiatives taken to increase production have started showing positive results. India's agriculture is now geared towards developing an upgraded marketing infrastructure in the 1990s. The government plans to diversify agricultural output to meet growing demands by providing better incentives to farmers, and by revitalizing rural banking.

Good monsoon seasons in 1990-91 generated agricultural production increases of 4.5 percent. However, the forecast for monsoon rainfall for 1992 is nine percent less than normal. This will undoubtedly affect agricultural production, thus growth in agriculture is forecasted at only two percent in 1991-92.

In 1991, the Rao government increased price supports on food crops by 10-12 percent, while raising fertilizer prices by 30 percent. Because of the lower estimated growth of agriculture in 1992, the government has been forced to maintain fertilizer subsidies. The Indian government is not following the World Bank's recommendation to privatize agriculture and rely on market forces. The government expects its new trade and industrial policies to correct distortions in intersector incentive patterns through the promotion of agricultural exports, diversification of agriculture and creation of a stronger infrastructure for agro-based industries.

Industry

India is among the world's ten largest industrial countries. Since the 1980s, India has developed a well-diversified industrial production sector encompassing activities from manufacturing to high-technology fabrication. Despite some imbalances and inefficiencies, India's industrial resource base is quite well-endowed and the country has achieved a high degree of self-reliance. Industrialization was assisted by a major infrastructural advantage, as India possesses an extensive network of railroads with over 100,000 km (60,000 miles) of track.

There is sufficient output from the industrial sector to meet domestic needs as well as export large quantities of manufactured goods. The sector's growth rate from 1970-71 to 1980-81 was 4.4 percent per year and accelerated to seven percent annually from 1981-82 to 1984-85 (Table 2.2). In the mid-1980s, the industrial sector generated a growth rate of 8.5 percent per year; in 1990-91 it grew 8.4 percent.

The relatively high rate of growth of the Indian economy in the 1980s was led by a rapid expansion of the industrial sector. This was accompanied by productivity gains in the manufacturing industries. Still, India's industrial production growth rate has been only about one-half of the rate achieved by many of the newly industrialized countries (NICs).

Agriculture-based industries now comprise only 33 percent of manufacturing value added, as compared to 65 percent in the 1950s. On the demand side, industrial growth in the 1980s was primarily stimulated by consumer spending. From 1985 onward, liberalization and changes in fiscal policies, including a reduction in tax rates, have put more purchasing power into the consumers' hands, as has the expansion in services and infrastructure.

Two important features of the renewed industrial growth in 1980s were: first, a higher growth rate in the production of consumer durable goods vis-a-vis capital and intermediate goods; and second, an increase in the share of chemical-based industries vis-a-vis metal-based industries. India has traditionally focused on metal-based industries, but the tremendous growth in the supply of oil feedstocks has encouraged the expansion of chemical- and petroleum-based industries, such as plastics, petrochemicals, and

Table 2.2: **Industrial sector's average annual growth rate, percent**

Period	Mining	Manufacturing	Electricity	Total
1970-71—1980-81	4.3	4.8	7.3	4.4
1981-82—1984-85	12.7	5.8	8.9	7.0
1985-86—1989-90	5.7	8.8	9.4	8.5
1990-91	3.5	9.2	8.6	8.4

Source: Economic Survey 1990-91

fertilizers. India's long-term interests in developing a self-reliant economy are, thus, closely linked with the development and utilization of petroleum and natural gas resources.

Public sector: India has traditionally had a large public sector, characterized by extensive regulatory authority and participation throughout the economy. The public sector has a monopoly in several basic industries. During 1990-91, the public sector units (PSUs) accounted for the production of 54 percent of the finished steel, 48 percent of the aluminum, 80 percent of the zinc, 95 percent of the shipbuilding, 46 percent of the nitrogen fertilizers, 98 percent of the coal, 97 percent of the electricity generation, and 100 percent of the power-generating equipment, as well as all of the crude oil and natural gas, hydro- and nuclear power produced in India.

The government provided Rs68 billion (US$2.9 billion) to PSUs as equity and loans in 1991-92. The collective losses of the PSUs were Rs8.5 billion (US$350 million) in 1990-91; but most PSUs have enormously undervalued assets which can be reassessed to boost net worth. The Center for Monitoring the Indian Economy (CMIE) has estimated that the government could gain Rs122 billion (US$5 billion) if 20 percent of the PSU shares could be sold at a price-earnings ratio of 1:18.

The Rao government is starting the process of transferring 20 percent equity of viable PSUs to mutual funds which, in turn, will list them on the stock exchange. The sales will bring in a net income of Rs25 billion (US$1 billion) by 1992.

A National Renewal Fund (NRF) to help the modernization efforts of the unprofitable PSUs was established under the 1991-92 budget authority. In addition, about US$500 million in funding will be provided by the IMF's second structural adjustment assistance loans (SAAL).

Private sector: The private sector is concentrated in the manufacturing, commercial and service industries. The public and private industrial sectors have specialized into activities centered on specific goods, customers and services. The private industrial sector has two distinct divisions — the Registered Sector consisting of factories registered under the Factories Act (1934), and the Non-registered Sector, which consists of family-run industries or small businesses.

The non-registered sector includes not only the unregistered factories, but also three million household and small-scale industries. The non-registered sector is an important contributor to national production, contributing about one-third of the total value added for industrial production. An Indian businessman is considered a much better keeper of the economy than the Indian bureaucrat. Besides the large industries, there are numerous small-scale and cottage industry units which provide services, handicrafts, and exportable items.

Industries in India: Various industries in India have shown differing growth rates over the period 1986-1991. However, the growth rate from 1986 onward has improved for almost all types of industrial activities (Table 2.3). The major industrial production in India is derived from four categories of industrial enterprises which are classified as follows:

Basic industries. This classification comprises industrial units in electricity generation, coal (including lignite), finished steel, fertilizers, cement, steel casting, pipes and tubes, stamping and forging, sulfuric acid, caustic soda, heavy structural aluminum ingots and copper metal. In terms of value, they represent about one-third of the total industrial production.

Capital goods industries. These industries build and repair ships and manufacture commercial vehicles, aircraft, automobiles and auto parts, electric motors, railway locomotives, textile machinery, electric generators, machine tools, tractors, diesel engines,

railway cars, railway motor starters and contractors, ball rollers and needle bearings, and boilers, among others. In terms of value, these industries represent about 15 percent of the total industrial production. India's capital goods industries include the general manufacturing and engineering industries in which energy use is high. The engineering industries consist of heavy and light mechanical engineering, electrical engineering and electronics industries.

In the automobile sector of the heavy engineering industry, the output of cars and jeeps in the year 1990-91 declined, while commercial vehicles registered a higher growth rate. The growth in the output of commercial vehicles is attributed to increased demand following sustained recovery in the general economic climate. The decline in the increase of jeeps and private cars seems to be a consequence of weakening demand owing to consumer resistance to higher prices. The sharp price increase in fuel and spare parts required for maintenance also has affected the demand for cars. The growth in the output of two wheelers (scooters and motorcycles) has been rising, as well as that of three wheelers (motorized rickshaws).

Intermediate goods industries: These industries manufacture of all types of fibers, including nylon and viscose filaments, jute and mesta textiles (sacks and hessian), giant tires, tin and metal containers, bolts and nuts, commercial plywood, paints, enamels and varnishes. The refining of petroleum products is also included in these industries. In terms of value, they contribute about one-fifth of the total industrial production.

Consumer goods industries. These industries manufacture cotton textiles, paper and paper boards, all types of cloth, sugar, tea, wheat flour/maida, artificial leather, cigarettes, beer, edible oil (vanaspati), tetracycline, penicillin, soaps and detergents, telephone instruments, wrist watches, and computers. In terms of value, these industries contribute about one-third of the total industrial production.

Table 2.3: **Industrial production**

Industry Item /Year (April-March)	Unit	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90
1	2	3	4	5	6	7	8
I. Basic Industries							
1. Electricity	Bill. Kwh	157	170	188	202	221	245
2. Coal including lignite	Mill. Tonnes	155	162	174	187	204	220
3. Finished steel	000' Tonnes	6,871	7,923	8,071	8,807	9,445	9,221
4. Fertilizers (nitrogenous and phosphatic)	,,	5,181	5,755	7,066	7,478	8,912	8,639
5. Cement, all kinds	,,	30,160	33,036	36,520	36,940	42,708	45,052
6. Steel casting	,,	159	229	239	300	333	350
7. Pipes and tubes (other than spun pipes)	,,	170@	1,075	1,147	1,127	1,113	1,198
8. Stamping and forgings	,,	154	165	165	135	152	166
9. Sulphuric acid	,,	2,795	2,555	3,014	3,202	3,363	3,365
10. Caustic soda	,,	746	727	764	958	903	927
11. Heavy structurals	,,	41	42	59	140	108	120
12. Aluminium ingots	,,	277	251	236	245	332	429
13. Copper metal (cathodes)	,,	33	30	3[illegible]	34	40	41
II. Capital Goods Industries							
14. Commercial vehicles	Numbers	96,810	103,050	105,997	119,872	115,789	124,836
15. Auto ancillary and parts	Rs. lakhs	82,508	96,161	102,606	90,941	141,279	159,846
16. Electric motors (DGTD)	000' HP	4,940	5,250	5,431	4,252	5,314	5,203
17. Railway locomotives	Numbers	200	210	261	223	281	276
18. Textiles machinery	Rs. lakhs	22,168	19,686	29,664	35,922	40,945	51,215
19. Electric generators	,,	17,825	18,931	13,025	23,259	19,173	21,[illegible]19
20. Machine tools	Rs. crores	336	338	407	469	593	733
21. Ship building and repairing	Rs. lakhs	14,164	37,829	32,726	27,896	42,598	46,862
22. Complete tractors	Numbers	84,920	76,350	79,940	82,933	109,643	125,102
23. Diesel engines	000' Numbers	1,254	2,046	2,094	1,899	1,855	1,774
24. Railway wagons	Numbers	13,010	13,100	16,471	15,906	21,516	23,626
25. Motor starters and contactors	000' Numbers	1,418	1,456	1,512	1,822	2,279	2,801
26. Railway coaches	Numbers	1,209	1,179	1,234	1,257	1,401	1,423
27. Ball roller and needle bearing	Lakh Numbers	479	579	618	704	1,104	1,191
28. Boilers	Rs. lakhs	45,590	61,660	73,623	64,651	77,835	88,392
III. Intermediate Goods Industries							
29. All yarn	000' Tonnes	1,382	1,448	1,528	1,555	1,562	1,639
30. Petroleum refineries and products of petroleum	,,	32,208	39,877	42,481	45,521	47,583	48,692
31. Jute and mesta textiles							
i) Sacking	,,	806	823	831	678	793	669
ii) Hessian	,,	325	311	349	316	314	347
32. Giant tyres	000' Numbers	4,616	5,971	4,683	4,546	5,612	5,805
33. Tin metal container	000' Tonnes	45	16	78	82	82	78
34. Bolts and nuts	,,	205	309	309	333	342	359
35. Plywood commercial	000' sq. Mtrs.	72,973	75,703	82,949	54,044	55,953	57,829
36. Paints, enamels and varnishes	000' Tonnes	129	139	212	320	337	343
37. Nylon filament yarn	,,	33	39	34	34	38	38
38. Viscose filament yarn	,,	33	42	45	57	69	67
IV. Consumer Goods Industries							
39. Cotton textiles (decentralised)	Mill. Mtrs.	6,427	7,627	7,650	9,018	7,003	7,356
40. Paper and paper boards	000' Tonnes	1,390	1,659	1,870	1,997	2,071	2,212
41. All cloth	Mill. Mtrs.	3,432	3,365	3,318	3,025	2,809	2,648
42. Sugar	000' Tonnes	6,152	6,759	7,701	8,761	9,576	9,423
43. Tea	,,	643	657	622	689	700	705
44. Wheat flour/maida	,,	3,526	3,546	3,779	3,486	4,493	4,738
45. Tetracycline	Tonnes	230	238	252	401	390	513
46. Artificial leather cloth	000' Mtrs.	22,300	25,400	17,736	19,388	32,418	39,023
47. Cigarettes	Crores	8,650	7,700	7,191	6,184	5,453	5,928
48. Beer	Mill. Ltrs.	205	204	187	149	172	199
49. Vanaspati	000' Tonnes	938	868	923	980	996	939
50. Penicillin	MMU	228	236	351	623	545	664
51. Soaps, all kinds	000' Tonnes	1,000	1,398	1,531	1,505	1,477	1,524
52. Telephone instruments	000' Numbers	834	931	734	759	1,144	1,236
53. Wrist watches	,,	5,540	5,320	7,501	7,467	9,162	9,779

Source: Ministry of Industry 1990

TRADE

India's economy has exhibited a steady increase in foreign trade, although foreign trade still contributes only a small percentage of GDP. Trade policy in the 1980s was successful in stimulating exports at some levels. India's trade policy sheltered domestic industry behind high nominal and effective tariffs, although capital imports were allowed to help modernize domestic industry and certain capital goods were permitted to compete with domestic products. In 1980-81, exports contributed 4.8 percent of the GDP; by 1989-90 this share rose to 6.4 percent. Imports accounted for 9.2 percent of GDP in 1980-81 and rose slightly to 9.3 percent by 1989-90. India had a trade deficit in the 1980s which continued through the early 1990s.

Despite sizeable exports, India's trade deficit reached Rs106 billion (US$6 billion) in 1990-91 vis-a-vis Rs77 billion (US$4.6 billion) in 1989-90. Exports rose by 17.5 percent (nine percent in dollar terms) to Rs325 billion (US$13 billion) and imports by 21.9 percent (13.1 percent in dollar terms) to Rs432 billion (US$19 billion) (see Tables 2.4 through 2.6).

Oil and product imports (US$5.5 billion) contributed significantly to the trade deficit, in addition to imported fertilizers, edible oils, rice and sugar. Despite high tariffs on imports (average ad valorem tariffs are 146 percent on intermediate goods, 107 percent on capital goods, 141 percent on consumer goods and 137 percent on all manufactured goods), the import growth rate was about 20.7 percent. In order to maintain a balanced trade account, exports that have grown at 15-20 percent would have had to have grown at a rate of 35 percent.

The government has tried to promote exports with specific incentives for exporters, which include cheap credits, tax breaks and other types of subsidies. Profits on exports have been exempted from corporate taxes. The exporters are given import replenishment licenses (REPs) which allow firms to buy imported materials and equipment. In addition, the government has established free-trade zones and operates a bonded manufacturing scheme. The state-owned enterprises such as the Indian Oil Company (IOC), the State Trading Corporation (STC) and the Mineral and Metal Trading Corporation have monopolized the trade of certain commodities.

Table 2.4: **Current account trade and trade deficits**

	1988	1989	1990	1991[a]
Exports, Rs billion	157.4	203.0	276.8	325.3
Imports, Rs billion	222.4	281.9	353.1	431.7
Deficit, Rs billion	65.0	79.0	77.3	106.4
Deficit, US$ billion	4.6	4.8	4.4	6.2

a: partially revised and provisional
Source: Economic Survey 1990-91

Table 2.5: **Exports of principal commodities, billion rupees**

Commodities	1985-86	1986-87	1987-88	1988-89[a]	1989-90[b]
Agricultural products	30.2	34.2	34.1	33.5	45.7
Ores/minerals	7.9	7.2	7.5	10.3	13.8
Total primary products	38.1	41.4	41.6	43.8	59.5
Cotton yarn	5.7	6.4	11.6	11.3	14.8
Readymade garments	10.7	13.3	18.1	21.0	32.3
Leather goods	7.7	9.2	12.5	14.9	19.5
Gems/jewelry	15.1	20.7	26.2	44.0	53.0
Chemicals	5.0	5.8	8.0	15.3	21.6
Engineering goods	9.5	11.3	15.0	23.6	33.2
Total manufactured goods	53.7	66.7	91.4	130.1	174.4
Total, including others	109.0	124.5	156.7	203.0	276.8

a: partially revised
b: provisional
Sources: Economic Survey 1990-91

Table 2.6: **Imports of principal commodities, billion rupees**

Commodities	1985-86	1986-87	1987-88	1988-89[a]	1989-90[b]
A. Bulk imports	107.6	80.2	90.8	111.8	142.4
Oil/products	49.9	28.0	40.4	43.7	62.7
Fertilizers	14.4	9.2	5.1	9.3	17.8
Iron and steel	14.0	15.6	13.2	19.4	23.1
Non-ferrous metals	5.4	5.2	6.4	7.9	12.5
Edible oils, cereals, etc.	14.7	11.8	15.0	17.4	9.1
B. Non-bulk imports	89.0	120.7	131.6	170.2	211.7
Capital goods	42.9	64.9	65.7	69.4	88.3
Other goods	22.4	27.3	32.4	46.2	55.4
Total	196.6	201.0	222.4	281.9	354.1

a: partially revised
b: provisional
Source: Economic Survey 1990-91

Indian exports have grown from Rs6.4 billion in 1960-61 to Rs325 billion in 1990-91. The Ministry of Commerce projects that Indian exports will rise to Rs1,000 billion (US$40 billion) by 1994-95, with textile exports increasing to Rs250 billion (US$10 billion) by 1994-95. Although India's share of total world trade is minuscule, about 0.4 percent, exports grew at an impressive rate during 1990-91. In April 1991, India recorded its first monthly surplus in foreign trade in four years; however, this was short-lived. The estimated export growth rate for 1990-91 was 20 percent per year.

India's major exports are textile goods, gems and jewelry, leather goods, engineering goods, chemicals, automotive components, and turnkey projects. Exports of agricultural commodities have risen by nearly 29 percent to Rs57.4 billion in 1990-91 from Rs44.7 billion in 1989-90.

In March 1991, the Reserve Bank of India (RBI) virtually cut off access to foreign exchange for imports, as the country's foreign exchange reserves dwindled to US$2.2 billion, barely enough for a month of imports. To open a letter of credit, importers in

India now have to put up an increasingly higher cash margin, which reached 200 percent in April 1991. Long-term measures to bridge India's trade gap are being taken by the Rao government.

Since July 1991, the Rao government has completely revised India's trade policy. With structural reforms to its Export-Import (EXIM) Policy, India has embarked on trade liberalization by abolishing the restrictive license-permit process. The cash compensatory support (CCS) to exporters has been eliminated; all exporters will now be allowed to obtain import replenishment licenses (REP) worth 30 percent of the value of exports which will be freely saleable. The OGL (Open General License) as well as other licenses have been abolished. With the 20 percent devaluation of the Indian rupee vis-a-vis four major world currencies, Indian exports are expected to expand.

In the past, trade between India and the former Soviet Union was designated in non-convertible rupees and was supposed to be balanced every year. Soviet military and project loans were denominated in roubles and paid through the export of goods from India. In addition, India received around 4.5 mmt of oil a year to be paid in roubles, so relieving pressure on India's limited foreign exchange reserves. However, these arrangements are falling apart. An unplanned trade surplus of Rs20 billion (US$1 billion) has arisen in India's favor and is being financed by short-term Indian credits to the former Soviet Union. India is now negotiating to trade directly with the former Soviet Union's five Central Asian republics instead of using the old rupee-rouble trade system.

Oil and petroleum product imports are a major contributor to the foreign trade deficit. In 1989-90, India imported about 26.8 mmt of oil and products, valued at Rs63 billion (US$3.6 billion), with an average cost of US$25.6 per barrel. This represented about 16 percent of the total import bill. Some of India's oil imports were acquired through barter—about 4.5 mmt a year were imported from the former Soviet Union. However, since early 1991, there has been disruption of trade with the former Soviet Union, and the bartered oil imports may soon come to an end.

The rise in oil prices in August 1990, at the beginning of the Gulf Crisis (1990-91), produced a tremendous increase in the prices India paid for its imports of oil and petroleum products. In 1990-91, the cost of oil imports escalated to about Rs105 billion (US$5.5 billion), approximately 30 percent of the total import bill. During the Gulf Crisis, every dollar increase in the world price of oil cost India an additional US$282 million.

The Gulf crisis dealt a serious blow to the Indian economy. The cost of imported oil and products went up and trade with the Gulf was disrupted, while remittances from Indian workers in the Gulf declined. In the past, remittances from abroad had helped offset the trade deficit.

The balance of payments position in 1990-91 became critically weak because of the rise in the trade deficit and the loss of invisible receipts. To make matters worse, domestic crude oil production suffered setbacks due to ethnic strife in Assam and production from 100 oil fields in the Bombay High and Gandhar areas had to be cut back for reservoir management.

The question in the wake of Rao government's economic reforms, trade liberalization and rupee devaluations is: *Will India be able to compete in the international market place in the future?*

EXTERNAL DEBT

India is Asia's leading debtor country, and its foreign debt is the third largest in the world. India built up its large external debt during a period of rapid economic expansion in the 1980s, particularly during the Congress-I (1984-89) administration. The country had a total foreign debt of about US$76 billion in 1991, up from US$19 billion in 1980. The deteriorating external payments position resulted in a drawdown of foreign reserves from Rs57.8 billion (US$3.6 billion) in March 1990 to Rs23.9 billion (US$1.4 billion) in January 1991. India's external debt was estimated to grow to US$80 billion by year-end 1991.

As a major recipient of donor aid and multilateral bank funding, India has used the funds to finance labor-intensive industrial projects, rural and agricultural development, as

well as energy sector programs. Foreign investment in India is low compared to other countries; net foreign direct investment in India in 1989 was only US$425 million, compared to US$2.25 billion in Mexico.

Foreign borrowing has become more difficult as India's sovereign lending assessments and creditworthiness were downgraded in 1990-91. External commercial borrowing and NRI deposits were valued at Rs423 billion as of March 1990 and now exceed 42 percent of total sovereign liabilities (Table 2.7).

India's debt service costs — the amount of export earnings taken up by repayment of loans and interest paid on them — have trebled over the decade to 27 percent of export earnings. Coupled with repayment of principle and interest on short-term loans and liabilities to non-resident Indian (NRI) accounts, the debt-service ratio reached 33 percent in 1991.

Interest on past loans has become the largest item of government spending, limiting public investment and proving problematic to the economic recovery. According to the World Bank, debt servicing could constrain India's economic growth rate to two percent a year over the rest of the decade.

India's debt situation was exacerbated by revenue losses due to the Gulf Crisis and the disruption of trade with the former Soviet Union. The negative effect of the Gulf Crisis on India's current account balance is estimated to be about US$1,390 million in 1990, US$2,160 million in 1991, and US$430 million in 1992. The higher subsidies for fuel and fertilizers, and the repatriation of 150,000 Indian workers from the Gulf have also contributed to higher government expenditures.

Commercial loans to India, totalling US$1.5 billion, were suspended in 1990, as a result of political uncertainty and fiscal crisis. Foreign loans became more difficult to acquire during 1991, with sovereign lending assessments from both Moody's and Standard and Poor's being downgraded. However, a cash crisis had been fended off by gold-based borrowings and emergency loans in 1991. There has been a 42 percent decline in the value of the Indian rupee against the five major foreign currencies, including the US dollar, since the beginning of 1990. Two official devaluations of the Indian rupee in July 1991 amounted to a 20 percent devaluation.

Table 2.7: **Patterns of external liabilities, billion rupees**

As of March	External assistance	External commercial borrowings	Liabilities to IMF	Non-resident Indian (NRI) deposits	Total	External liabilities* as percent of total
1985	240.0	69.1	48.9	38.2	396.2	27.1
1986	266.4	80.8	52.7	66.5	456.3	32.3
1987	323.1	112.4	55.5	78.5	569.5	33.5
1988	365.8	135.4	47.3	100.5	649.1	36.4
1989	468.4	191.5	37.0	141.5	838.4	39.7
1990	541.0	245.0	25.7	178.3	990.0	42.7

* Including external commercial borrowings and NRI deposits
Note: As of July 1991, depending on the nature of liabilities/debts and their terms and condition of payments, some of the debt figures in rupees have been escalated with the devaluation of the Indian rupee by 20% vis-a-vis the US$
Sources: Economic Survey 1989-90 and 1990-91; Economic and Political Weekly, February 1991

In addition to these trends, the country's accelerating political instability began to affect the levels of deposits in non-resident Indians' (NRI) accounts, which have been a vital source of hard currency. The country's reliance on the US$10 billion temporary deposits of foreign exchange by NRIs remained high.

The prospects for Indian external liabilities are changing as a result of the Rao government's policy reforms and structural adjustments. The Aid-to-India Consortium has pledged US$6.7 billion in funding ($2.3 billion for rapid disbursement) for the year ending in March 1992, up US$600 million from the previous year. India is seeking US$8.8 billion from the Consortium for 1992-93. Japan awarded a soft loan of Rs20 billion (106 billion yen) in April 1991, and the World Bank plans to increase its lending to India to US$3 billion during 1991-92, up from US$2.05 billion in 1990-91.

India negotiated two loans from the IMF totalling US$1.8 billion in January 1991, under the Compensatory Contingency and Financing Facility (CCFF). The IMF's eligibility criteria for this facility has been broadened to include oil price increases. These loans will be repaid over five years at an interest rate of nine percent, with the

first payment not due for three years. In October 1991, India conveyed for the first time its desire to tap into IMF low-cost financing under the Enhanced Structural Adjustment Facility (ESAF). A US$5 billion credit facility with the IMF was approved in principle.

The International Financial Corporation (IFC) has extended funding to India's private sector totalling US$985 million as of June 30, 1991; India ranks third in the world in the IFC's cumulative borrowings.

Three

ENERGY IN THE ECONOMY

ENERGY RESOURCES PLANNING

In India, the energy resources planning process at the national level occurs in two Union government organizations: the National Development Council (NDC) and the Indian Planning Commission (PC). The Planning Commission is the branch of the Ministry of Finance and Planning that authors the nation's five-year and annual development plans. The Planning Commission, which is chaired by the Prime Minister, prepares the general national development Plan in draft form, which must be reviewed by the Cabinet and the NDC. The integration of the development projects of the States into the emerging Plan framework is then implemented and the final Plan is submitted to the Cabinet, the NDC, and the *Lok Sabha* (Parliament) for the final approval. The Plan furnishes estimates of financial and tangible resources, investment possibilities and output levels of various sectors of the economy.

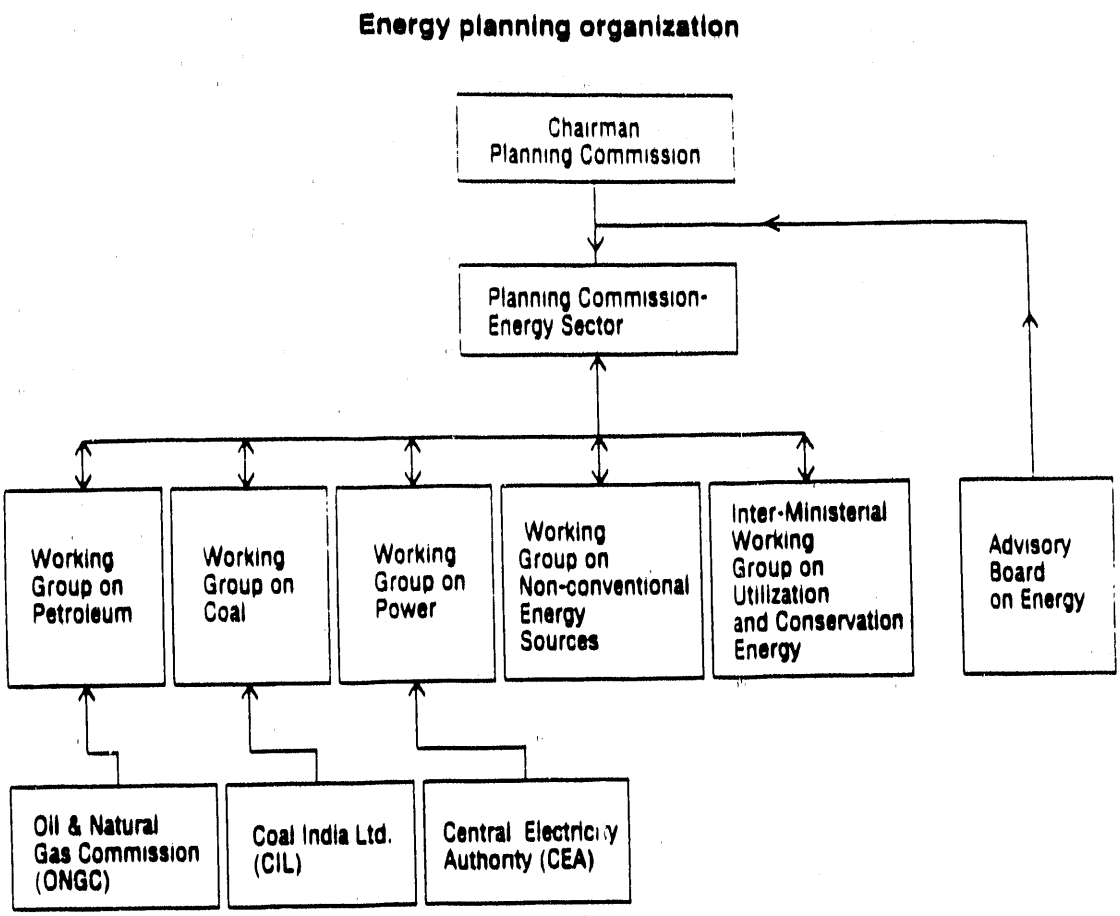
Energy sector policies are set to make the national economy resilient to the fluctuations of world energy prices and availability of supply. Planning for exploration and development of indigenous energy resources is given high priority in overall national development. Investments in the energy sector conform to the Planning Commission's national plans, which have a five-year duration and a fifteen-year perspective. The Planning Commission establishes targets for energy production in the Five-Year Plan that seek to satisfy growing energy demands of various economic sectors. Assignment of sectorial priorities and allocations of funding are also the responsibility of the Planning Commission. The Planning Commission requests that various working groups in each sector of the economy set production targets and development strategies. Specific aspects of policy implementation are assigned to various agencies and public sector corporations at the Central and State level.

Within the Planning Commission, there are five working groups that deal with petroleum, coal, electricity, nonconventional energy sources, and energy utilization and conservation. The Energy Utilization and Conservation Group is an Inter-Ministerial Group. There is also an Advisory Board on Energy which reports to the Prime Minister independently (see Figure 3.1).

Four Union ministries also play important roles in the development and implementation of national energy plans: the Ministry of Energy, the Ministry of Petroleum and Chemicals, the Ministry of Steel and Mines, and the Ministry of Science and Technology. Organizations that are subject to national or State-level authority include: the Central Electricity Authority (CEA), the National Hydroelectric Power-generating Corporation (NHPC), the National Thermal Power Corporation (NTPC), the Nuclear Power Corporation (NPC), the State Energy Boards (SEBs), the Oil and Natural Gas Commission (ONGC), the Oil India, Ltd. (OIL), the Indian Oil Corporation (IOC), the Gas Authority of India, Ltd. (GAIL), the Oil Industry Development Board (OIDB), the Department of Coal (DOC), the National Coal Development Corporation (NCDC), the Coal India, Ltd. (CIL), the Department of Nonconventional Energy Supply (DNES), and the Indian Research Energy Development Agency (IREDA), among others.

The Ministry of Petroleum and Chemicals is responsible for policy planning, development, exploration, production and execution of oil and natural gas projects. The import and export of crude oil and petroleum products, as well as the refining, distribution and marketing of petroleum products within India, are also overseen by the ministry. The government's think tank for petroleum policy is the Oil Coordination Committee (OCC). The ministry oversees the operations of the ONGC, the OIL, the IOC, the GAIL, and the OIDB, among other organizations. The ONGC has five research and development institutes, including the K.D. Malaviya Institute of Petroleum Exploration, the Institute of Drilling Technology, the Institute of Reservoir Studies, the Institute of Engineering and Ocean Development, and the Institute of Production Technology.

Figure 3.1: **Energy planning organization**



Source: Author 1991

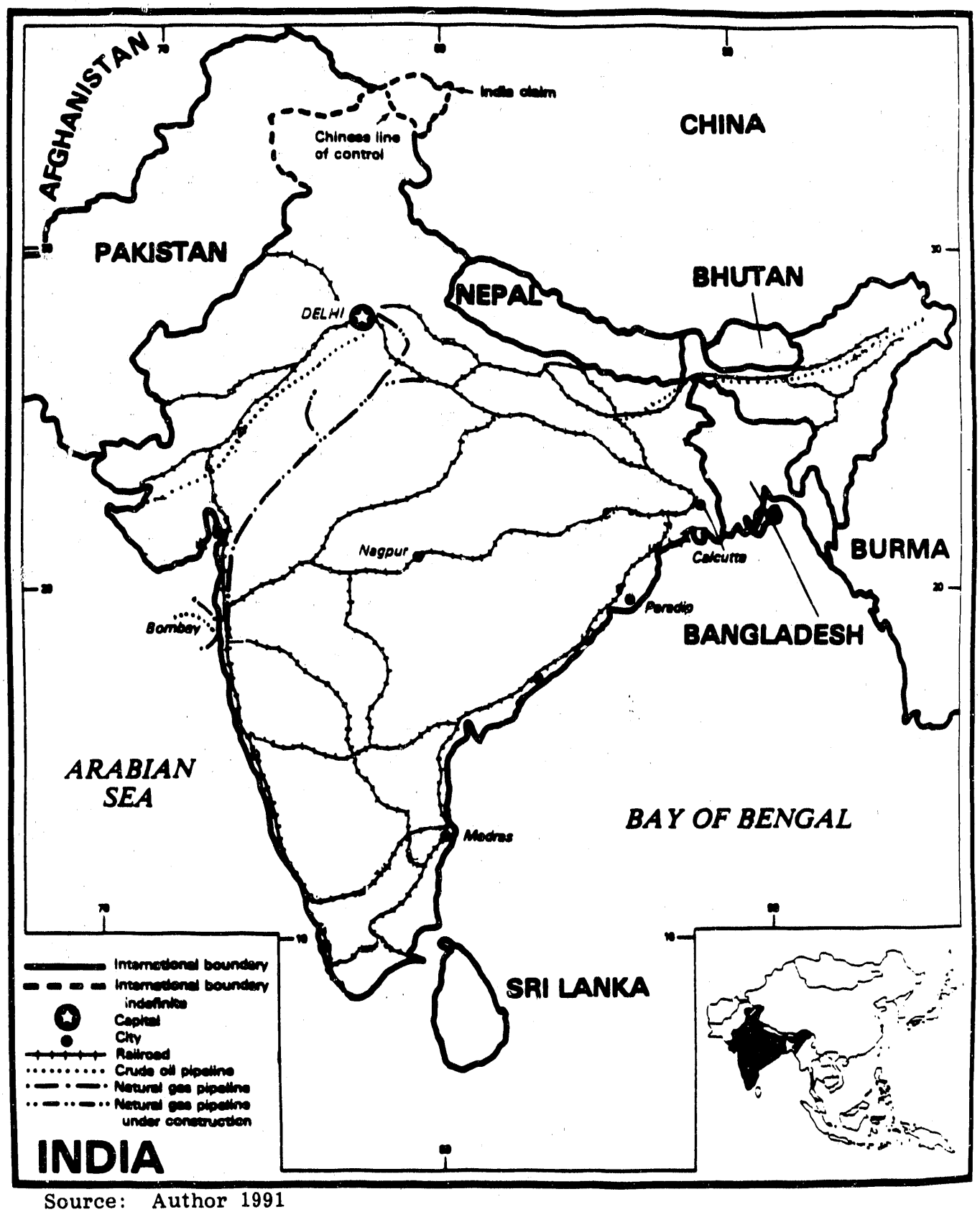
An Advisory Committee on Environmental Planning and Coordination has been functioning since 1981 to advise the Ministry of Petroleum and Chemicals on all aspects of environmental policy and planning. Assistance for the promotion and development of environmental safeguards for the oil and gas industry in all of its activities is provided by the Oil Industry Development Board (OIDB). In addition, a Safety Council, supported by an Oil Industry Safety Directorate (OISD), was set up in 1987 to formulate and implement self-regulatory measures to enhance safety in the Indian oil and gas industry.

The Department of Coal in the Ministry of Energy has responsibility for exploration and development of coking and non-coking coal and lignite. Levels of production, supply, distribution and prices of coal, low-temperature carbonization of coal, and the production of synthetic oil from coal are also handled by the department.

The production, distribution and marketing of energy resources in India is controlled by public sector units (PSUs). PSUs are engaged in the extraction of coal, oil and gas as well as power generation. Responsibilities for power generation and distribution are split between the Central government and State PSUs. The PSUs currently produce 100 percent of the crude oil and natural gas, 98 percent of the coal, 100 percent of the lignite and 97 percent of the electricity in India. The 1991-92 government budget for the energy sector is Rs135 billion (US$5.4 billion).

Figure 3.2 shows the locations of the major elements of India's fuel transportation infrastructure, including oil and gas pipelines and railways that transport most of the country's coal supplies.

Figure 3.2: **Oil and gas pipelines and railways**



Source: Author 1991

ENERGY SUPPLY AND DEMAND

India's economic growth is expected to result in increased energy intensity and consumption. With a population of 844 million people, India constitutes a huge market and growth in energy production has not kept pace with demand. The gap between supply and demand has steadily grown, particularly for electricity and petroleum products — a gap that is expected to widen in the 1990s. The key to India's continued economic growth is meeting its commercial energy requirements.

India produces 85 percent of its own energy needs; the remaining 15 percent is met by imported crude oil and petroleum products. In recent years, small quantities of low-ash coking coal have also been imported. India derives its energy needs from five primary energy sources: coal, oil, natural gas, hydropower, and nuclear power generation; secondary sources include biomass, wind, and solar energy.

Commercial sources account for over 60 percent of India's total energy supply; this share is estimated to expand to 80 percent in the next decade. The mix of commercial sources of energy is: coal and lignite, 56 percent; oil and natural gas, 40 percent; hydroelectric power, three percent; and nuclear power, one percent.

The performance of the energy sector during the fiscal year 1990-91 has not been encouraging. Electricity generation, production of crude oil and refinery throughput showed signs of deceleration or actual decline. Coal production grew marginally from 1989-90 to 1990-91. India's *Economic Survey* (1990-91) states that "these trends suggest that infrastructural constraints may have an adverse impact on growth of output in the economy."

Industrial production and trade were both booming until the middle of 1990. Two fuel price hikes in 1990 — one of 15 percent in March, after the 1990-91 national budget was presented, and another of 30 percent, following the beginning of the Gulf Crisis in August — produced an adverse impact on major sectors of the Indian economy, including transportation, agriculture, manufacturing and services. In 1990-91, the GDP grew five percent, and the Finance Ministry projected four percent GDP growth for the current fiscal year (1991-92). However, faced with constraints on energy imports, tight credit and restrained investment, this may be too optimistic a projection for the Indian

economy.

Energy demand has been increasing since independence in 1947. The relationship between the economic growth rate and energy demand has kept pace, and energy demand has grown steadily at rates of six to eight percent per year. In 1991, there was no significant slowdown in energy demand, despite higher oil prices due to the Gulf Crisis, a slightly reduced rate of economic growth, and exceptionally good weather and monsoon rainfall.

As the Indian economy has developed, there has been a continuing shift in the composition of energy demand towards commercial energy sources (coal, oil, natural gas, hydro-, and nuclear power) and away from traditional or noncommercial fuels (firewood, crop residues and animal wastes). At present, these traditional fuels still account for almost 48 percent of total primary energy requirements (TPER). The need for firewood and fodder was about 133 million tonnes (mmt) in 1990-91. This is significantly more than the share of coal, the largest source of commercial fuel, which meets about one third of primary energy consumption. Oil (some of it imported) and gas, together, account for one-fifth of TPER, while nuclear and hydropower, combined, meet less than one-tenth of the total.

The total supply of primary commercial energy increased by nearly two and one-half times from the 1970s to the 1980s. The supply of primary commercial energy is estimated to have increased from about 89 million tonnes of oil equivalent (mmtoe) in 1980-81 to 119.73 mmtoe in 1984-85 at a growth rate of 7.7 percent per year. During the Seventh Five-Year Plan (1985-90), the energy supply increased from 133 mmtoe to 176 mmtoe at the rate of nearly seven percent per year. The supply of commercial energy for 1990-91 is estimated at 187.83 mmtoe.

In general, there has been a shift from coal towards greater reliance on oil as a source of energy in India. Table 3.1 shows the shares of India's commercial energy supply by source for 1990-91 and the forecast for 2009-2010. The share of coal and lignite is expected to increase to 64 percent by 2009-10, up from its 56 percent share in 1990-91, while the share of oil and natural gas will decline to 34 percent from 40 percent in 1990-91. The hydropower and nuclear generation shares will marginally decrease in

Table 3.1: **Share of commercial energy by source, percent of total**

Source	1990-91[a]	2009-10[b]
Coal and lignite	56	64
Oil and natural gas	40	34
Hydropower and nuclear generation	4	2
Total	100	100

a: actual
b: estimate
Sources: Economic Survey 1990-91, Planning Commission 1989 estimates

Table 3.2: **Supply of commercial energy by source, million tonnes of oil equivalent**

Year	Coal	Lignite	Oil	Natural gas	Hydro- and nuclear power	Imports of oil and coal	Total
1989-90	102.5	2.7	32.1	11.9	5.5	21.8	176.5
1994-95	143.6	3.8	38.4	14.9	6.4	35.4	242.5
1999-00	194.3	5.1	50.3	20.8	7.5	49.0	327.0
2009-10	335.9	8.8	78.8	36.4	9.2	86.4	555.5

Source: Planning Commission 1989

the energy mix. India's energy supply from different sources from 1989-90 through 2009-10 is shown in Table 3.2. Imports of oil and coal will make up a greater share of the energy mix in 2009-10 compared to their 1989-90 share.

Oil

More or less the same growth trend as seen in the overall energy supply in India can be observed for hydrocarbons. Oil production more than tripled in the 1980s. Production

Table 3.3: **Production trends in petroleum sector, million tonnes**

Item	1988-89	1989-90	1990-91*
Crude oil production	32.0	34.0	33.0
1. Onshore	10.9	12.3	11.8
a. ONGC	8.5	9.6	9.6
b. OIL	2.4	2.7	2.7
2. Offshore (ONGC)	21.1	21.7	21.2
Petroleum products	48.8	48.6	48.5
Natural gas (billion cubic meters)	13.2	16.9	17.9

* Provisional
Note: ONGC is the Oil and Natural Gas Commission; OIL is the Oil India, Ltd.
Source: Economic Survey 1990-91

grew from 10.5 mmt in 1980-81 to 34 mmt in 1989-90, and declined somewhat in 1990-91 to 33 mmt (Table 3.3).

The Indian economy has become more oil-intensive in recent years. Consequently, dependence on oil as a source of energy rose significantly in the 1980s. Oil is used as a swing fuel in meeting supply shortfalls in the other sources of energy.

India met 60 percent of its petroleum demand from domestic production in 1989-90; however, self-sufficiency declined somewhat in 1990-91 to 57 percent (Table 3.4). India's potential petroleum reserve base is estimated to be large enough to maintain levels of self-sufficiency at 60 percent until 1995 and 45 percent until 2000. However, achieving these levels of self-sufficiency will require that discoveries be made at a higher level between 1990 and 2005 (350 mmt/y or 2,625 million bbl/y of oil and oil equivalents of gas), than during 1975-1990 (239 mmt/y or 1.790 million bbl/y of oil and oil equivalents of gas).

India is currently at a critical stage with regard to oil self-sufficiency. The decline in self-sufficiency will constrain India's economic growth, government revenues, compound the present serious balance of payments and debt situation, and increase the

Table 3.4: **Demand for petroleum products, million tonnes**

	1989-90 actual	1990-91 estimate	1994-95 estimate
Demand for petroleum products	53.8	58.9	77.7
Crude oil equivalent 1*1.0683	57.5	62.9	83.1
Indigenous production	34.7	33.0	50.3
Self-sufficiency (%)	60.3	57.1	60.6
Imports	26.8	27.0	32.7
Value US$ billion	3.6	5.5	6.1

One tonne = 7.5 barrels
Source: Oil and Natural Gas Commission, Performance, Productivity and Growth 1980-90

risk posed by possible future international supply disruptions and/or price shocks. In October 1991, the government's think tank for petroleum policy, the Oil Coordination Committee (OCC), recommended substantial cuts in consumption of petroleum products.

India's ability to satisfy future oil demand is far from certain, as indicated in Table 3.4. Petroleum development projects that were stalled for the past two years will result in at least three years of stagnating and/or declining output while demand increases.

Refinery production of petroleum products reached 48.6 mmt in 1989-90, which represents a 6.3 percent increase over the 45.7 mmt produced in 1988-89. Production during 1990-91 was projected to decline to 48.5 mmt (Table 3.3). In recent years, most of the production increases have been in middle distillates — kerosene (SKO) and high speed diesel oil (HSD), in particular, and light diesel oil. These are also products that play major roles in consumption (Table 3.5). It is expected that kerosene and diesel will continue to account for more than half of product demand throughout the 1990s.

Demand for petroleum products in 1990-91 was approximately 59 mmt, up from 54 mmt in 1989-90. This was partially met by the 33 mmt of domestic crude production. The balance was provided by 27 mmt of crude and product imports, valued at US$5.5 billion (Table 3.4).

Table 3.5: **Petroleum product demand estimates, thousand barrels per day**

Product	1989-90*	1994-95	1999-2000
LPG	68.6	111.9	152.4
Gasoline	78.6	121.2	160.7
Naphtha	126.2	144.0	191.8
Kerosene/jet fuel	208.8	316.0	404.9
Diesel	411.5	612.3	834.9
Fuel oil	161.9	215.8	245.6
Other	63.4	121.9	156.2
Total	1071.1	1643.1	2146.5

* Actual consumption
Sources: Indian Oil Corporation Annual report 1990, Economic Survey 1991

Planning Commission sources assert that the major factors responsible for slower growth in the consumption of products during 1990-91 were a high rate of inflation and the trimming of government expenditures, rather than supply restrictions. In March 1990, prices were raised 10 to 16 percent, and after the Gulf Crisis, there was a 25 percent Gulf surcharge on products. The Wholesale Price Index (WPI) rose by 12.1 percent in 1990-91, the highest rate in recent years (1980-91). As of December 1991, inflation was running 15 percent.

Consumption is projected to increase to 77.74 mmt in 1994-95, which will be met by 50.3 mmt of indigenous oil production (including production from private and foreign companies) and 32.7 mmt of imports (Table 3.4). For the rest of the decade (1995-2000), demand is estimated to rise by 31 percent. Demand is projected to reach about 102 mmt by the year 1999-2000, and 127 mmt by 2004-05.

Petroleum products play an important role in the energy supply of different sectors of the economy. The share of petroleum products in the total supply of commercial energy increased rapidly in the past, and this trend has continued, even after the steep increases in oil prices since March 1990.

Table 3.6: **Consumption of petroleum products by sector, percent**

Sector	1990-91	1999-2000
Transportation	48	52
Industry	32	29
Residential	20	19
Total	100	100

Source: Economic Survey 1990-91

The residential sector consumes about 20 percent of petroleum products as fuel for domestic heating, cooking and lighting (Table 3.6). The transportation sector consumes about 48 percent of the country's petroleum products as fuel for vehicles, tractors, airlines, shipping and the military. The industrial sector consumes about 32 percent of petroleum products as feedstocks and/or fuel for fertilizers, petrochemicals, tubewells and pumpsets, thermal power plants, road construction and a variety of industrial applications.

In India, product consumption typically declines in the first half of the year and then rises in the second half. The decrease in consumption in the first half of the year has varied between two to six percent since 1981-82, whereas growth during the second half of the year has remained above 10 percent since 1982-83.

Oil and product trade: India's crude and product import bill escalated by 53 percent to about US$5.5 billion in 1990-91, compared to 1989-90's bill of US$3.6 billion (Table 3.4). The cost of oil imports in 1990-91 was about 33 percent of the total import bill, almost equal to India's total trade deficit for the fiscal year. An extra US$1.9 billion were incurred due to the high cost of oil imports during the Persian Gulf Crisis and the disruption of oil trade with the former Soviet Union.

Imports of 18.5 mmt of crude oil and 14 mmt petroleum products are estimated for 1991-92. Kerosene and diesel account for nearly 90 percent of the total imports of petroleum products. India is the single largest importer of kerosene in the world. For the first time in many years, substantial quantities of gasoline amounting to 470,000

tonnes, were imported in 1990-91. The demand for gasoline is growing at 10 percent per year and could rise to 32.4 mmt by 1994-95.

Exports of petroleum products, which have been traditionally low in the past, started rising beginning in 1983-84. Exports were about 2.6 mmt in 1989-90 and 1990-91, averaging 53,420 b/d.

Natural gas

The share of natural gas in total supplies of primary energy increased from about two percent in 1970-71 to more than eight percent in 1990-91. Natural gas production is expected to increase from 18 billion cubic meters (bcm) in 1990-91 to 31 bcm by 1994-95.

Natural gas is considered to be an attractive substitute for oil in the energy scenario in India. About 29 percent of the gas produced in India is currently flared; which is far lower than the 40-50 percent flared in the 1970s. The government is considering additional investments to further reduce the flaring and utilize the gas as an energy source (see Chapter Four).

Coal

Coal is the most abundant commercial energy source in India. Given the relative abundance of coal among primary sources of energy, fuel substitution in favor of coal may become imperative. However, the share of coal as a primary source of energy declined in the 1980s. Coal's share of primary energy, which was almost 62 percent in 1970-71, increased marginally to 63 percent in 1980-81, but then remained consistently below 60 percent after 1985-86. In 1990-91, about 56 percent of India's energy requirements were met by coal and lignite.

Coal production increased 5.4 percent during 1990-91 compared with 3.2 percent in 1989-90. Shipments of coal from mines to consumers increased 4.4 percent in 1990-91, compared with 4.3 percent in 1989-90.

Coal production in India has consistently fallen short of the annual production targets set for the Seventh-Year Plan period (1985-1990). The annual targets for production have also been consistently lower than the demand estimates of the Planning

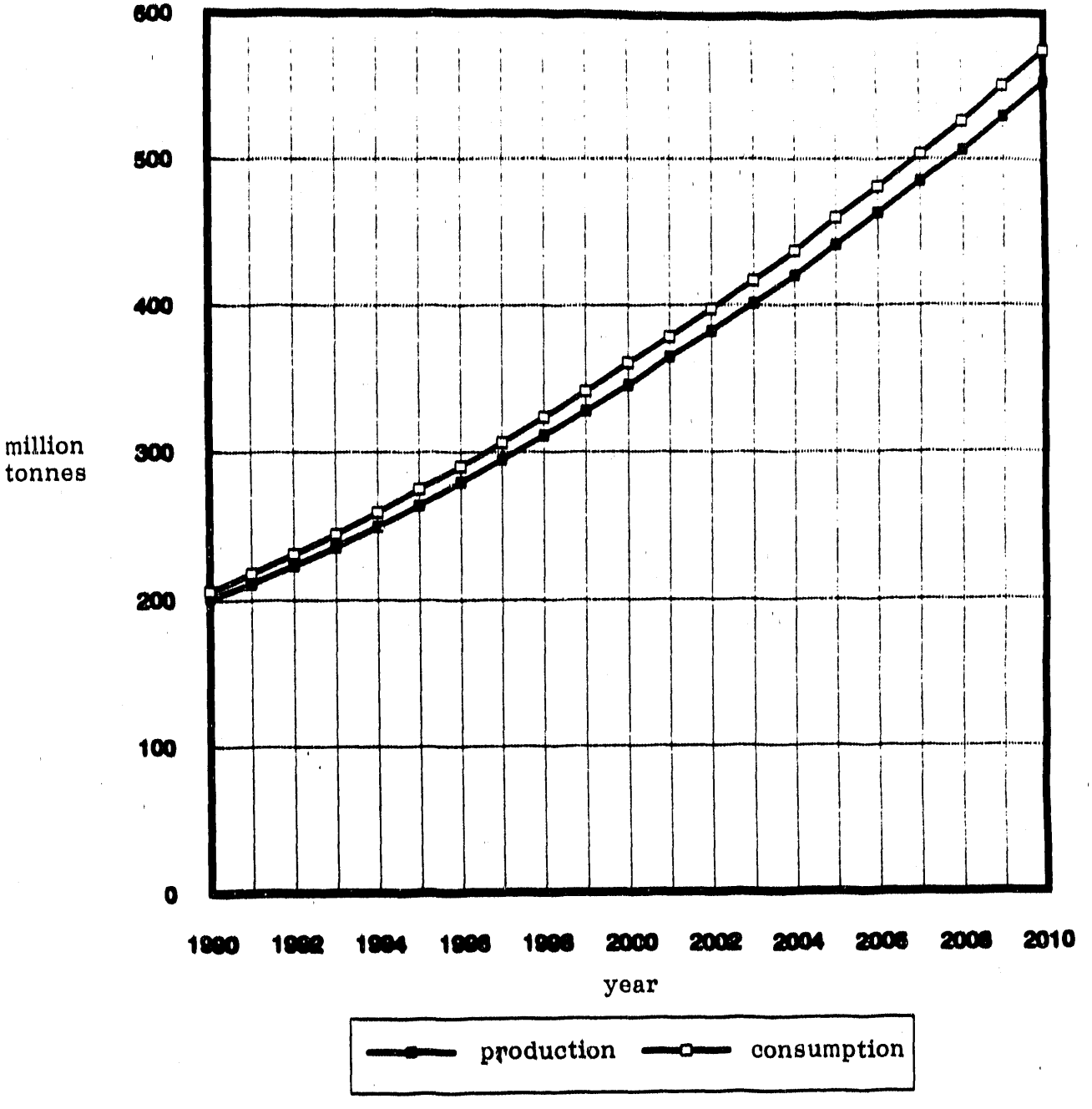
Commission. In addition, stocks of coal at the pitheads have been rising.

The Planning Commission has estimated that the country's demand for coal in 1990-91 was 230 mmt. Domestic production of 212 mmt was sufficient to cover 92 percent of demand; however, only 200.4 mmt of coal were shipped to customers, meeting only 87 percent of demand. The gap between demand and production was to be met by stocks drawn down from the pitheads and by imports of coking coal. The projection for coal production and consumption from 1990 through 2010 depicts a widening gap, as demand increases at much higher rates than production (Figure 3.3). Increasing demand in the future will have to be met by imports. The total demand for coal and lignite in 1994-95 has been estimated by the Planning Commission Working Group on Coal at 320.9 mmt, plus 8.6 mmt of washery midlings for power plants (Table 3.7).

Coal demand has been increasing steadily in the early 1990s. Table 3.7 shows coal demand by industry in 1990-91. The demand for coal is predominantly in thermal power generation; this demand is expected to continue to increase during the 1990s and beyond. During 1990-91 there were reports of considerable shortages of coal. In addition, with the recent increases in railway freight rates, the relative price of coal compared to oil has increased. There were reports that some customers have reacted to the increase in costs and shortages of coal by switching to fuel oil.

Also, there are major cost uncertainties associated with the transportation logistics and environmental impacts (pollution, acid rain, global warming, etc.) of coal. Sweeping changes are required to implement clean coal technologies and improve combustion efficiency in the coal-based thermal power plants. Demand for energy has so far exceeded supply, that any coal saved through increased efficiency would be burned in additional power generation to satisfy demand.

Figure 3.3: **Coal production and consumption gap**



Source: East-West Center Coal Project

Table 3.7: **Coal and lignite demand in various industries, million tonnes**

Sector/industry	1990-91	1994-95
Steel and coke ovens	31.7	
Power utilities	128.0	
midlings	3.0	
Captive power	13.1	
midlings	1.2	
Railways	5.8	
Cement	11.5	
Fertilizers	4.6	
Soft coke	3.1	
Others (kilns, chemical, textile paper industries, colliery consumption, etc.)	31.7	
Exports	0.3	
Total	229.8	320.9
Total midlings	4.3	8.6
Total	234.2	329.5

Source: Economic Survey 1990-91; Planning Commission 1989-90

ENERGY CONSUMPTION BY SECTOR

Among the major sectors of the economy, industry accounts for about half of the total final commercial energy consumed. The transportation sector is the next largest consumer of commercial energy, which together with industry, accounts for about 75 percent of consumption. Table 3.8 shows the comparative shares of different sectors in the end-use consumption of energy in India from 1953-54 to 1988-89.

Energy intensity

The energy intensity of the economy is measured as total energy consumption divided by GDP measured in constant rupee terms. In India, the elasticity of energy consumption in relation to GDP growth has decreased significantly over the past two decades — from

Table 3.8: **Share of different sectors in energy consumption, percent**

Sector	1953-54	1960-61	1970-71	1980-81	1988-89
Industry	39.8	40.7	51.6	57.0	50.4
Transportation	46.2	44.9	29.4	23.5	24.5
Agriculture	1.7	1.8	3.8	6.1	9.0
Residential	9.9	10.6	14.3	12.3	13.8
Others	2.4	2.0	0.9	1.1	2.3
Total	100.0	100.0	100.0	100.0	100.0

Source: Economic Survey 1989-90

1.37 in 1970-71 to 1980-81 down to 0.82 during the period 1980-81 to 1988-89. This is primarily due to a higher rate of GDP growth and not because of any significant conservation measures. The elasticity of energy demand is still very high when compared to developed countries, where it is between 0.4 and 0.5.

Oil intensity in final commercial energy consumption has increased significantly, rising from 17 percent in 1953-54 to 43 percent in 1988-89 (Economist Political Weekly, Feb.16, 1991).

Industrial sector

Industry remains a heavy consumer of coal-based energy and electricity. The use of petroleum products, such as lubricants, is also increasing with the growth of the industrial sector.

On the average, it was found that fuel consumption accounts for about 10 percent of the total value of output of the manufacturing sector as a whole. In absolute terms, the iron and steel industry is the largest consumer of energy, followed by industries that produce cement, fertilizers and pesticides, aluminum, textiles, and ferroalloys. The cement industry, which is the second largest consumer of energy, has shown a marked decline in the ratio of fuels consumed to value of output since 1982-83. The ratio has fallen from about 32 percent to about 26 percent. Among the other major consumers, the aluminum, zinc and basic chemical industries have also experienced a decrease in the

ratio over the period 1980-81 to 1985-86.

Of the six major energy consuming companies in the manufacturing sector in the year that ended March 1988, the Steel Authority of India, Ltd., was the largest consumer, with fuel consumption worth Rs48.6 billion or 9.6 percent of the value of output. The energy expenditure of Bharat Aluminum Co., Ltd., was 44.6 percent of its value of output. For the fertilizer industry, fuel consumption represented 29 and 26 percent of the value of output for the Fertilizer Corporation of India, Ltd., and the National Fertilizer, Ltd., respectively.

Transportation sector

The increasing use of energy in India is attributed primarily to structural changes in the transportation sector and in the lifestyle of the population. The increasing energy intensity of the transportation sector is due to an increase in the share of private motor vehicles in total vehicles that rose from 67 percent in 1970-71 to 78 percent in 1987-88, and the decreasing share of railroads in passenger transit.

Road transport: Energy consumption in the transportation sector has increased steadily in the 1980s and early 1990s, although the sector's share of total energy consumption is far lower than it was in the past (Table 3.8). The share of road transportation traffic, both passenger and freight, in total traffic continues to increase. It is estimated that in 1990-91, the share of road vehicles in passenger traffic was 80 percent, while the share in total freight traffic was about 50 percent.

The road network was extended 17 percent during the Seventh Five-Year Plan (1985-90) to a total distance of 1.97 million kilometers by 1990. The total length of the national highways is 33,600 km, a network that grew six percent during the same period.

The number of registered vehicles increased from nine million in 1984-85 to about 20 million in 1990-91. India is the world's second largest scooter manufacturer, third largest manufacturer of two-wheelers, and fourth largest manufacturer of three-wheelers in the world.

In the transportation sector, there has been a substantial shift from coal to oil. This is due to the expansion of road transportation, as well as the increasing use of

diesel-powered vehicles. The Indian railways have also switched part of their fleet of coal-based locomotives to diesel and electrification.

Railways: For such a large and populous country, India has a well-developed and relatively efficient rail transportation system. An elaborate railway network, first established in the mid-19th century, has been expanded to link almost all parts of India. In 1988-89, Indian railways had a route length of 61,990 km and carried 329.5 million tonnes of freight and 350 million passengers. The impact of the transportation sector on the economy is very significant, as most of the passenger and freight traffic is handled by the railways.

Most of India's locomotives are powered by coal or diesel fuel, but, increasingly, electrification of the track is being completed. About 13.5 percent of the track had been electrified by 1988-89, particularly on routes linking the country's major cities. Several express trains that are equipped with air-conditioned sleeper coaches run between these cities.

By comparison, India's road transportation system is less well developed and is variable in terms of quality. A network of national highways is being developed between the major metropolitan centers. Apart from these major roads, pavement quality and all-weather traversability is less consistent. The rural roads are poorly built and inadequately maintained, thus adding considerably to the problem of marketing agricultural products.

Aviation: The civil aviation sector consists of two distinct segments: the airports and the airlines. The International Airport Authority of India (IAAI) operates all of the international airports — Bombay, Calcutta, Delhi, Madras and Trivendrum. The National Airport Authority (NAA) is responsible for management of all other domestic civil airports.

India has a vast aviation fleet of domestic and international carriers. The airlines have high fleet utilization of their equipment. The state-owned international airline, *Air India*, operates over a network covering 25 countries. The capacity of Air India increased from 1,600 million available tonnes per kilometer (ATKM) in 1980-81 to 2,257 million ATKM in 1990-91. Correspondingly, the traffic has increased from 980 million

revenue tonnes per kilometer (RTKM) in 1980-81 to 1,381 RTKM in 1990-91.

The domestic carriers, mainly *Indian Airlines*, fly a variety of domestic and regional (South and Southeast Asian) routes. The capacity of *Indian Airlines* has increased from 700 million ATKM in 1980-81 to 917 million ATKM in 1990-91, while traffic has increased from 400 RTKM to 691 RTKM.

Vayudoot Airlines is a local domestic carrier that provides service to geographically remote areas. It increased its RTKM from 4.9 million in 1984-85 to 14.7 million RTKM in 1990-91, and its ATKM increased from 7.3 million to 23 million.

Shipping: India's shipping fleet is the second largest in Asia and includes many types of cargo vessels and oil tankers that link India with practically all ports of the world. In addition, there are substantial shipbuilding facilities at both the eastern and western ports of India.

The cargo handling capacity at India's eleven major ports was assessed at 161 mmt in 1990-91, up from 132 mmt in 1984-85. The 152 mmt of cargo handled during 1990-91 exceeded the target of 151 mmt and the 148 mmt handled in 1989-90. Major commodities handled are POL (petroleum, oil and lubricants), iron ore, coal, fertilizers and raw materials, food grains, and containerized cargo. About 65.8 mmt of POL were handled in 1990-91, compared with 63.4 mmt in 1989-90.

The fleet size, as of March 1991, was 418 vessels of 6.03 gross replacement tonnes (GRT), up from 408 vessels at 5.98 GRT in 1989-90. The provisional figure for overseas trade during 1990-91 was about 112 mmt, compared with 108 mmt in 1989-90. Coastal shipment of coal to South India via Haldia, Paradip and Viskhapatnam increased by nine percent to seven mmt in 1990-91, compared with 6.4 mmt in 1989-90.

Agricultural sector and rural energy demand

India's annual agricultural production comes from about 175 million hectares of farmland, livestock and dairy farms, and associated agriculture-based industries. India's success in agricultural production has been substantial and has been achieved through the increasing consumption of energy sources in agriculture. Rising energy demand in the agricultural sector is the result of increasing farm mechanization, irrigation by tubewells

and pumpsets, and use of fertilizers and fuels in agriculture-based industries. The agricultural sector presently uses nine percent of commercial energy production, mainly in the form of petroleum products and electricity. Its share of total commercial energy demand has been steadily increasing over the last 15 years. Past and projected energy demand in agriculture from 1986-87 to 2009-10 is shown in Table 3.9.

Estimates are that energy consumption in agriculture rose from 16 kilograms of oil equivalent per capita in 1970-71 to 61 kilograms in 1980-81 and to almost 100 kilograms in 1990-91. Over the same period, total commercial energy consumption in agriculture increased by 253 percent, while the value of gross crop output (at 1970-71 prices) increased by only 23 percent. This indicates a substantial increase in the commercial energy intensity of the Indian agricultural sector.

The energy supplied for agricultural production per hectare of land in India has doubled during the past decade. Fertilizers are heavily used in India, and mechanical power for water pumps is essential for extensive irrigation. This reflects the trend towards modernization of agriculture in India — both for land preparation and for irrigation. However, mechanization of field work is still minimal. Only about a fifth of all the energy brought to the farm goes to fuel farm machinery, tractors or trucks. Although agriculture is still not a major commercial energy consumer at the national level, it may account for a significant share of commercial energy consumption in certain States, and during the cultivation and harvesting seasons. Electricity supplied to an agricultural user in India is heavily subsidized, as a farmer pays only 20 percent of the marginal cost of electricity generation. Diesel oil and other petroleum products are also subsidized for farmers.

While consumption of energy in agriculture is rising, the populous countryside in India is experiencing a serious energy deficit. Rural India is even deficient in firewood. About 250 million people lack sufficient fuel for their domestic cooking needs. The plight of rural dwellers is even worse in winter in northern India, due to a lack of fuel to stay warm or cook meals during the cold season. The rural people endure the bitter energy crisis of the world's poor — a lack of kerosene as well as the scarcity of firewood.

Table 3.9: **Energy demand in agriculture, million tonnes of oil equivalent**

Process	1986-87	1994-95	1999-2000	2009-2010
Land preparation	0.74	1.06	1.34	2.07
Irrigation	3.73	5.12	5.85	7.67
Total	4.47	6.18	7.19	9.74

Source: Tata Energy Research Institute 1991

Table 3.10: **Energy consumption in rural and urban households, 1987-88, average monthly per capita energy consumption**

	Rural household	Urban household
Commercial fuel		
Soft coke(kg)	0.19	2.61
Kerosene (liters)	0.43	0.97
LPG (kg)		0.18
Electricity (kWh)	0.41	2.92
Biomass fuel		
Firewood (kg)	13.17	9.73
Agricultural waste (kg)	4.92	0.67
Dungcake (kg)	11.82	3.00
Charcoal (kg)		0.30

Source: Dharmarajan, K., TERI Energy Policy Issues, v.4, 1988

A comparison of India's rural and urban residential energy consumption for 1987-88 is shown in Table 3.10.

Four-fifths of residential energy in Indian villages is gained by burning biomass. About half of that fuel is from crop residues, including cereal straws, stalks and vines from the fields. The other half includes branches, twigs, roots, needles and bark raked from the woodland floor. Dried bovine dung is also burned as fuel. In addition, biogas from waste and bovine dung furnishes a small share of energy consumption.

The fuel for household cooking is burned at low efficiency in traditional *chullas* (stoves). A proliferation of high-efficiency household chullas for use in rural villages has been undertaken by the government. In the near-term, there is also the need for the expansion of private firewood lots.

As an indicator of the extent to which the energy system has still to develop, nearly 60 percent of India's villages are yet to be connected to the public power grid. The government's social and regional development program is attempting to extend rural electrification. Current investments in rural electrification account for about one-third of total investment in the electric power sector. These investments would have to be maintained or increased in order to achieve the target of electrification of all the villages in the country. Thus, it is likely that there will be a dramatic increase in the number of electricity consumers during the 1990s.

The Indian government has declared its aim of connecting every village of 500 people or more to an all-weather road by the year 2000. There are an estimated 600,000 villages in India and only 40 percent of these villages are on the road network. Although passenger and goods traffic has increased more than 30-fold since 1947, road lengths have increased only five-fold. An improved network of farm roads would make it possible for market-oriented farmers to specialize in cash crops and higher value-added crops, such as fruits, which spoil quickly. The energy demand for rural areas will be increasing with the expansion of agriculture-based industries and the development of cold-storage facilities. In addition, the rapid rate of domestic appliance penetration, the increased mechanization of agriculture, and the expansion in the use of pumpsets for irrigation will also contribute to increased energy consumption in rural areas during the 1990s and beyond.

Residential sector

The residential sector accounts for over 50 percent of total energy use in India, with the largest share comprised of noncommercial and biomass fuels (Table 3.10). A wide variety of energy consuming end-use activities characterize this sector. These include cooking, lighting, space heating and cooling, refrigeration and pumping.

Table 3.11: **Energy sector outlays in Five-Year Plans, Rs billion**

Five-year plan	Total energy outlay	Total Plan outlay	Energy as a share of total outlays (%)
2nd Plan (1956-61)	4.9	48.0	10.1
3rd Plan (1961-66)	12.9	80.9	16.0
4th Plan (1969-74)	28.7	159.0	18.0
5th Plan (1974-79)	101.3	392.9	25.5
6th Plan (1980-85)	265.3	975.0	27.2
7th Plan (1985-90)	636.0	1,800.0	30.5
8th Plan (1992-97)	1,040.0	3,350.0	31.0

Source: Ministry of Planning, 1990-91

ENERGY SECTOR INVESTMENTS IN THE EIGHTH FIVE-YEAR PLAN AND BEYOND

One of the greatest challenges to India today is the management of domestic energy demand and supply. The development of commercial energy is highly capital-intensive and investments in this sector have steadily increased during successive Five-Year Plans (Table 3.11). The need for investment in the energy sector depends partly on the energy intensity of the path of development chosen and partly on the efficiency of use of energy resources, as well as their environmental impacts.

To cater to the rising demand for energy, it is essential that the energy sector investment policies provide for adequate supplies of energy to the entire population and promote the growth of the economy on a sustainable basis. The investments required are immense and the government does not have the resources for such undertakings. Thus, the Rao government is beginning to open the energy sector up to private sector participation. Private sector participation in the energy sector will certainly help alleviate the energy crunch faced by many segments of the economy in India.

Oil and natural gas development

The Planning Commission has projected that the demand for oil products could rise to about 78 mmt by 1994-95 and has made plans to limit it to 68 to 70 mmt (this decision predates the Gulf War). Domestic crude production is to increase to 50.3 million tonnes by the year 1994-95, supplying approximately 60 percent of the requirements for oil. This compares with 60 percent of total supply met from indigenous sources at the end of the Seventh Five-Year Plan (1989-90).

In order to increase domestic oil production, the Indian government has revised bidding terms for the fourth round of oil exploration blocks offered for investment and joint ventures to foreign and private oil companies. It is important to mention, in this context, that in a memorandum of assurances to the IMF on the adjustment program to be financed by its US$5 billion loan, the Indian government specifically committed itself to the return of multinational oil companies. India is also committed to free-market pricing for energy as dictated by its largest donor, the World Bank.

As of the end of Seventh Five-Year Plan, the reserve-to-production ratio for crude oil was 21:1. Generally speaking, a minimum acceptable ratio is 15:1. The government's priorities for oil and gas development during the Eighth Five-Year Plan are:

a) to augment crude oil production to an optimum level;

b) to arrange for the substitution of natural gas for oil products in diverse activities;

c) to minimize the risks of exploration in different basins in India and also undertake exploration activities abroad;

d) to take up cost-effective expansion of existing capacity; and

e) to pursue measures of energy conservation and fuel substitution.

Environmental management and conservation

Since the industrial accident at Bhopal, there has been a great public awakening to the importance of environmental protection. The Indian government's concern for the environment is largely a reflection of public concerns. Energy sector policies encompass environmental regulations.

As the energy sector in India is under the purview of the Union government and its PSUs, the government is involved in the environmental impacts of all aspects of the energy chain — from the extraction of fossil fuels and petroleum refining to waste disposal and the dismantling and decommissioning of plants. The Union government has pledged to provide the Indian people with an adequate, safe, economic and equitable supply of energy on a sustainable basis. Now amplified by a growing population, energy use has become a public issue in India — locally, because emissions contaminate air, water and soil; regionally, because of acid rain; and globally, because there is the possibility of global warming.

The environment has become a more pressing concern in India with the passage of the Environmental Protection Act in 1986. Other legislation affecting the energy sector include the Forest Conservation Act (1980), the National Forest Policy (1988) and the Coastal Management Act. The government has identified 17 categories of industry as heavily polluting units and new measures call for all energy and industrial units to get environmental clearances.

New pollution control measures are emerging that are aimed at reducing greenhouse gases, acid rain precursors, lead, zinc and aromatic emissions. The specifications most often enforced are limits to the sulfur content of various petroleum cuts and the concentration of aromatics in motor fuels. India's domestically produced light crude oil facilitates the upgrading of the quality of fuels.

Measures taken by the government to encourage conservation of petroleum products in transportation, industry, agriculture and residential sectors have not met with much success. Despite three product price hikes since March 1990, the consumption of petroleum products has continued to register growth in all sectors.

Energy consumption by a population of 844 million people produces varying emissions of carbon dioxide, methane, nitrous oxide, sulphur dioxide, lead, volatile organic compounds (VOCs) and chlorofluorocarbons. The Indian population is estimated to reach one billion by the year 2000. Economic growth levels as envisaged in the Eighth and Ninth Five-Year Plans will rapidly increase the density of greenhouse gas emissions and other pollutants. Significant investments must be made to manage these

emissions so as to limit serious acid rain damage locally and postpone the regional and global climatic changes.

India's rank in the 1990 World Resources Institute "Greenhouse Index" is seventh, with a contribution of 3.9 percent of the global greenhouse gas net emissions in 1987. Of India's total carbon dioxide heating equivalents (CDHEs), the largest, by far, come from the CO_2 produced by coal-fired power plants. Demand for coal is projected to exceed 500 mmt in 2010, with fully 80 percent to be consumed for power generation (Figure 3.3).

The trend of acid deposition in India will become much worse over the 1990s and beyond. Driven by the energy-intensity of coal and lignite consumption, the emissions of the acid precursors SO_2 and NOx are essentially uncontrolled. With greater energy intensity, the SO_2 emissions will increase manifold during the 1990s.

Fossil fuels are already used in large quantities such that local air pollution, based on ambient air quality concentrations, is becoming a serious problem in almost all industrial and urban centers. Even the Mekrana marble tiles on the *Taj Mahal* have become victims of acid rain brought by the refineries in Agra. Increasing levels of pollutant deposition are measured in rural areas as well.

Concern about acid rain and greenhouse gases in India is heavily influenced by concerns over economic growth and associated energy consumption and production. There has been considerable analytical work done to analyze future emissions of greenhouse gases and the strategy to manage these levels for sustainable development.

Policies to reduce acid rain and greenhouse gases require implementation of technical measures, including "green technologies" as well as more broad-based economic and institutional responses. The "polluter-pays" principle may be a viable option, as the PSUs are the country's largest energy producers and consumers. The following policy issues are relevant to the Indian environment:

1. Establishment of an adequate national monitoring system for pollution-related problems;
2. Development of a regional program on acid rain in cooperation with the public and private sectors;

3. Implementation of pricing policies to ensure the effectiveness of the "polluter-pays" principle;
4. Power plant and industrial emission control requirements;
5. Petroleum product fuel standards; and
6. Fuel-switching policies for power and industrial sectors.

Energy efficiency

It is possible to save 20 percent of India's energy bill through cost-effective methods and available technologies to improve energy efficiency. This would translate into a savings of Rs470 billion (US$20 billion). India is in need of an efficient energy management system, as presently it is experiencing rapid industrial expansion, high energy costs, limited energy resources and a rising chorus of environmental concerns. Such a system is necessary to contain the need for fossil fuel-generated power and thereby reduce the environmentally damaging emissions of carbon. The United Kingdom has offered India US$100 million as part of an aid package in the area of cost-effective generation, transmission and distribution of electricity.

OUTLOOK—THE YEAR 2000 AND BEYOND

Resource requirements for meeting India's energy needs are tied to future scenarios of growth. The need for energy in the future will depend largely on the level of economic activity and the growth of population. By the year 2000, India's population is expected to reach one billion. Certain assumptions vis-a-vis the projected growth of population and income can be made to determine scenarios for the energy sector. For possible alternative scenarios, the following may be assumed:

I. Growth of population and urbanization are contained, with a high growth of national income, or
II. Growth of population and urbanization are high, with a corresponding low growth of national income.

Resource requirements for meeting the energy needs for both of the scenarios are high. Very large increases are required in the capabilities to mine coal and to generate electricity. In addition, coal and electricity have to be transported/transmitted. This requires corresponding increases in the capacities of infrastructure.

For example, rural electrification may be desired to increase the welfare of the rural areas, yet it requires substantial investments. If rural electrification does not progress as expected, the demand for kerosene will go up. If the railway electrification program falls short of the expected projections, there will be a larger requirement for diesel or the railways will not be able to carry all of the traffic. In short, there has to be a certain consistency in the development of different sectors. Some of the major options for meeting the future needs include the following:

1. Increased coal or gas substitution for electricity;
2. Accelerated electrification of railways to reduce demand for diesel;
3. Increased pace of residential electrification to reduce demand for kerosene and diesel;
4. Gas-based fertilizer plants in place of naphtha or fuel oil-based plants;
5. Use of coal instead of fuel oil for domestic uses to save kerosene;
6. Conversion of oil-based power plants to dual-fired (gas/coal) plants;
7. Sweeping changes are required for implementing clean coal technology and improving energy efficiency in coal-based thermal power plants, as well as instituting renewable energy technologies; and
8. The options for reducing global climate change are important in the future energy scenario.

Four

OIL AND NATURAL GAS

DEVELOPMENT OF THE INDIAN OIL INDUSTRY

The Industrial Policy Resolution of 1948 placed the hydrocarbons sector under state control. In 1956, the Indian government decided that industries occupying "the commanding heights of the economy," such as the petroleum industry, should belong to the public sector. That year, an Act of Parliament set up the Oil and Natural Gas Commission (ONGC) to attend to the country's oil and natural gas resource exploration and development.

With a fledgling national oil company and a perception that multinational oil companies were not interested in India, the government pursued a policy aimed at achieving hydrocarbon self-sufficiency.

Until the 1960s, most of the exploration activities were concentrated in the Cambay Basin and the Upper Assam Shelf, but results were not promising. By the early 1960s, with the Soviet Union's assistance, India vigorously expanded its exploration activities. Soviet geologists delineated the hydrocarbon potential of western Indian offshore areas in the Arabian Sea. The early 1970s brought encouraging results in offshore areas with the discovery of a giant oil field, the Bombay High field, by the ONGC.

The Oil India, Ltd. (OIL), formerly the Burmah Oil Company, was a joint venture established between the Indian government and the Burmah Group in 1971. The partnership was dissolved by mutual consent in October 1981, when the OIL became a government enterprise.

Table 4.1: **Recoverable reserves of oil and natural gas, million tonnes of oil equivalent**

	Crude oil	Natural gas	Total
1987-88	638	522	1,160
1988-56	726	589	1,352
1989-90	750	602	1,352
1990-91*	775	650	1,425

* estimate
Sources: Economic Survey 1990-91; Report of Working Group on Petroleum 1989; ONGC Annual Report 1990

The state-owned companies, the ONGC and the OIL, are the primary producers of oil and natural gas in India. Almost all of the choicest offshore and onshore exploration blocks are within their domain.

HYDROCARBON RESERVES AND PRODUCTION

India has the sixteenth largest hydrocarbon reserves in the world. In 1991, it had the largest hydrocarbon reserves among the SAARC nations and the third largest reserves in Asia. India's oil and natural gas reserves are shown in Table 4.1.

Discovery of oil in 1974 at a giant field at Bombay High in the Western Offshore Basin put India on the world's oil map. India's oil and natural gas reserves have increased significantly since 1975, following discoveries off the Maharashtra and Gujarat coasts in the Arabian Sea.

India's 1990-91 estimated hydrocarbon reserves were 20 billion tonnes of oil equivalent (toe) or 150 billion barrels, of which 45 percent are natural gas. Only 25 percent (five billion toe or 37.5 billion bbl) have been established as geological reserves. The balance of the recoverable hydrocarbon reserves of oil are placed at about 775 million tonnes (mmt) (5.8 billion bbl) and those of gas at about 650 million tonnes of oil equivalent (mmtoe) (4.750 billion bbl). Through secondary recovery methods, about 300 mmt (2.25 billion bbl) of oil, as well as another 80 mmtoe (600 million bbl) of associated and non-associated natural gas are extractable.

About 50 percent of India's reserves are found in three basins: the Upper Assam Basin, the Western Offshore Basin, and the Gandhar-Cambay Basin. The largest field, the Western Offshore Basin's Bombay High field, has 300 mmt (2.3 billion bbl) of recoverable reserves.

India is the top oil producer among the SAARC nations in South Asia. It was the third largest oil producer in Asia in 1990; however, in 1991 it slipped to fourth place behind Malaysia. The Western Offshore, Gujarat and Assam fields are the three main producers of hydrocarbons in India. Nearly two-thirds (65 percent) of production is from offshore fields (see Table 4.2).

At current rates of production, crude oil reserves will last another 20 years and natural gas reserves will last another 50 years. Exploration drilling density in India is 12 wells per 10,000 km^2, compared to the world average of 95 wells per 10,000 km^2. The wildcat well success ratio in India is 1:1.85. The ONGC cost of finding oil was US$0.67 per barrel during 1986-88.

India's crude oil production increased from 10.5 mmt in 1980-81 to 21.1 mmt in 1982-83 and 30.2 mmt in 1985-86. Most of the rise in production was led by the Bombay High field, where production increased from five mmt in 1980-81 to 12.9 mmt in 1982-83, and to 20.8 mmt in 1985-86. Presently, the crude oil production at the Bombay High field has more or less stabilized at about 21 mmt (430,000 b/d) per year. This field continues to be the country's most productive.

India's crude oil production declined 3.1 percent to 33 mmt (247 million barrels or 678,700 b/d) in 1990-91, from the peak production in 1989-90 of 34 mmt (256 million bbl or 682,000 b/d). Production was three mmt (10,000 b/d) short of the target of 36 mmt in 1990-91. During 1990-91, the ONGC produced a total of 30.38 mmt of crude oil or about 624,250 b/d, exceeding its target by 3.9 percent. The OIL produced 2.65 mmt of crude oil (54,450 b/d) during 1990-91 (Table 4.2).

Production of natural gas in India was nearly 18 billion cubic meters (bcm) in 1990-91, an increase of 5.8 percent over 1989-90's output of 17 billion cubic meters. Of the total output, the ONGC produced 365.4 billion cubic feet (bcf) or 976.5 million cubic feet per day (MMcf/d) of gas.

Table 4.2: **Crude oil production, million tonnes**

	1987-88	1988-89	1989-90	1990-91*
1. Onshore	10.2	10.9	12.4	11.8
a. ONGC	7.8	8.5	9.7	9.2
b. OIL	2.5	2.4	2.7	2.7
2. Offshore-ONGC	20.2	21.1	21.7	21.2

* provisional
Source: Economic Survey 1990-91

The 1990-91 decline in oil production was due to political unrest in Assam and a cut-back in production from the 100 overworked wells in the Bombay High and Gandhar fields. As a consequence, the 1991-92 production target of 35 mmt (263 million bbl) has been reduced to 32 mmt (240 million bbl). Agitation in Assam since 1990 has resulted in disruptions of supplies and an annual loss of about one mmt of production, worth Rs1 billion (US$70 million) at current prices. In addition, there are 1,200 "sick wells" operated by the ONGC in which another one mmt of annual production is locked up.

EXPLORATION

In recent years, India discovered significant hydrocarbon deposits both onshore and offshore, including the 59 fields found by the ONGC during the Seventh Five-Year Plan. These deposits include the Cauvery Basin (Tamil Nadu), the Cambay Basin (Gujarat), the Heera and Panna fields (Bombay Offshore), the Krishna-Godavari Basin (Andhra Coast), and the onshore fields in the foothills of the eastern Himalayas in Assam. By the mid-1990s, these new discoveries could be contributing 15-20 mmt annually in additional production. The new fields in the Cauvery Basin, the Daman offshore, and the Krishna-Godavari Basin together could provide six mmt per year, with significant gas output; the Bombay High and Assam fields could contribute another three mmt.

The Rao government recently made the upstream sector more attractive to private and foreign investment by offering upgraded concession terms. A consortium of seven

foreign companies is now exploring on better terms (70:30 entitlement) than were awarded earlier by the Indian government. Increased private participation is expected to accelerate the pace of hydrocarbon discoveries.

The OIL made discoveries in northeast India which include the Borbil, Dholiya (gas), Dirio, Kumchai, and Shalmani fields which were all found in 1987, as well as the Dikom (1990) and Kathaloni (1991) fields. Recent gas discoveries in Rajasthan include the Tanot and Ramgarh fields (1988), and the East Tanot and Dandewala fields (1990). The ONGC made 10 new hydrocarbon discoveries during 1989-90, with total hydrocarbon reserves of 150.4 mmt or about 1.05 billion bbl.

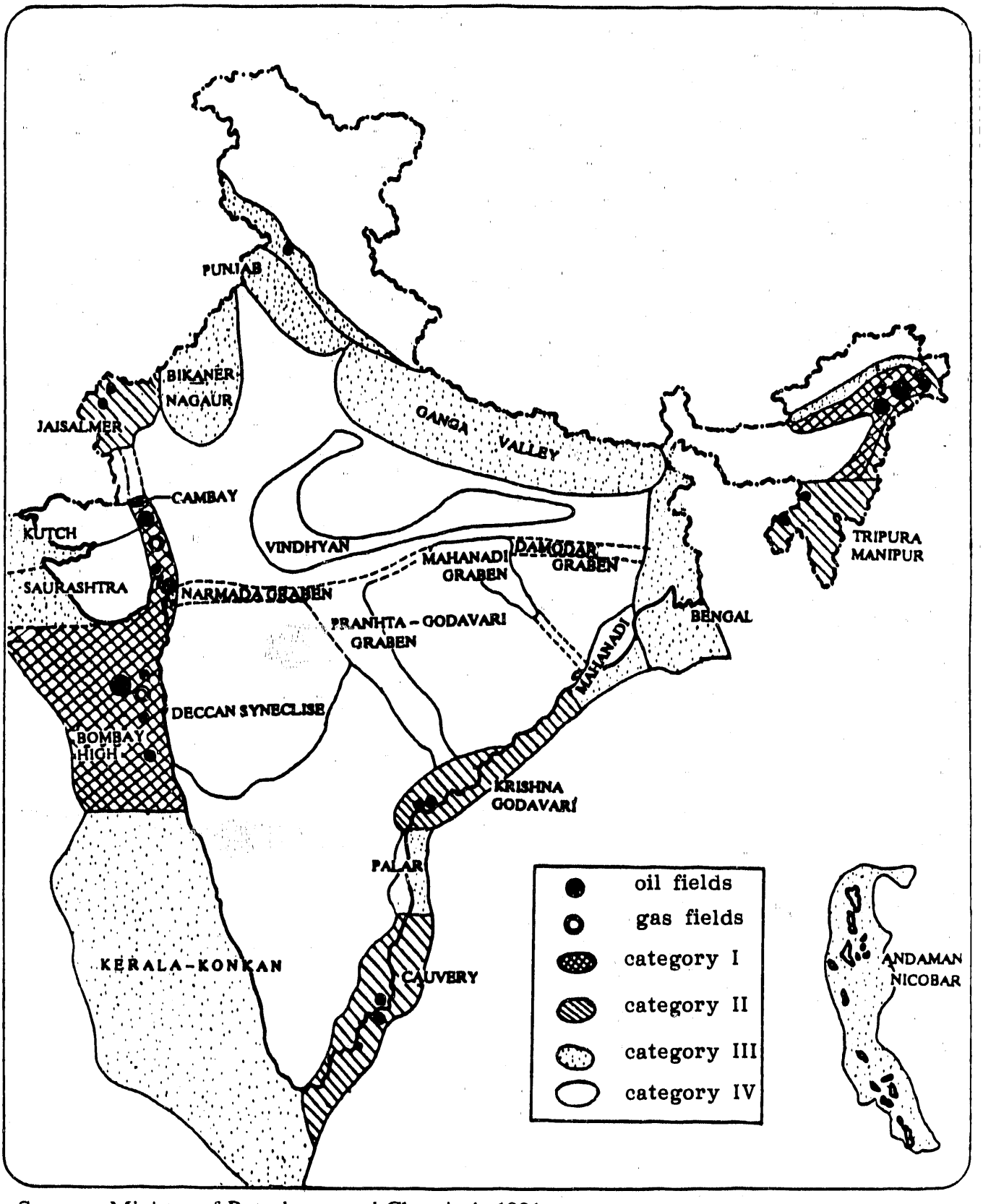
With no new discoveries to match the Bombay High field and in order to regulate the depletion of reserves, the Indian government has decided to peg crude oil production at 21 mmt per year at Bombay High. The strategy is towards more balanced production, as the recoverable reserves would allow India to sustain crude oil production until the end of the century.

Hydrocarbon prospects

India has 26 sedimentary basins covering an area of 1.72 million km^2. Approximately 1.40 million km^2 of the basins are located onshore and about 0.32 million km^2 are offshore. Of the 20 billion tonnes of oil equivalent of estimated hydrocarbon reserves, 63 percent are located in offshore sedimentary basins, while 37 percent are onshore. Major sedimentary basins have been delineated on the basis of the geology of petroleum-bearing rock formations and the potential for oil and gas reservoirs. These are categorized into five major categories as follows (Figure 4.1):

Category I basins: These sedimentary basins are proved hydrocarbon-bearing basins with commercial production. These include the Gandhar-Cambay Basin (Gujarat), the Western Offshore Basin, the Upper Assam Shelf and the Arunachal Pradesh Basin. About 60 percent of the country's reserves are found in these basins. Exploration activities in Category I basins are still being carried out. Additional discoveries in these basins are likely to be in subtle geological structural and stratigraphic traps with limited reserves.

Figure 4.1 **Oil and gas fields and geological basins**



Source: Ministry of Petroleum and Chemicals 1991

Category II basins: These sedimentary basins have known occurrences of hydrocarbons for which the potential is very high. These include basins in Rajasthan, Cauvery, Krishna-Godavari, Cochin-Mangalore, the Andaman Islands, West Bengal, the Himalayan foothills and in Assam-Arakan. Oil is being produced in the Cauvery, Krishna-Godavari, and Arakan Folded Basins. These basins contain about 30 percent of the total hydrocarbon reserves. Geophysical surveys indicate that there are several large geological structures in these basins that are favorable for hydrocarbon accumulations.

Category III basins: These sedimentary basins have no significant hydrocarbon occurrences, but have favorable geological prospects. These include the Kerala-Konkan, Lakshadweep and Mahanadi Basins. About 10 percent of hydrocarbon reserves are found in these basins. There are a limited number of large geological structures in these basins that are favorable for hydrocarbon accumulations.

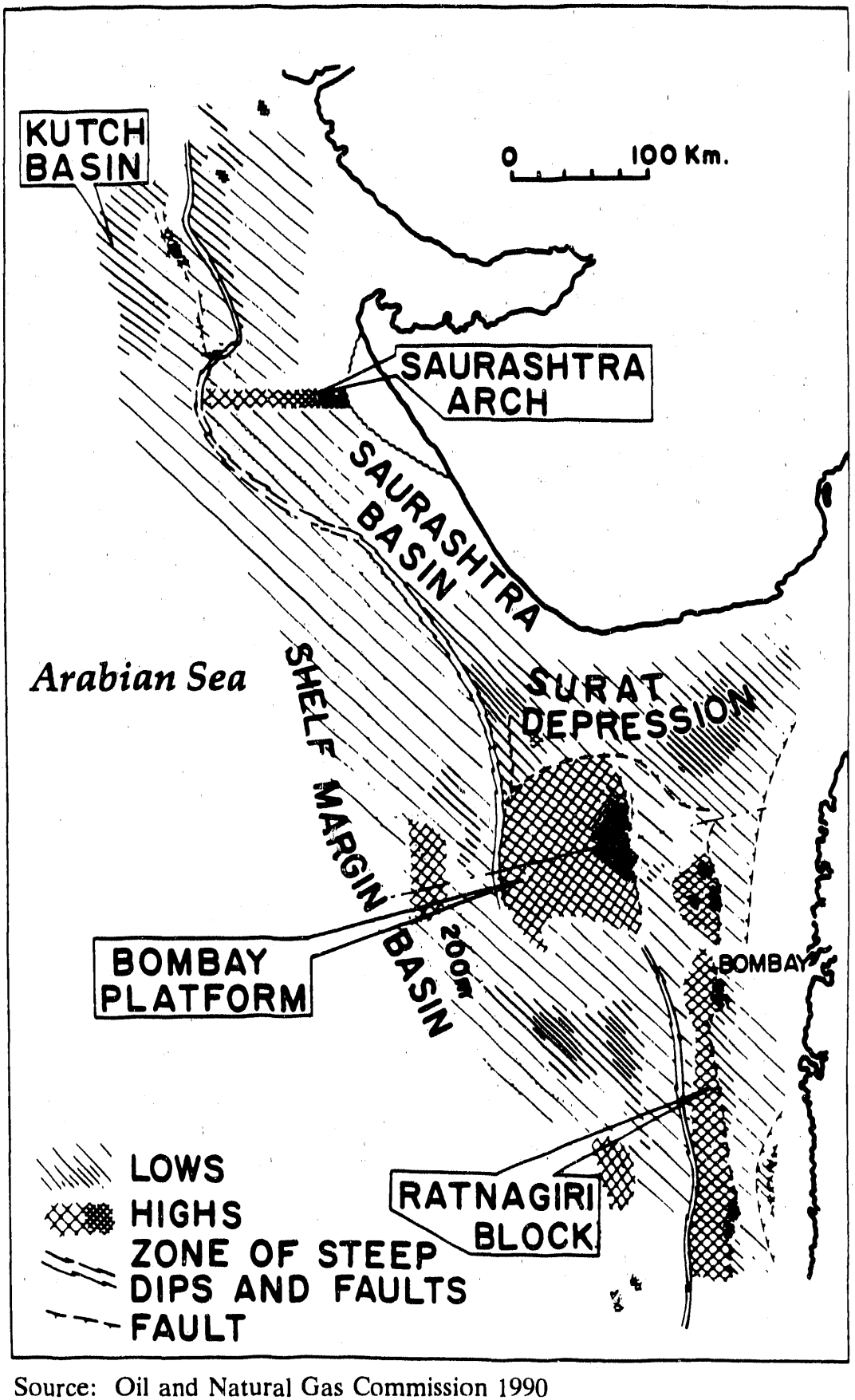
Category IV basins: These sedimentary basins are devoid of any favorable geological conditions. However, further exploration may improve their prospects. These areas include the Vindhyan, Pranhta-Godavari Graben, the Deccan Syncline and the Damodar Graben.

Western Offshore Basin

The western coast of India lies on a broad shelf believed to be the largest continental terrace in the world. The offshore sedimentary basin area, to a water depth of 200 meters, covers 390,000 km^2. The Western Coast Shelf region has several promising sedimentary basins. Ranging from north to south, the Shelf comprises the Kutch Basin, the Saurastra Basin, the Bombay Offshore Basin, the Konkan Basin, and the Kerala Basin. Only the Bombay Offshore Basin has proved to be both oil- and gas-bearing.

Bombay Offshore Basin: The Bombay Offshore Basin, a broad marine shelf, has India's largest oil and gas fields, including the giant Bombay High field (Figure 4.2). It is the mainstay of India's hydrocarbon self-reliance strategy. With recent discoveries, the basin's production of 21.20 mmt of oil and 13 bcm of gas in 1990-1991 is projected to rise to 46 mmt of oil and 28 bcm of gas output by 1994-95.

Figure 4.2: **The structural elements of the Bombay Offshore Basin**



Source: Oil and Natural Gas Commission 1990

Bombay High oil and gas fields. The initial discovery of oil in a carbonate reservoir at the Bombay High field in 1974 was a milestone in the Indian oil industry. The field has enabled India to maintain an accelerated rate of oil and gas development and has been the focus of production growth.

The Bombay High field structure was mapped by the Soviet survey ship *Akademic Arkhangelsky* using seismic reflection methods in 1964. The structure extends north-northwest to south-southwest through an anticlinal fold with a faulted eastern limb. The anticline is about 65 km long and 23 km wide, covering an area of 1500 km^2. Before the first well was drilled, a detailed structural survey was made by CGG, a French company, in 1972.

The Bombay High field is the largest oil and gas field in India, with original-oil-in-place (OOIP) reserves of about 6.6 billion barrels and recoverable reserves of over 1.3 billion barrels (1989 estimates). Estimated reserves are as high as 431 mmt of oil and 447.5 bcm of gas.

The Bombay High field has about 450 offshore wells, of which 304 are producing. The oil- and gas-bearing horizons are at depths varying from 1,000 to 2,000 meters below sea level. Average production in 1990-91 was 420,200 barrels per day (b/d). Cumulative production as of January 1, 1991, was 1,400 million barrels. The Bombay High Field has been the top oil and gas producer in India since 1975.

The Bombay High structure has four hydrocarbon-bearing zones: L-I, L-II, S-I, and L-III. S-I is a gas-bearing sandstone reservoir and L-III is the main carbonate reservoir. There are two producing horizons of Miocene age: L-II in the northern part of Bombay High, and L-III in the southern as well as northern fields. The Bombay High field is divided into North and South sectors, separated by a graben trending east to west. The main producing zone is a Miocene Limestone, Miocene L-III reservoir, which is present throughout the field. It is an oil-bearing zone, with a gas cap located at the crestal part of the structure. The major hydrocarbon accumulation is in the carbonate horizons with intergranular porosities of 15-20 percent.

The L-III Reservoir is a heterogeneous, complex, layered reservoir, with individual layers separated by thin shale bands. There are five main layers: A1, A2, B, C and D2.

Layer A2 consists of seven sub-layers, A2-I through A2-VII. Geological studies and electric logs indicate that there are common gas-oil and gas-water contacts for the L-III reservoir.

The Bombay High crude is a sweet oil with 39° API gravity and a pour point of 30°C. It produces high yields of middle distillates, kerosene and naphtha, with high aromatic content. The atmospheric residue is waxy, with a yield of 30 weight-percent and a pour point of 50°C. The vacuum residue yield is about 10 weight-percent, and the pour point is about 70°C.

Associated gas in the Bombay High area has a C1 fraction (methane) of about 79 percent, and nine percent C2 (ethane), six percent C3 (propane), and 2.4 percent C4 (butane). The rest of the gas is made up of carbon dioxide (6.5 percent), and small fractions of C5/C6, oxygen and minor gases. Ethylene is produced from a combination of C2/C3 fractions, while LPG is produced from a combination of C3 and C4 fractions.

Bombay High South. The initial development of the Bombay High South (BHS) field started in the early 1980s, with an accelerated production plan. Thirty-three platforms were installed and 165 development wells were drilled, each with a two km well spacing. The BHS field has been in production since September 1980. Maintenance of pressure by using water injection in the L-III reservoir began in 1987. The BHS has a current oil production of 310,000 b/d, with a water injection rate of 390,000 b/d. The planned production of 300,000 b/d will be sustained for three years, with a water injection rate of 600,000 b/d. Three rows of injector wells have been drilled.

Eight additional well platforms and a water injection module, with a processing capacity of 320,000 b/d, have been planned, based on studies by the Institute of Reservoir Studies. This will give the field a total recovery capacity of 298.4 mmt by March 2010, which is 40 mmt more than previously planned. With the implementation of the ONGC's development scheme, the recovery rate will rise to 33 percent of the original oil in place, which is estimated to be 877 mmt. Peak production will reach 13 mmt per year for two years. To achieve this level of recovery, the water injection rate will have to rise to 900,000 b/d.

Bombay High North (L-II). The L-II reservoir is located in the northern part of the Bombay High Basin. Several wells, from a total of five platforms in Bombay High North (BHN), are already producing from L-II, which has so far yielded four mmt of oil production. L-II is a Miocene age reservoir, and has a gross thickness of about 55 m. Located at a water depth of 960 meters, it is subdivided into three sub-units: L-IIA, L-IIB and L-IIC. The producing zone is in reservoir L-IIB, which is the thickest and bears a gas cap; L-IIA is only five meters thick, while L-IIC is devoid of hydrocarbons. The OOIP and initial recoverable oil as of January 1, 1990, are 101 mmt and 27 mmt, respectively.

The original development plan for the reservoir was based on a report by Total—Compagnie Française de Pétroles (1981) which envisaged five well platforms with a production potential of about 15,000-30,000 b/d. Water injection was to be initiated after five years of production — that is, after a recovery of five percent of the OOIP. Present production is about 26,000 b/d, including 10,000 b/d from four horizontal wells. The ONGC's development scheme for L-II is to install additional wells — 44 producer and 16 injector wells — to increase the peak production to 1.84 mmt for two years. At the end of the reservoir life, production will be about 0.65 mmt, with a water cut of about 73 percent. The maximum water injection rate is estimated to be 86,500 b/d.

Neelam field: The Neelam field is crucial to the ONGC's Eighth Five-Year Plan target. Together with the important Mukta field, over six mmt per year (120,000 b/d) will be produced. The Neelam field is located 10 km east of the Heera field and about 45 km southeast of Bombay. The Neelam field is claimed to be the most promising field in the Western Offshore after the Bombay High field. The ONGC struck oil at well B-131 in January 1987 and at well B-132 in June 1987. The delineation drilling of the two projects revealed that they were drilled in part of a larger structure now named the Neelam oil and gas field. The field's OOIP is estimated to be 150 mmt and 28 bcm of gas. The recoverable reserves are estimated to be 50 mmt of oil and 12 bcm of gas.

The Neelam field consists of two perpendicular crescent-shaped structures, earlier designated as B-131 and B-132, at water depths of 55 to 62 m. The structures have an area of about 186 km^2. The northern structure has a gas cap. The area-weighted

average effective oil thickness in the northern structure is 13.5 meters and in the southern part, 35 meters. A maximum of 63 m thickness has been observed in well B-132-2. The gas cap has an aerial extent of 10 km^2, with a maximum effective thickness of 25 meters.

The initial reservoir pressure is estimated at 151 kg/cm^2, while the bubble point pressure is 151 kg/cm^2 in the northern structure and 99.3 kg/cm^2 in the southern part. The reservoir properties are reasonably good. Porosities in the oil zone average 21.5 percent in the north and 20 percent in the south. The upper 20-30 m of the oil column have much better porosity and permeability, with a range of 300 to 500 millidarcies (md) permeability in the southern part and 100-150 md in the northern part.

Since April 1990, the Neelam field has been producing about 8,000 b/d from four wells. The crude oil produced is sent through an 18 km long pipeline to the Heera processing platform. A Rs20 billion (US$1 billion) development plan for the Neelam field will result in the production of six mmt of crude annually, with a peak oil production of 120,000 b/d and two million cubic meters (mmcm) of gas by 1994-95.

Mukta field: The Mukta field, located 35 km east of Bombay High, is a combination of two structures, B-57 and B-19. The ONGC struck oil in 1981 at water depths of 56 to 70 meters at a well on structure B-57. The Mukta structures have an area of about 125 km^2 and total reserves are estimated to be 57.4 mmt. Eleven exploration and appraisal wells have been drilled on B-57 and two on B-19. The Mukta field has a complicated structure, with a northeast-southwest elongation containing several accumulations. A number of trending faults dissect the structure, dividing it into six different blocks with different fluid contacts.

Of the six structural blocks, four hold commercially exploitable hydrocarbons. There are several oil- and gas-bearing zones. The Bassein Limestone zone, the producing reservoir of Zone A, contains free gas throughout the field. The three units of Zone B — B-Upper, B-Middle and B-Lower — are primarily oil accumulations, with small gas caps and thick transition zones. Porosity ranges from two to 15 percent with permeability ranging mainly from one to 60 md, with a few cases where it is around 100 md.

The current development plan envisages exploitation of the Mukta field through 37 producing and 13 injecting wells at a cost of Rs14 billion (US$700 million). The field is expected to be on stream within 33 months of October 1990. There are two variants under consideration in the development plan. Variant I is based on an OOIP of 42.62 mmt, under which the B-57 field structure can produce at a peak rate of 1.24 mmt per year for three years. Cumulative oil recovery over 21 years will be 11.9 mmt, which corresponds to 27.9 percent of the OOIP. Variant II, based on an OOIP of 45.62 mmt, envisages a plateau production rate of 1.45 mmt per year for three years. Cumulative oil recovery over 21 years will be 12.09 mmt, which corresponds to 26.5 percent of OOIP. For the B-19 field, the OOIP is 11.8 mmt, and recovery is estimated at 2.95 mmt.

Heera field: The ONGC discovered the Heera field in the Western Offshore Basin in September 1977. Located 80 km southwest of Bombay in the Arabian Sea, Heera (previously known as B-38 and B-37B) measures 20 km long and 8 km wide at a water depth averaging 50 m. The field is divided into two parts, Heera North and Heera South, by a graben. A major fault is present on the eastern side of the structure, running northwest to southeast. The faults forming the graben have an east-west trend.

The producing zone at the Heera Field contains three stratigraphic horizons composed of alternating structures of Upper Oligocene, Bassein Limestone of Oligocene—Middle Eocene, and Basal Clastics of Paleocene age. The observed permeability at the Heera field is low — about 20 md. The OOIP for Heera North was put at 38.65 mmt and for Heera South at 83.69 mmt.

Due to the difficulties of optimizing recovery at Heera, the ONGC developed the field in phases. In Phase I, thicker oil-bearing sections of the Bassein Limestone were developed for a production of 25,000 b/d with three platforms, each supporting nine wells. For Heera North and the graben area, four additional platforms are to be firmed up. Facilities for the injection of 60,000 b/d of water and the production of 40,000 b/d of crude were set up by 1988.

After Heera Phase I went on stream in 1986, Heera Phase II, based on a reserve estimate of 132 mmt with a revised OOIP of 166.65 mmt, was planned. Under Phase II, eight platforms are to be installed, four in the crestal portion and four in the flanks, with

37 injecting and 37 producing wells. The platforms and well locations in the down-dip section of the Heera field have been positioned laterally to enable the drainage of the hydrocarbon reserves in the southwest corner of the Heera South field. The plateau production rate envisaged under Phase II is 1.8 mmt per year. Up to 85,000 b/d of water may need to be injected to maintain pressure and optimum recovery.

The Heera Phase II development is part of a second delivery route for Bombay Offshore oil and gas and will include the largest processing complex installed in India. It is designed to produce 23 mmt of crude by the year 2000. The production will peak at 1.8 mmt per year in 1996. The development project will cost Rs10 billion, with a foreign exchange component of Rs7 billion (US$400 million). It will include three separate projects: 1) five well platforms (H-QRSTF), 2) the Heera-Uran Trunk (HUT) pipelines for both oil and gas, and 3) the Heera Processing Complex (HPC). The World Bank has provided funding for the HUT project by allocating US$60 million for laying and coating of both trunk pipelines.

The Phase III development will focus on the central and down-dip parts of Heera South and partial development of Heera North. Because of geological complexities, the remaining blocks—Heera South Up-Dip, Basal Sands and Alternations — will be developed last in Phase III.

Bassein oil and gas field: The Bassein offshore field was discovered in the Western Offshore Basin off the Maharashtra coast in the Arabian Sea in 1976. It is a giant gas field with recoverable gas reserves estimated at six trillion cubic feet (tcf), as well as some oil accumulation. The Bassein gas field has put India on the world's gas map.

The "free gas" in the Bassein area contains about 79 percent C1 (methane), seven percent C2 (ethane), 4.5 percent C3 (propane), and two percent C4 (butane). The rest of the gas is made up of carbon dioxide (6.5%), and small fractions of C5/C6, oxygen, etc.

From a 1990-91 gas production level of 455 million cubic feet a day (MMcf/d), plans have been made to increase the production to 700 MMcf/d, allowing for more than 20 years of future production. The gas is piped to the Hazira onshore terminal through a 234 km, 36-inch diameter submarine pipeline. From Hazira, the gas is supplied to three

fertilizer plants and two gas-based power stations. Gas will also flow to central India via the Trans-India (Hazira-Bijapur-Jagdishpur) pipeline that is partially in operation and partially under construction.

In 1990, the ONGC began to produce oil from well BA-1 in the South Bassein Field, which is located 80 km northwest of Bombay. The development of this field is significant due to presence of a thin oil rim, with estimated reserves of 785 million barrels of oil below the gas zone.

In 1991, oil was found offshore at the RBC-1 well in the Ratnagiri sector of the Bombay Offshore, 100 km southwest of Bombay. The producing interval forms the lower part of the Bassein Limestone structure, which is the main oil- and gas-bearing horizon in other Bombay offshore fields.

Assam Fields

Oil was discovered in Assam in northeast India in 1876. Many of the oil and gas fields discovered at that time are still in operation. Assam was the leading producer of hydrocarbons until the discovery of the Bombay High Field in 1975. Production levels have continued at a plateau over the past decade. Declining oil production in mature fields, such as the Nahorkatiya and Moran fields, and civil strife in Assam contributed to an overall decline in production for several years during the Seventh Five-Year Plan (1985-90).

Assam's rank as a regional oil producer in India dropped to third place in 1990-91. The OIL and the ONGC are the two operators in Assam. The OIL produced 2.65 mmt in 1990-91 and the ONGC's output was about one mmt.

Although the crudes produced by the OIL and the ONGC in Assam are from different fields, they have similar characteristics. The ONGC's crude oil is somewhat heavier than the OIL's crude. The sweet crudes have a 30-34° API gravity and the naphtha, kerosene and gas oil fractions have a high aromatic content. The crudes also yield, on average, a 20 weight-percent waxy vacuum residue. The OIL's crude production will stabilize at the current level, while the ONGC's crude production will increase in the future. The gas find at Tripura has a 98 percent C1 fraction (methane).

Gandhar and Gulf of Cambay (Gujarat) oil and gas fields

The Gandhar and Gulf of Cambay basins on India's West Coast in Gujarat have deposits of oil and gas in both offshore and onshore areas. The Gandhar Belt includes the Main Gandhar, Dahej, Beghraji, Pakhajan, Amod, Goladra, and Jambusar fields. The Cambay Belt includes the main Gulf of Cambay, Nada, Malpur and South Gulf fields.

Gandhar field: The Gandhar oil and gas field, discovered in 1984, is located about 80 km southwest of Baroda in Gujarat and is one of the largest fields in India. The entire Gandhar-Dahej Belt, encompassing an area of 800 km^2 from north of the Dhadhar River to the Narmada River in the south, is considered to be of great hydrocarbon potential. The occurrences of oil and gas reservoirs vary in depth from 2,750 to 3,100 m.

The estimated reserves of the Gujarat Belt are about 692 million tonnes of oil equivalent (mmtoe) of oil and gas, of which about 220 mmtoe were proved as of January 1989. There are an estimated 208 mmtoe of oil and gas in the Gandhar field in an area of 130 km^2. The other fields in the belt with established oil and gas reserves are Nada with 6.2 mmt, Pakhajan with 1.68 mmt, Dahej with 4.3 mmt and Hazira with 0.005 mmt of reserves.

There are two main types of crude oil produced in Gujarat. The first is a light crude oil of more than 40° API gravity which is produced at the Ankleshwar and Gandhar fields. The Ankleshwar and Gandhar crude oil is sweet, paraffinic, and leaves a waxy vacuum residue of six to seven weight-percent. The Ankleshwar crude has a high yield of naphtha and kerosene, with a low aromatic content, and also produces a high liquefied-petroleum gas (LPG) yield. The Ankleshwar field is currently in its depletion stage, while the Gandhar field is just starting to produce.

In the North Gujarat fields, a second crude oil of varying gravities is produced. The mixture has an average gravity of about 25° API, with a high pour point and a high waxy residue content. Production of this crude is expected to be 7,500 b/d in 1992-93 from 140 wells in the Beghraji field.

The "free gas" in the Gandhar field is virtually identical in composition to that in the Bassein field in that it contains about 79 percent C1 (methane), seven percent C2

(ethane), 4.5 percent C3 (propane), and two percent C4 (butane). The rest of the gas is made up of 6.5 percent carbon dioxide, with smaller fractions of C5/C6, oxygen and other gases. The daily gas production is expected to average 3.8 million cubic meters a day (mmcm/d) in 1990-91, 10.4 mmcm/d in 1994-95 and 20 mmcm/d by 1999-2000.

The ONGC has had an excellent record of drilling in the area: of the 38 wells drilled so far, 35 have struck proved hydrocarbon-bearing zones. The exploratory drilling plans envisage adding 325 mmt of oil and oil-equivalent gas reserves by 1994-95. The oil production from the Gandhar field was expected to be 1.37 mmt by year-end 1991, and is projected to increase to 3.19 mmt by 1994-95 and 4.97 mmt by 1999-2000.

The total investment envisaged for the Gandhar field by 1999-2000 is estimated to be Rs504 billion, of which Rs220 billion will be drilling costs. The installations, collection system and pipelines will cost Rs139 billion and operating costs will be Rs145 billion. The Asian Development Bank has sanctioned a US$267 million loan for the project. The revenues generated from the sale of oil, gas, and LPG from this field were Rs20 billion in 1990-91; earnings are estimated to increase to Rs155 billion in 1999-2000.

The Cauvery Basin (Tamil Nadu)

The estimated hydrocarbon reserves of the Cauvery Basin are 540 mmt, of which 300 mmt are onshore and 240 mmt are offshore. In mid-1989, 53 mmt of geological reserves were estimated. The four fields discovered include the Narimanam, Kovikalappal, Naanilam and Bhuvanagari fields. These oil fields are likely to come into production during the Eighth Five-Year Plan period. In addition, a Soviet team has indicated geological reserves of about 24 mmt in the Ariyalur-Pondicherry Depression.

The ONGC made two significant offshore hydrocarbon strikes at the PY-3 and PY-1 structures. A number of additional oil-bearing structures are expected to be discovered near the PY-3 and PY-1 structures by mid-1993. As of early 1990, seven rigs were deployed onshore and two were deployed offshore in the basin. At the end of the Seventh Five-Year Plan, total wells drilled numbered 111 and total investment stood at Rs57 billion.

The ONGC plans to increase the number of rigs to 15 onshore and four offshore by 1995. About 150 mmt of oil and oil equivalents of gas are expected to be added to the reserves by 1995. The crude oil production potential is expected to reach 1.3 mmt annually and the potential for gas is expected to be as high as one million cubic meters per day.

Krishna-Godavari Basin (Andhra Coast)

The Krishna-Godavari Basin encompasses an area of 20,000 km^2 on land and 21,000 km^2 offshore. The estimated reserves are 760 mmtoe of oil and gas, 275 mmtoe onshore and 485 mmtoe offshore. These reserves are composed of 423 mmtoe of oil and 337 mmtoe of gas. Nearly 25 mmtoe of the hydrocarbon resources, comprised of 13.20 mmt of oil and 11.39 mmtoe of gas, have been converted to geological in-place reserves. Recently, gas was found onshore at the Penumadam-1 structure, located 18 km northeast of Narasapur, and at the Banda-Murlanka AN-1 structure, 10 km south of Amalapuram.

In the basin, there were seven rigs operating onshore and two rigs offshore during 1989-90. By the end of the Eighth Five-Year Plan, the ONGC plans to increase the number of onshore rigs to eleven and offshore rigs to four. Total investment at the end of the Seventh Five-Year Plan stood at Rs100 billion. The result of the effort is that almost 14 percent of the estimated reserves in the basin have been determined to be geological in-place proved reserves. About 130 mmt are likely to be added to the geological proved reserves by 1995. The production potential of the basin is likely to rise to 0.75 mmt per year of oil and 6.14 mmcm per day of free and associated gas by the end of the Eighth Five-Year Plan.

NATURAL GAS

Reserves

With several significant natural gas discoveries, India's gas reserves increased five-fold during the 1980s and are expected to further increase in the 1990s. The gas reserves are sufficient for 50 years of consumption at present rates. As with the crude oil reserves, gas reserves increased substantially upon the discovery of the Bombay High field in 1974.

Table 4.3: **Natural gas output and reserves, billion cubic meters**

Year	Production	Flared	Net output	Reserves
1970-71	1.4	0.8	0.7	62.3
1988-89	13.2	3.7	9.3	579.5
1989-90	17.0	5.4	11.5	654.6
1990-91	18.0	6.5	16.5	700.0*

* estimate

Source: Economic Survey 1990-91

The proved reserves of natural gas have risen from 410 bcm in 1981 to 700 bcm in 1991 (Table 4.3). Of these reserves, the Bombay High field alone accounts for 447 bcm. Potential reserves are estimated to be 408 trillion cubic feet (tcf) and are concentrated mainly in Gujarat, Assam, Rajasthan, Tripura, and Nagaland.

Production and utilization

Gas production in 1990-91 was approximately 18 billion cubic meters, averaging 49 million cubic meters per day (mmcm/d) (Table 4.3). About 76 percent of the total production comes from the Bombay High field, notably the Bassein South gas field. About 10 percent of output is produced in Gujarat, five percent in Assam and nine percent in Tripura, Rajasthan, and other areas.

While crude oil production stagnated after 1984-85, natural gas production increased. In terms of oil equivalents, gross natural gas production increased from a meager 1.6 mmtoe to nearly 17.3 mmtoe in 1990-91. Natural gas production is expected to rise to 31 billion cubic meters by 1995 from the 1991-92 target production of 20.5 bcm.

In the early seventies, between 45 to 50 percent of the gross production was flared. Since then, the share of gas flared has decreased, and in 1989-90, only 29 percent of

gross gas production was flared. Natural gas has been emerging as a rapidly expanding supplementary source of energy and also as feedstock for the fertilizer and petrochemical industries. The utilization of gas in 1990-91 was 12.8 bcm, as compared to 11.2 bcm in 1989-90. Gas is consumed mainly in power generation (36 percent), and fertilizers (41 percent); the rest is consumed by petrochemicals, sponge steel industries, and commercial and residential uses.

To further commercialize the use of natural gas, the 1,730 km long trans-India Hazira-Bijapur-Jagdispur (HBJ) pipeline, with a carrying capacity of 15 mmcm a year is near completion. This pipeline will take gas from the Bombay High field through the Hazira onshore terminal to consumers in central India. The gas is to be consumed along the HBJ pipeline by a series of gas-based fertilizer plants and power stations. A National Grid System covering 11,500 km, with a carrying capacity of 120 mmcm a year, is being planned. Currently, India has only 2,571 km of gas pipelines, including the HBJ Link. The part of the HBJ pipeline that is already operational has spawned fertilizer and power plants in Gujarat, Madhya Pradesh and Uttar Pradesh. The feasibility of moving gas from the Western Offshore fields to States in the south of India was studied by the Rao government in 1991.

Natural gas will play a very important role in meeting the future energy demands of India. India's gas production has been expanding rapidly, but it is only very recently that concerted efforts have been made to capture rather than flare associated gas, to explore for non-associated gas, and to invest in a transmission infrastructure to effectively move natural gas. The Ministry of Petroleum and the ONGC decided in 1991 to stop the flaring of natural gas in the Bombay High field by closing down some oil wells with a high gas:oil ratio. This strategy involves cutting oil production by three to four mmt and investing Rs18 billion in compression facilities to save approximately 11 bcm of gas valued at about Rs30 billion.

The state-owned Gas Authority of India, Ltd. (GAIL), spearheads India's gas utilization drive and has lined up high value-added customers for India's offshore gas. Three fertilizer plants, located near Bijapur, Jagdispur and Aonla in Uttar Pradesh, are now seeking to enlarge their capacities. In addition, gas-based power plants at Anta,

Rajasthan and Auraiya, Uttar Pradesh, have started producing electricity. Construction of the 600 MW gas-based Kawas Plant in Gujarat was started in January 1991, with the turnkey contract going to GEC-Alsthom. In the second phase of the gas utilization drive, the GAIL intends to fractionate gas in a LPG plant at Bijapur, Uttar Pradesh, that is currently under construction. Feasibility studies for additional power plants with the capacity to utilize two to six million standard cubic feet per day (mmscf/d) at Gandhar, Hazira, and Vogodhia in Gujarat, Usar in Maharashtra, and Lakwa, Assam, are being currently undertaken.

A number of petrochemical projects have also been planned. The GAIL has proposed upgrading the Hazira-Bijapur-Jagdispur (HBJ) gas pipeline and establishing gas-based petrochemical complexes in the Indian states of Madhya Pradesh and Uttar Pradesh. The state-owned Indian Petrochemical Company, Ltd. (IPCL), Baroda, has also suggested setting up a petrochemical complex in Gandhar, Gujarat. The Assam Industrial Development Corporation (AIDC) is setting up a petrochemical gas-cracking complex in Assam.

Priorities are being worked out to determine the basis of highest economic use. For this purpose, the netback for each use is calculated. The GAIL has formulated a gas utilization policy that defines the priorities for gas use as follows:

- Natural gas should be viewed as a multi-use rather than a single-use product, where each fraction is utilized to secure the highest return to the economy.
- The butane and propane fractions (C3 and C4) should be used to manufacture LPG for domestic fuel.
- Only the surplus propane should be used for the manufacture of propylene.
- The ethane fraction should be used for the manufacture of ethylene.
- The methane fraction has competing demands in the form of fertilizers, power generation, and in the industrial and residential applications.

OUTLOOK FOR HYDROCARBON PRODUCTION

Under the Eighth Five-Year Plan, the ONGC and the OIL have been given a production target of 45 mmt by 1994-95, vis-a-vis a production level of 34 mmt in 1989-90. The total

targeted increase in crude oil production during the Eighth Five-Year Plan is 16.66 mmt, against 12.89 mmt during the Seventh Five-Year Plan. The plan calls for the OIL to raise its production to 3.9 mmt, and for the ONGC to raise production to 40 mmt by 1994-95. Total crude production is to be 50.3 mmt by 1994-95, including production by private and foreign firms.

Development outlays for the Eighth Five-Year Plan will amount Rs200 billion (US$12 billion), compared to Rs100 billion in the Seventh Five-Year Plan, and Rs68 billion in the Sixth Five-Year Plan.

An internal Ministry of Petroleum document presented to the Planning Commission states that the oil reserves-to-production ratio may decline from 20.5:1 to just 11:1 by the year 2000 and to 7:1 by 2005. This means, that at current rates of production, supplies in 2005 will last just seven years and, by 2012, India will have nearly depleted its reserves, unless, of course, new oil discoveries are made. As things stand, the ONGC's targets for the Eighth Five-Year Plan have been recently scaled down. The geological reserves accretion target was revised from 1.232 mmt to 1.039 mmt. A cut in the ONGC's exploratory drilling budget in the Eighth Five-Year Plan from the proposed Rs260 billion to Rs170 billion has been made accordingly.

Nevertheless, there are uncertainties involved in achieving the target production of 50.3 mmt in 1995. There have been reports that the targets are far too ambitious for sustained oil and gas production from the operative fields. A high level of production requires extensive technical and financial outlays and competent management of reservoir operations. Recently, controversy has surrounded the ONGC's operational management of its Western Offshore Basin's Bombay High fields. A 1991 report by Total—Compagnie Française de Pétroles (TCFP) suggests that over the next five years, a total of 14 mmt (105 mmb) of crude oil will be lost as a result of production difficulties, mainly associated with offshore areas.

Foreign investment and joint ventures in hydrocarbon exploration and development

The Rao administration is maneuvering towards a free-market system in the energy sector. India plans to invest 31 percent of total outlays in the Eighth Five-Year Plan in

the energy sector. The country needs additional outside investment and joint ventures in order to meet its energy needs in the 1990s and beyond. In order to attract foreign investment and encourage joint ventures, India has opened up the single largest exploration acreage available anywhere in the world today. The rationale behind opening the fourth round of oil exploration (1991-92) to foreign firms is that India's two public sector companies, the ONGC and the OIL, have neither the money nor the expertise to exploit the prospective blocks offered. For instance, the cost of developing the oil discovered at the PY-3 field (Cauvery Offshore block) is too prohibitive for the ONGC, and thus the PY-3 is open for bidding.

India is stepping up its long-delayed petroleum development projects. The ONGC has drawn up plans for a broad program to boost oil and gas production and, at the same time, to end gas flaring in the Bombay High area by 1995. This development will require US$2.8 billion, with a foreign exchange component of US$1.6 billion. The International Finance Corporation (IFC), the branch of the World Bank that lends to the private sector, has acquired a 25 percent interest in a joint venture in the proposed Krishna-Godavari offshore exploration project. In addition, the World Bank has approved a loan for US$450 million and, in August 1991, Japan made a US$100 million loan to India for natural gas development.

In September 1991, the Indian government changed bidding terms for foreign and private company investments in oil and gas exploration and development. Of the 27 offshore blocks offered in a third round in 1986, nine were taken up by five international companies; however, difficulties surfaced in actual implementation of the contracts. The most recent exploration round for private investment, India's fourth since 1980, comes five years after the third round, which did not result in any discoveries. This round had been delayed since 1988, virtually stopping all new ventures. The fourth round offers 124,300 km^2 of prospective exploration areas in seventeen basins. Bidding will close in February 1992 and exploration contracts will be awarded in October 1992. Foreign and Indian companies will be allowed to bid for 72 exploration blocks, which include 39 offshore and 33 onshore blocks.

In the fourth round of bidding, the split ratio of initial oil entitlement has been improved to 70:30 in a company's favor from the earlier 60:40 terms. Government participation — through either the ONGC or the OIL — in the development and production stages has been reduced to 30 percent. If either the ONGC or OIL wants to retain the earlier 40 percent option, the state company will have to share 10 percent of the exploration costs. In the previous rounds, only the foreign companies invested risk capital, while the ONGC and OIL shared in the development costs. The contract for an oil and associated gas find will be operational for 25 years, and in the case of free gas fields, the contract can be extended to 35 years. The government is not demanding up-front payments such as signature bonuses or royalties.

Five

COAL

DEVELOPMENT OF THE COAL INDUSTRY

Coal has been mined in India since antiquity. The modern era of the Indian coal industry began in 1947, following the country's independence. State involvement began in 1956 when the National Coal Development Corporation (NCDC) was set up. The pace of coal mining accelerated after the nationalization of the coal industry in the early 1970s. Currently, the coal industry comes under the direction the Department of Coal in the Ministry of Energy. The Central Mine Planning and Design Institute at Ranchi is responsible for mine planning.

The Department of Coal (DOC) oversees the development and production of coal and lignite in India. The functions assigned to the DOC include the exploration and development of coking and non-coking coal and lignite deposits; regulation of coal production, supply, distribution and prices; administration of coal mines; and regulation and coordination of public sector enterprises dealing with coal and lignite.

Following nationalization in 1973 and reorganization in 1975, most of the coal mines came under the control of the Coal India, Ltd. (CIL), with its eight subsidiary companies, and the Singareni Collieries Company, Ltd. (SCCL). Currently, the CIL is the principal producer, accounting for 88 percent of total production. Although a considerable amount of exploratory drilling needs to be carried out in order to upgrade and extend reserves in many areas, the main requirement in the coal sector is to increase production.

Coal is the most abundant commercial energy source in India. At the present rate of consumption, India's coal reserves will last another 400 years. Given the abundance of coal among primary sources of energy, fuel substitution in favor of coal may become imperative in India. However, the share of coal in primary sources of energy has been on the decline since the 1980s. The share of coal, which was almost 62 percent in

1970-71 increased slightly to 63 percent in 1980-81, but remained consistently below 60 percent after 1985-86. In 1990-91, coal and lignite accounted for only 56 percent of the commercial sources of energy. During 1990-91 there were considerable shortages of coal in some parts of the country. With the recent increases in railway freight rates, the relative price of coal with respect to oil has increased. Some customers have reacted to the increased price and shortages of coal by switching to fuel oil.

RESERVES

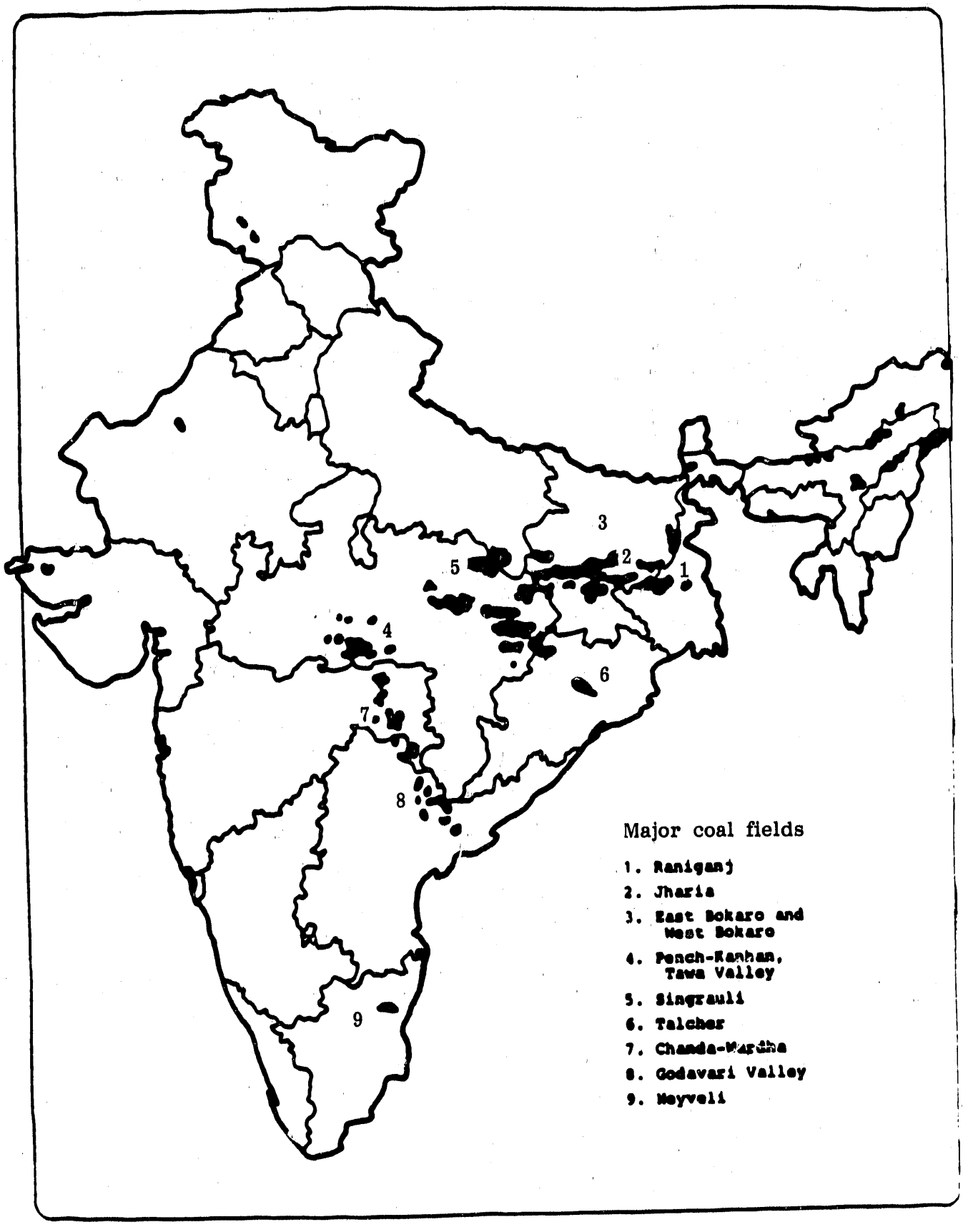
India has the fourth largest coal reserves in the world. Its ranks first in coal reserves among the SAARC nations in South Asia and second in Asia. Most of the coal reserves are found in the Permo-Carboniferous rocks in the Gondwanaland coal deposits. Other coal-bearing formations are in Mesozoic and Tertiary rocks. Figure 5.1 shows the distribution of coal fields in India.

Reserves of all types of coal that occur in seams exceeding 0.5 meters in thickness and within a depth of about 1,200 meters totalled around 192 billion tonnes (bt), as of January 1, 1991 (Table 5.1). About 59 bt of these reserves are proved deposits. There are 84 bt of indicated reserves and 49 bt of inferred reserves. In 1990, gross reserves increased by 16 bt and proved reserves by three bt from 176 bt; 1990 coal reserves are shown in Tables 5.2 and 5.3.

The state of Bihar has the largest coal reserves of all States and Union Territories. With 59 bt of reserves in 1990, it had almost one-third of the total Indian coal reserves (Table 5.3). Orissa, Madhya Pradesh and West Bengal have the next largest coal reserves with 41.5 bt, 28.8 bt, and 29.6 bt, respectively. During the period 1986-1989, there were increases totalling nearly 13 bt of coal reserves in Orissa, 8.3 bt in Madhya Pradesh, and 3.3 bt in Bihar. However, the increase in Orissa, representing 43 percent of the total increase, was of low-grade coal.

Among coal fields, the Raniganj coal field (West Bengal/Bihar), has the largest reserves with about 27 bt, followed by the Talchir (Orissa) (22 bt), Ib River (Orissa) (19 bt), and Jharia (Bihar) (19 bt) coal field. Other major coal fields include Karanpura, East and West Bokaro (Bihar), Pench-Kanhan Tawa Valley (Madhya Pradesh), Singrauli (Uttar Pradesh and Madhya Pradesh), Chanda-Wardha (Maharashtra), Godavari Valley (Andhra Pradesh), and Neyveli (Tamil Nadu).

Figure 5.1: **Coal fields**



Source: Ministry of Energy

Table 5.1: **Coal reserves 1991, million tonnes**

Proved	Indicated	Inferred	Total
58,984	84,022	49,354	192,359

Source: Economic Survey 1990-91

Types and grades of coal

Of the 176.33 bt of India's coal reserves in 1990, only 27.7 bt were of the coking coal variety. However, a relatively large portion of the non-coking coal reserves are of poor quality. Of the 102 bt of proved and inferred non-coking coal reserves, 61.4 bt (62 percent) are of E to G grade. It may be noted that non-coking coal is classified from category A to G, depending upon the useful heat value. Grade A non-coking coal has a useful heat value exceeding 6,200 kilocalories per kilogram (kcal/kg); category B has 5,600 kcal/kg; C has 4,940 kcal/kg; D has 4,200 kcal/kg, E has 3,360 kcal/kg; F has 2,400 and G has 1,300 kilocalories per kg.

Indian coals are largely of bituminous grade, and almost all of these are in the geologic Gondwana Basin of Carboniferous age in Bengal and Bihar. The coking and blendable coal amounts to less than 16 percent of the total resources and occurs in the Jharia and Raniganj coal fields. The lower quality coals have a wider distribution elsewhere in India. These coals have a high ash content, except in the case of coal seams that are interbedded with coal of low sulfur-content.

Raniganj coal fields, West Bengal/Bihar

The Raniganj coal fields in West Bengal and Bihar contain the largest coal mines in India with coal reserves of 27 bt. About 25.6 bt (94 percent) of total reserves are of the non-coking variety. The remaining reserves consist of medium coking and blendable varieties. Of the 6.9 bt of proved non-coking coal reserves, only about 1.15 bt (17 percent) are of grade categories A and B. The category C grade of non-coking coal accounts for 3.9 bt (57 percent) of the proved non-coking coal reserves. The remaining reserves are classified in the Category D to G grades. A large part of the proved coal

Table 5.2: **Coal reserves by category 1990, million tonnes**

Type of coal	Proven	Indicated	Inferred	Total
Prime coal	4,171	1,129	-	5,300
Semi-coking	9,333	11,388	1,684	22,405
Non-coking	38,630	61,675	48,320	148,625
Total	52,134	74,192	50,004	176,330

Source: Economic Survey 1990-91

Table 5.3: **Coal reserves by State 1990, million tonnes**

State	Proved	Indicated	Inferred	Total
Andhra Pradesh	4,597	1,006	4,483	10,086
Arunachal Pradesh	16	8	65	90
Assam	28	151	29	277
Bihar	24,460	27,834	6,838	59,132
Madhya Pradesh	7,725	14,273	6,816	28,814
Maharashtra	2,423	929	1,920	5,272
Meghalaya	85	56	320	462
Nagaland	-	5	7	12
Orissa	4,829	15,387	21,343	41,557
Uttar Pradesh	662	400	-	1,062
West Bengal	7,312	14,141	8,112	29,565
Total	52,137	74,190	49,933	176,260

Source: Department of Coal 1990

reserves lie at depths to 600 meters. More than a third of the indicated and inferred reserves, and one-half of the medium coking coal lie between depths of 600 and 1,200 meters.

Jharia coal fields, Bihar

The Jharia coal fields have been mined since 1890 and contain India's only source of prime coking coal. The Jharia coal fields are located in an east-west trending morphotectonic half graben extending over 450 km^2. The coal is found in Permian coal-bearing rocks. Most of the coal reserves in the Jharia field lie at depths within 600 meters of the ground surface; of the 19.4 bt of coal reserves, 14.2 bt are known to lie at depths of no more than 600 meters. The coal fields contain 5.2 bt of prime coking coal and 6.2 bt of medium coking coal reserves.

Shallow subsurface fires at 70 locations in 40 collieries have affected the condition of the coal deposits and the minability of coal in adjoining areas. In addition, the fires have polluted the environment and endangered the surface infrastructure. Some of these fires started 50 years ago, blocking the exploitation of about 1.86 bt of good quality coking coal. About 40 mmt of coal have already been exhausted by the fires. The Department of Coal has made plans to control the fires at the 70. This is estimated to cost Rs11.2 billion (US$300 million).

Ib River and Talchir coal fields, Orissa

Almost all of the reserves in these fields lie at depths of less than 600 meters. About 31.4 bt of the total 41.6 bt of coal deposits are within 300 meters of the surface. Less than 12 percent of the total known reserves are proved; and, of the proved reserves, most are of category E to G grades. There are no known deposits of prime or medium coking coal in the region. However, this region has assumed considerable importance as the largest coal discoveries in recent times have been reported there.

COAL PRODUCTION

Coal production nearly doubled from an estimated 114 mmt in 1980-81 to nearly 212 mmt in 1990-91. The 1990-91 coal production was 5.4 percent higher than the 1989-90

production of 201 mmt (Table 5.4); however, production was approximately 12 mmt short of the 1990-91 target of 224 mmt.

Production in 1990-91 included 189.6 mmt from the CIL, 17.7 mmt from the SCCL, and 4.4 mmt from other coal companies. The target for the CIL was set by considering an eight mmt reduction in stocks; however, the budget year that ended in March 1991 recorded an increase of 5.4 mmt of the pithead stocks to 43 mmt, 14.5 percent higher than in 1989-90.

Production in the coal regions in 1990-91 was adversely affected by power shortages, flooding during the monsoon season, and a miners' strike in the SCCL mines during September and October of 1990. The shortfall between actual and target production in 1990-91 could also have been partly the result of a conscious decision to curb mounting stocks.

The Public Sector Units (PSUs) account for almost 98 percent of total coal production in India. Coal production and shipments for the years 1989-90 and 1990-91 are given in Table 5.5 for the CIL, the SCCL, and other companies.

During 1990-91, there were 14 coal development projects under implementation, each costing over Rs1,000 million (US$100 million). Out of these, nine were delayed due to various logistics problems and rehabilitation of displaced people.

Production trends

Much of the impressive growth in industrial production during the 1980s can be traced to the steady rise in coal production during the same period. An increase in open pit mining and new mining techniques have increased coal production in recent years. Larger and more powerful equipment is being deployed to permit mining down to depths of 500 meters and open up more areas in coal fields. Improvements in production have outstripped the capacities of transportation and distribution systems, resulting in stock pileups at the pitheads.

Table 5.4: **Coal production, million tonnes**

Year	Production
1970-71	73.7
1971-72	72.4
1972-73	77.2
1973-74	78.2
1974-75	88.5
1975-76	99.7
1976-77	101.0
1977-78	101.0
1978-79	102.0
1979-80	104.0
1980-81	114.0
1987-82	124.0
1982-83	130.5
1983-84	138.2
1984-85	147.4
1985-86	154.2
1986-87	166.0
1987-88	188.3
1988-89	195.0
1989-90	201.0
1990-91	211.7

Source: Department of Coal 1991

Productivity in underground and open pit mining

The share of open pit mines in total coal production was about 26 percent at the time of natio alization in 1973-74. This share increased to 49 percent at the end of the Sixth

Five-Year Plan (1980-85) and grew to 60 percent by the end of the Seventh Five-Year Plan. In 1987-88, the share of open pit mining in the CIL-operated mines was 63 percent; for the SCCL it was 23.4 percent.

Productivity in underground mines is very low compared to that in the open pit mines. The productivity of the CIL underground mines in 1989-90 was 0.53 tonnes of output per manshift (OMS), compared with 2.87 tonnes OMS in the open pit mines. The corresponding figures for SCCL mines were 0.71 and 4.51 tonnes OMS, respectively. Productivity of the CIL's underground mines did not show any improvement throughout the 1980s, while productivity of open pit mines doubled. The SCCL's underground mines recorded some slight productivity improvement during the same period.

The CIL improved its overall productivity measured in terms of raw coal output per manshift. It achieved an overall OMS of 1.31 tonnes in 1990-91, compared to 1.21 tonnes in 1989-90. The OMS of the SCCL mines increased from 0.9 tonnes in 1989-90 to 1.18 tonnes during 1990-91.

COAL CONSUMPTION AND DISTRIBUTION

Demand for coal during 1990-91 reached 230 mmt against a production level of 212 mmt. However, due to a mismatch between production and distribution arrangements, shipments of coal in 1990-91 were only 200.4 mmt, leaving a shortfall of nearly 30 mmt that was partially met through imports of coking coal. The requirements for coking coal by steel plants was 20 mmt during 1990-91. However, the steel industry, as well as thermal power plants, were threatened with closure because of coal shortages due to insufficient rail wagon availability. In January 1991, the Federation of Indian Chambers of Commerce and Industry requested that the government import five mmt of coal. Imports of low-ash coking coal for steel plants have been increasing. About 5.1 mmt of special low-ash coking coal had to be imported in 1990-91, up from 4.5 mmt in 1989-90.

Shortages of coal have generated concern among industrial users since 1989. Despite the planned production process and elaborate arrangements for distribution of coal, shortages are prevalent throughout the country. In early 1990, the economy was reeling under the strain of coal shortages, despite mounting stocks at the pitheads.

Table 5.5: **Coal production and shipments, million tonnes**

Company	Production 1990-91	Production 1989-90	Shipments 1990-91	Shipments 1989-90
Eastern Coal Fields, Ltd.	23.5	24.5	22.3	24.4
Bharat Coking Coal Fields, Ltd.	26.7	26.6	22.2	23.4
Central Coal Fields, Ltd.	30.1	28.6	27.5	27.7
Northern Coal Fields, Ltd.	27.9	23.3	27.3	22.3
Western Coal Fields, Ltd.	22.8	23.0	23.4	21.5
Southeastern Coal Fields, Ltd.	58.1	51.8	55.5	50.0
Northeastern Coal Field, Ltd.	0.7	0.8	0.9	0.8
Total Coal India, Ltd. (CIL)	189.6	178.6	179.0	170.1
Singareni Collieries Co., Ltd.	17.7	17.8	17.1	17.2
Other/TISCO/DVC/IISCO*	4.4	4.5	4.3	4.6
Total	211.7	200.9	200.4	191.9

* Tata Iron and Steel Mills (TISCO), Damodar Valley Corporation (DVC) and Indian Iron and Steel and Mines (IISCO)
Source: Department of Coal 1991

Pithead stocks have increased from 30 mmt at the beginning of the Seventh Five-Year Plan in 1985 to 43 mmt by the end of March 1991.

In June 1990, there were complaints of severe coal shortages from manufacturing associations (metal forging, cement, refractories, glass and pottery, soda ash, textiles, fertilizers, etc.) in northern India. According to a report, these units in northern India received only 100,000 tonnes of coal every month against their requirements of about 240,000 tonnes.

While coal stocks were piling up in Bihar and West Bengal, the western and southern Indian States were also feeling acute shortages of coal. The southern States suffered chronic shortages of coal averaging three to four mmt annually.

Despite problems in meeting demand through domestic production and shipments of coal, in March 1991, the CIL had announced a plan for an eight-fold increase in

household consumption of coal from 50,000 tonnes per month to 400,000 tonnes. The idea is to eventually substitute coal for 14,000 tonnes of imported kerosene and save foreign exchange worth Rs52 million (US$2 million) every month.

The distribution of coal in India is determined on the basis of assessed demand of various coal consumers and is controlled through statutory regulation by government bodies. The distribution of coking coal required by the metallurgical industries is regulated by the Colliery Control Order (1945) and its distribution is determined by the Office of the Coal Controller.

For non-coking coal, there is no statutory control on distribution. The Long-term Standing Linkage Committee, operating as part of the Department of Coal, establishes linkages with power stations and cement factories. The linkage to industries in the non-core sectors and to fertilizer plants is established by the non-core sector Linkage Committee of the CIL. These committees meet every quarter year and allocate coal to power plants and cement factories.

Coal shipments from mines in 1990-91 totalled 200.4 mmt, up 4.4 percent over the 192 mmt shipped in 1989-90. Shipments of coal from mines to consumers are coordinated between various state enterprises through the Department of Coal.

Coal is transported from mines to distribution centers via railways, trucks, and rail/ship routes. The Indian Railways is the principal agency for coal transportation, accounting for about 62 percent of total shipments. The average coal loading by the CIL increased by 4.6 percent from 12,225 wagons per day in 1988-89 to 12,793 wagons per day in 1989-90. The coal loading by the SCCL, however, declined by 9.9 percent from 1,425 wagons per day in 1988-89 to 1,284 wagons per day in 1989-90.

The Indian Railways and the CIL are at odds with each other over the freight loading and transport problems. The CIL blames the Railways for not supplying enough wagons, and the Railways accuse the CIL for failure to supply adequate coal for loading. The CIL collieries often cannot load coal in the wagons supplied, because not enough coal is available at the pitheads. Conversely, other pitheads have more extensive stocks than the railroad is able to load.

LIGNITE

Lignite reserves are estimated to be about 6.2 billion tonnes (bt) as of 1989 (Table 5.6). Lignite deposits occur in Neyveli (Tamil Nadu), where about 4.45 bt are in the inferred category, of which about 2.1 bt are in the proved category. Other deposits occur in Kerala (100 mmt), Rajasthan (770 mmt), Gujarat, Pondicherry, and Jammu and Kashmir (90 mmt).

Lignite production in India increased by 24.3 percent during the Sixth Five-Year Plan and 10.6 percent during the Seventh Five-Year Plan. Production of lignite is estimated at 13 mmt in 1990-91, up from 12.8 mmt in 1989-90. Production of lignite by the Neyveli Lignite Corporation (NLC), the state company, rose to 11.8 mmt in 1990-91 from 11.2 mmt in 1989-90. Small quantities of lignite are also produced in the mines of the Gujarat Mineral Development Corporation (GMDC). The NLC has recorded significant achievements in power generation and is a model agency for the development of lignite deposits in Rajasthan, Gujarat and Jammu and Kashmir.

OUTLOOK FOR COAL

The Planning Commission (PC) has set an annual coal production target of 282.6 mmt by fiscal year 1994-95, reflecting an average annual growth rate of seven percent over the production level of 201 mmt in 1989-90. Demand is forecasted to reach 285 mmt in 1994-95. New mining projects are expected to produce 17 mmt of the targeted increase of 81 mmt, and the balance will be procured from existing mines. Plans are in place to increase annual coal production to 450 mmt by 1999-2000, and 600 mmt by 2010.

The PC has allocated Rs6 billion (US$250 million) for coal development during 1990-95. By 1995, the CIL's development projects are expected to increase production capacity by 132 mmt, and the SCCL will add another 15 mmt to its capacity. However, a severe squeeze on investments may be a limiting factor in expansions of production capacity, as the capital available for mining expansion is limited and caters to far lower levels of output.

The Planning Commission's Working Group on Coal and Lignite has estimated total combined demand for coal and lignite in 1994-95 at 321 mmt, including 8.6 mmt of

Table 5.6: **Lignite reserves by State, million tonnes**

State	Proved	Inferred
Tamil Nadu	2,100	4,450
Pondicherry	-	480
Rajasthan	385	640
Gujarat	94	247
Jammu and Kashmir	7	83

Source: Department of Coal 1990

washery midlings for the power plants. To meet this demand, a production target of 304 mmt has been set for the CIL/SCCL coal mines and NLC/GMDC lignite mines, and 5.8 mmt for the Tata Iron and Steel Mills, Indian Iron and Steel, and Damodar Valley Corporation mines. The balance is to be met by drawing down pithead stocks.

The Working Group has proposed a total investment of Rs204 billion for the coal industry and Rs38 billion for the Neyveli Lignite Ltd. An alternative scenario is that an investment of Rs165 billion would be needed to yield 295 mmt of coal by 1994-95 from the CIL and the SCCL mines.

The Eighth Five-Year Plan proposes linking the Kalinga coal field, Talchir (eight mmt capacity), with the Mangalore, Tuticorin and North Madras Extension Project by rail/ship route. For non-coking coal, the increased use of coal-handling plants (CHPs) for proper sizing of coal and removal of extraneous substances is being planned.

The Geological Survey of India (September 1989 Report) has chalked out a seven point strategy for coal exploration during the Eighth Five-Year Plan Period. This strategy identifies coking coal-bearing sectors in the Sohagpur coal field (Madhya Pradesh) and the east and south Karanpura field (Bihar), and points out superior-quality coal areas in virgin areas of Raniganj, south Karanpura, Talchir and Tatpani-Ramkola. The northeastern regions of India will also be explored. Total outlays of Rs904 million (1990-1995) will involve drilling operations totalling 304,000 meters.

ENVIRONMENTAL MANAGEMENT AND RESTORATION OF LANDSCAPE

In 1984, the Bureau of Industrial Costs (BICP) had recommended that a tax of Rs5/per tonne of coal mined should be collected. The revenues, totalling Rs1,000 million on 200 mmt of production, are to be handed over to a separate authority for the required restoration and environmental management of the coal mining areas. The coal mining companies favor the levying of the tax, but want to appropriate it themselves. In addition, they want the responsibility of restoration to be given to them.

Stabilization of the landscape in the mining districts needs to be given priority, especially as environmental degradation and worker safety are closely related. Flooding of the tunnels in the monsoon rainy season is a major hazard. Many mines and their pits and tunnels are flooded due to active erosion. This poses a threat to worker safety with consequent loss of productivity. About 200 miners were drowned at a mine site in eastern India on June 10, 1991, by flooding during the monsoon.

Six

ELECTRICITY GENERATION

DEVELOPMENT PLANNING

The power sector in India comes almost completely under the control of the government through the Central Electricity Authority (CEA). The CEA regulates the power sector and the allocation of electricity among various sectors of the economy. The Department of Power (DOP) in the Ministry of Energy is responsible, along with the CEA, for laying policy guidelines for the generation, allocation, transmission, distribution and conservation of electric power in India. The DOP and the CEA periodically assess the load forecast and review the progress of projects dedicated to hydro-, thermal and nuclear power generation. The DOP oversees the operations of the public sector units (PSUs) at the Central and State levels. India's power sector has five major generation and distribution systems organized by regions: North, West, South, East and Northeast (Figure 6.1).

The India Electricity Supply Act was amended in 1976 to provide for the establishment of public sector generating companies by the Central and State governments. Two Central companies, the National Hydroelectric Power Generating Corporation (NHPC) and the National Thermal Power Corporation (NTPC) were set up. A third public sector generating company, the Nuclear Power Corporation (NPC), was established to develop nuclear power potential on an integrated basis.

Public sector units (PSUs) account for 97 percent of the electricity generated by the utilities. Under the New Industrial Policy (NIP) announced by the Rao government in July 1991, the private sector is being invited to invest in power generation.

Figure 6.1: **Power generation plants — regional distribution**

THERMAL POWER PLANTS

HARYANA
1 Faridabad
2 Panipat
RAJASTHAN
3 Kota
PUNJAB
4 Guru Nanak Dev
5 Ropar
UTTAR PRADESH
6 Anpara
7 Harduaganj
• 8 Obra
9 Panki
10 Panchha
11 Riverside
12 Renusagar
•13 Singrauli
14 Vindhyachal
•15 Rihand
DELHI
16 Indraprastha
17 Rajghat
18 Badarpur
GUJARAT
19 Dhuvaran
20 Gandhinagar
21 Sabarmati
22 Ukai

MADHYA PRADESH
23 Amarkantak
•24 Korba
25 Satpura
MAHARASHTRA
26 Ballarshah
27 Bhusawal
•28 Chandrapur
29 Khaperkheda
•30 Koradi
31 Nasik
32 Paras
33 Parli
•34 Trombay
35 Tata Elect Co
36 Uran
ANDHRA PRADESH
37 Kothagudem
38 Nellore
39 Ramagundam
40 Vijayawada
KARNATAKA
41 Raichur
TAMIL NADU
42 Basin Bridge
43 Ennore
•44 Neyveli
45 Tuticorin

BIHAR
46 Barauni
•47 Bokaro
48 Chandrapura
49 Muzaffarpur
50 Patratu
WEST BENGAL
51 Bandel
52 Gauripur
53 Kolaghat
54 Durgapur
55 Mulajore
56 Southern Gen Stn
57 New Cossipore
58 Titagarh
59 Farakka
60 Santaldih
ORISSA
•61 Talcher
ASSAM
62 Bongaigaon
63 Chandrapur
64 Galiki
65 Kathalguri
66 Lakwa
67 Namrup

• Major plants

REGIONAL ELECTRICITY BOARDS ——
STATE ELECTRICITY BOARDS ——
MAIN SITE OF THE BOARD o

Source: Central Electricity Authority

India's electric power sector has been traditionally under the domain of the public sector. The power sector has been constrained in its capital investment by limited public sector budget resources. In the 1980s, the power sector accounted for 16 to 20 percent of public sector investments, around 2.2 to 2.4 percent of the GDP. Over 70 percent of the power sector investment was for the expansion of generation capacity, while the balance was shared between transmission and distribution systems. The trends in installed capacity, power generation and operational efficiency of power plants are shown in Table 6.1. Per capita electricity consumption in India was about 320 kWh in 1990-91. Despite electrification of all towns and 80 percent of the villages, the percentage of households linked to the electric power grid remains at only about 14 percent. The government has planned to provide electricity to all of the 600,000 villages in India by the year 2000.

POWER SUPPLY

Since 1947, there has been a phenomenal growth in India's electric power generation capacity (Tables 6.1 and 6.2). The installed capacity has increased from 1,363 MW in 1947 to 72,020 MW by 1991, which includes 65,120 MW from utilities and 6,900 MW from non-utilities (Table 6.2). The average growth rate in India's electric power generation capacity over the last 30 years has been 9.4 percent per year.

As of March 1991, thermal power constituted more than two-thirds of the total utility power generation capacity of 65,120 MW and total power generation of 264.2 billion kWh in India. Installed generation capacity in 1990-91 included: thermal power 44,990 MW; hydropower 18,530 MW; and nuclear power 1,600 MW. Capacity was increased by 2,777 MW during 1990-91, which was only 66 percent of the targeted 4,212 MW. Of this increment, 2,331 MW was thermal and 446 MW was hydropower generation capacity.

Power generation increased to 264.2 billion kWh in 1990-91, as compared to 245 billion kWh in 1989-90 — a growth rate of 7.8 percent during 1990-91, compared with 10.9 percent growth in 1989-90. However, production fell short of the 271.2 billion kWh target in 1990-91. The deceleration in generation increases was due to a decline in the increases in thermal power generation.

Table 6.1: Power generation, capacity and operational efficiency

	Thermal (including nuclear)				Hydro				Total			
	Installed capacity (Million kw)	Generation (Million kwh)	Variation over previous year (%)	Generation in kwh per kw of installed capacity	Installed capacity (Million kw)	Generation (Million kwh)	Variation over previous year (%)	Generation in kwh per kw of installed capacity	Installed capacity (Million kw)	Generation (Million kwh)	Variation over previous year (%)	Generation in kwh per kw of installed capacity
1947	0.85	1,879	-	2,211	0.51	2,194	-	4,302	1.36	4,073	-	2,995
1948	0.90	2,202	17.2	2,447	0.51	2,373	8.2	4,653	1.41	4,575	12.3	3,245
1949	0.98	2,419	9.9	2,468	0.56	2,490	4.9	4,446	1.54	4,909	7.3	3,188
1950	1.15	2,587	6.9	2,250	0.56	2,520	1.2	4,500	1.71	5,107	4.0	2,987
1951	1.26	2,998	15.9	2,379	0.58	2,860	13.5	4,931	1.84	5,858	14.7	3,184
1952	1.35	3,321	10.8	2,460	0.71	2,799	-2.1	3,942	2.06	6,120	4.5	2,971
1953	1.57	3,783	13.9	2,410	0.73	2,914	4.1	3,992	2.30	6,697	9.4	2,912
1954	1.70	4,285	13.3	2,521	0.79	3,237	11.1	4,097	2.49	7,527	12.3	3,021
1955	1.76	4,850	13.2	2,756	0.94	3,742	15.6	3,981	2.70	8,592	14.2	3,182
1956-57	1.83	5,367	10.7	2,933	1.06	4,295	14.8	4,052	2.89	9,662	12.5	3,343
1957-58	2.01	6,297	17.3	3,133	1.21	5,072	18.1	4,192	3.22	11,369	17.7	3,531
1958-59	2.15	7,146	13.5	3,324	1.36	5,848	15.3	4,300	3.51	12,994	14.3	3,702
1959-60	2.34	8,006	12.0	3,421	1.53	7,027	20.2	4,593	3.87	15,033	15.7	3,885
1960-61	2.74	9,100	13.7	3,321	1.91	7,837	11.5	4,103	4.65	16,937	12.7	3,642
1961-62	2.80	9,856	8.3	3,520	2.42	9,814	25.2	4,055	5.22	19,670	16.1	3,768
1962-63	2.86	10,560	7.1	3,692	2.94	11,805	20.3	4,015	5.80	22,365	13.7	3,856
1963-64	3.41	12,861	21.8	3,772	3.17	13,957	18.2	4,403	6.58	26,818	19.9	4,076
1964-65	4.01	14,764	14.8	3,682	3.39	14,799	6.0	4,365	7.40	29,563	10.2	3,995
1965-66	4.90	17,765	20.3	3,626	4.12	15,225	2.9	3,695	9.03	32,990	11.6	3,653
1966-67	5.33	19,642	10.6	3,685	4.76	16,734	9.9	3,516	10.09	36,376	10.3	3,605
1967-68	6.40	22,537	14.7	3,521	5.48	18,658	11.5	3,405	11.88	41,195	13.2	3,468
1968-69	7.05	26,711	18.5	3,789	5.91	20,723	11.1	3,506	12.96	47,434	15.1	3,660
1969-70	7.97	28,943	8.4	3,631	6.13	23,046	11.2	3,760	14.10	51,989	9.6	3,687
1970-71	8.33	30,579	5.7	3,671	6.38	25,248	9.6	3,957	14.71	55,827	7.4	3,795
1971-72	8.64	32,901	7.6	3,808	6.61	28,024	11.0	4,240	15.25	60,925	9.1	3,995
1972-73	9.50	37,350	13.5	3,932	6.78	27,196	-3.0	4,011	16.28	64,546	5.9	3,965
1973-74	9.70	37,717	1.0	3,888	6.96	28,972	6.5	4,163	16.66	66,689	3.3	4,003
1974-75	10.79	42,318	12.2	3,922	7.53	27,875	-3.8	3,702	18.32	70,190	5.2	3,831
1975-76	11.65	45,929	8.5	3,942	8.47	33,302	19.5	3,932	20.12	79,231	12.9	3,938
1976-77	12.44	53,497	16.5	4,300	9.03	34,834	4.6	3,858	21.47	88,333	11.5	4,114
1977-78	13.65	53,362	-0.3	3,909	10.02	38,007	9.1	3,793	23.67	91,369	3.4	3,860
1978-79	15.85	55,364	3.8	3,493	10.83	47,159	24.1	4,354	26.68	102,523	12.2	3,843
1979-80	17.07	59,149	6.8	3,465	11.38	45,478	-3.6	3,996	28.45	104,627	2.1	3,678
1980-81	18.42	64,302	8.7	3,491	11.79	46,542	2.3	3,948	30.21	110,844	5.9	3,669
1981-82	20.17	72,536	12.8	3,596	12.17	49,565	6.5	4,073	32.34	122,101	10.2	3,776
1982-83	22.31	81,890	12.9	3,671	13.75	48,373	-2.4	3,707	35.36	130,263	6.7	3,684
1983-84	25.48	90,223	10.2	3,541	13.86	49,954	3.3	3,604	39.34	140,177	7.6	3,563
1984-85	28.12	102,848	14.0	3,657	14.46	53,785	7.7	3,720	42.58	156,633	11.7	3,678
1985-86	31.20	119,104	15.8	3,817	15.47	50,933	-5.3	3,922	46.67	170,037	8.6	3,643
1986-87	32.97	133,841	12.4	4,059	16.20	53,764	5.6	3,319	49.17	187,605	10.3	3,815
1987-88	36.79	154,498	15.4	4,199	17.26	47,396	-11.9	2,746	54.05	201,894	7.6	3,735
1988-89	40.91	163,332	5.7	3,992	17.80	57,793	21.9	3,247	58.71	221,125	9.5	3,766
1989-90	44.13	183,145	12.1	4,150	18.08	61,996	7.3	3,429	62.21	245,141	10.9	3,941
Annual rate of increase (%) between												
1950-51 & 1960-61	9.1	13.4			13.1	12.0			10.5	12.7		
1960-61 & 1970-71	11.8	12.9			12.8	12.4			12.2	12.7		
1970-71 & 1980-81	8.2	7.9			6.3	6.3			7.4	7.1		
1979-80 & 1989-90	10.0	12.0			4.7	3.2			8.1	8.9		
1950-51 & 1989-90	9.8	11.5			9.3	8.6			9.7	10.4		

Source: CMIE, compiled from various official sources

Table 6.2: **Electric power generation capacity 1991**

Type — utilities	Capacity, megawatts (MW)	Share of capacity, (%)
Thermal	44,990	69.1
Hydropower	18,530	28.5
Nuclear	1,600	2.4
Total	65,120	100.0

Source: Ministry of Energy 1990-91

Thermal power generation, including nuclear power, grew at only 5.1 percent during 1990-91, compared with 12.1 percent in 1989-90. Non-utility power generation was 16 billion kWh in 1990-91.

Electricity generation recorded an average annual growth rate of 8.5 percent during the Sixth Five-Year Plan (1980-85), with growth rates for hydropower at 3.5 percent, thermal 12 percent, and nuclear 12.4 percent. During the Seventh Five-Year Plan (1985-90), total power generation grew at an average annual rate of 9.4 percent, with hydropower growing at 3.5 percent, thermal power at 12.6 percent and nuclear power at 3.5 percent. The share of thermal power in power generation has been steadily rising. In 1990-91, thermal power plants produced 192.7 billion kWh, an increase of 5.1 percent over 183.3 billion kWh produced in 1989-90.

In India, electricity supply patterns by source estimated for the years 1994-95 through 2009-10 are predominantly skewed in favor of thermal power plants, as shown in Table 6.3. As there is an abundance of coal deposits adjacent to major industrial centers in India, there has been significant growth in the number of coal-based power plants. According to the Planning Commission, the power sector has almost trebled its coal use since 1947. Coal consumption in the power sector will increase to about 240 million tonnes (mmt) in the year 2000, up from the 1990-91 consumption of 140 mmt. Underlying this growth would be an increase in coal-powered generation capacity to 60,000 MW.

For the thermal power plants based on coal, the design norms for utilities indicate an overall coal-to-electricity conversion efficiency of 31.6 percent.

Table 6.3: **Electricity supply patterns, million tonnes of oil equivalent**

Year	Hydro	Thermal	Nuclear	Total
1989-90	5.17	15.19	0.58	20.94
1994-95	6.21	28.01 (3.62)	1.14	35.36
1999-00	9.21	38.20	1.59	49.00
2009-10	18.48	64.27 (7.76)	3.66	86.41

() Annual generation by gas turbine/combined cycle plants
Source : Planning Commission 1989

However, the actual operating efficiencies are often lower. The generation-weighted average conversion efficiency in India, as a whole, was 28.8 percent in 1986-87.

In India, actual power generation in recent years has been much less than the installed capacity — most of time less than 60 percent. Major reasons for this slack include: a) a low plant load factor in the thermal power plants; b) overdependence on hydropower, without adequate thermal power back-up; c) shutdowns in the nuclear power plants; and 4) capacity assigned for standby generation in thermal power generation.

Plant load factor (PLF)

There has been continuous improvement in the performance of thermal power stations in recent years. At the beginning of Sixth Five-Year Plan, the plant load factor (PLF) of thermal power plants was 43.3 percent. The PLF improved to 50.1 percent by 1984-85 and to 56.5 in 1987-88. However, during 1988-89, the PLF went down to 55 percent, because of lower agricultural demand on account of a favorable monsoon season. In 1989-90, the PLF improved to 56.5 percent; however, it went down to 53.8 percent in 1990-91.

The Central sector PLF in 1989-90 was 62.2 percent, as compared to 62.6 percent in 1988-89. The PLF of the State sector was 53 percent, up from 51.6 percent during the previous year. The private sector PLF during 1989-90 was 69.5 percent, substantially higher than the 63.2 percent in 1988-89.

Transmission and distribution (T & D)

Electricity generation and transmission systems in India are not highly efficient, although there have been improvements in recent years. Transmission losses are estimated to be around 22 percent of the total power generated. Power generation by utilities was 264 billion kWh in 1990-91 which was about 7.7 percent short of demand, resulting in load-shedding and power shortages. Improved efficiency in T & D could compensate for the shortfalls.

Despite large investments in the power sector over four decades of planned development, there are persistent power shortages in India. The T & D system in India faces several problems. The expansion in length and capacity of the network has not kept pace with additions in generation capacity. In certain instances, the utilization of generation capacity has been reduced simply because of poor reliability of the T & D network. This has aggravated power shortages in certain parts of the country. Furthermore, in the absence of regional or national integration of the T & D network, the power supplies can not be optimized.

National Thermal Power Corporation (NTPC)

The National Thermal Power Corporation (NTPC) was responsible for 15.5 percent of the total generation capacity additions by the end of the Sixth Five-Year Plan (1981-85). During the Seventh Five-Year Plan (1985-90), the NTPC contributed nearly 43 percent of the additions in total thermal power capacity. The NTPC has executed and managed projects worth Rs160 billion (US$10 billion) since 1976. Its share in India's total projected thermal capacity by 1994-95 will be about 37 percent. The NTPC is currently building and operating nine super-thermal power stations. These include power plants at Singrauli, Rihand and Dari (Uttar Pradesh), Ramagundam (Andhra Pradesh), Farakkha (West Bengal), Vindhyachal (Madhya Pradesh), Kahalgaon (Bihar) and Talchir (Orissa). The NTPC is also constructing and operating four gas-based projects, with a total capacity of 15,687 MW, at Anta (Rajasthan), Auraiya and Dadri (Uttar Pradesh), and Kawas (Gujarat).

Public Sector Electricity Corporations (SEBs)

There are sixteen public sector electricity corporations, known as State Electricity Boards (SEBs), operating in the States and Union Territories. The responsibility for setting electricity rates in relation to tariffs for different categories of consumers, including agricultural and small-scale industrial users, rests with State governments. Annual losses of the SEBs stand at US$1 billion due to the existing tariff structure which is not based on economic pricing of electricity. Power supplied to agriculture is heavily subsidized. An agricultural user in India pays just over 20 percent of the marginal cost of generation for his electricity needs.

POWER CONSUMPTION

The pattern of electricity consumption has undergone changes during the last two Plan periods. On the eve of the Sixth Five-Year Plan (1979-80), 59 percent of total electricity consumption was accounted for by the industrial sector, while the share of agriculture was 17 percent. However, during the last year of the Seventh Five-Year Plan (1989-90), the share of agriculture in electricity consumption rose to 25 percent, while that of the industrial sector declined to 46 percent. The commercial and service sectors have maintained approximately the same shares of consumption. The residential sector has registered significant increases in electricity consumption, with increasing consumption in urban areas.

Consumption trends between 1970-71 and 1990-91 reflect the increasing shares of the agricultural and residential sectors, with proportional declines in the industrial, transportation, and other sectors of consumption. The trends in sectoral power consumption from 1970-71 to 1990-91 are presented in Table 6.4. The trends in regional power demand from 1989-90 to 1990-2000 are presented in Table 6.5.

Industry is the largest consumer of electricity in India and accounts for 46 percent of consumption. The bulk of the electricity consumed in the industrial sector is utilized by energy-intensive industries such as aluminum, iron and steel, electroplating, textiles, chemicals, paper, oil refineries and collieries.

Table 6.4: **Patterns of electricity consumption (utilities only), percentage utilization**

Year	Residential	Commercial	Industry	Transportation (Railways Tramways)	Agriculture	Others
1970-71	8.8	5.9	67.6	3.2	10.2	4.3
1979-80	10.8	6.0	58.9	2.9	17.2	4.2
1984-85	13.6	6.1	55.2	2.5	18.4	4.2
1987-88	15.2	6.1	47.5	2.5	24.2	4.5
1988-89	15.3	6.2	47.6	2.5	24.1	4.5
1989-90	16.1	5.8	46.3	2.4	25.0	4.4
1990-91*	16.5	5.8	46.0	2.5	25.0	4.3

* provisional
Sources: Economic Survey 1990-91; Central Electricity Authority, 13th Annual Power Survey of India 1988

Table 6.5: **Electricity demand by region (utilities only)**

Region	Demand in million kWh			Annual rate of increase (%)		
	1989-90	1994-95	1999-2000	1989-90 through 1994-95	1994-95 through 1999-2000	1989-90 through 1999-2000
North	72,080	114,786	182,239	9.8	9.7	9.7
South	72,474	109,038	163,180	8.5	8.4	8.5
West	65,330	99,177	150,177	8.7	8.7	8.7
East	36,134	56,211	88,035	9.2	9.4	9.3
Northeast	3,041	5,552	10,142	12.8	12.8	12.8
All India	249,059	384,764	593,773	9.1	9.1	9.1

Source: Central Electricity Authority, 13th Annual Power Survey of India 1988-89

The overall energy intensity of industry in India is heavily affected by the relative weight in total industrial production of a few industries which consume large quantities of power per unit of output. The growth of industrial consumption of electricity will be greatly influenced by the pace at which these industries are expanding. Electricity consumption growth rates and consumption of electricity in terms of dollars of value added per kWh are

low in India compared to industrialized countries.

Agriculture is expanding its share of electricity consumption and now accounts for 25 percent of total consumption. Energy intensity per unit of output is also increasing and attests to bumper production in agriculture.

The residential sector (including households and commercial establishments) is also expanding, with about 22 percent of the electricity consumption in India. By 2001, residential use could represent 25-30 percent of power consumption. Moreover, demand for electricity is expected to rise with population growth, urbanization, industrialization and increases in agricultural productivity. Changes in the life style of the population, the proliferation of home appliances, rapid urbanization and growth of cities will bring about greater power demand.

Private sector participation

The New Industrial Policy (NIP), announced in July 1991, opens up to the private sector power generation, supply, distribution and transmission. The features of the NIP include the following incentives for the private sector:

1. A higher debt-equity ratio for financing new projects;
2. An increase in the standard rate of return permissible to private companies under the Electricity Supply Act (1948); and
3. Capitalization of interest during construction for expansion schemes and sanction for licenses of longer duration.

A 500 MW thermal power station at Chandil, Bihar, is being built by the R.P. Goenka Group. The Goenka Group will sell 80 percent of its production to industrial consumers in Ranchi and Jamshedpur and the rest will be sold to the SEB Bihar.

POWER SHORTAGES AND RELIABILITY COSTS

India faces power shortages that averaged over 10 percent per year since 1974-75 (Table 6.6). In India, power shortages are routine and have affected most sectors of the economy, especially those where demand has increased more rapidly than supply. Shortfalls in

Table 6.6: **Electric power shortages, percent**

1974-75	14.1
1975-76	10.3
1976-77	5.8
1977-78	15.5
1978-79	10.3
1979-80	16.8
1980-81	12.6
1981-82	10.8
1982-83	9.2
1983-84	10.8
1984-85	6.7
1985-86	7.9
1986-87	9.4
1987-88	10.9
1988-89	7.7
1989-90	7.3
1990-91*	7.0

* estimate

Source: Economic Survey, various issues 1974-75 through 1990-91

electricity generation result in chronic shortages as well as poor reliability of supply. The power shortages in India have had many insidious effects on the economy. One of the most crippling effects is the loss of productivity that an insufficient and unreliable supply of power causes in industrial production.

In India, the cost of unreliability in electricity supply to the industrial sector has been estimated at 1.5 percent of GDP. The losses on the account of forgone services associated

with residential and commercial outages are also very high. The Federation of Indian Chambers of Commerce and Industry (FICCI) estimated that the loss of industrial production in 1986, due to a 10 percent power shortage, cost the country Rs70 billion (US$6 billion), or about 12 percent of total industrial production in the country. The low level of generation remains an obstacle for industrial expansion. Both industrial and manufacturing outputs were down two percent during January-June 1991 vis-a-vis the January-June 1990 levels.

POWER SECTOR EXPANSION DURING THE EIGHTH FIVE-YEAR PLAN

The Eighth Five-Year Plan's addition to power capacity was to be 72 percent higher than that in the Seventh Five-Year Plan period. The Eighth Five-Year Plan period has now been revised from 1990-95 to 1992-97. The NTPC has planned a chain of 12 super-thermal power plants in the Singrauli region (Madhya Pradesh/Uttar Pradesh), with total production of 20,000 MW during 1991-95. Singrauli has been designated as the "future power capital of India." Annual requirements for 85 mmt of coal for generation of 20 GW of electricity will be met from the coal fields in the region which have total reserves of nine billion tonnes (bt), of which 2.7 bt are recoverable through open pit mining.

A study made by the Rail India Technical and Economic Services (RITRES) in collaboration with the Central Electricity Authority (CEA) has indicated the need for siting coal-based thermal power stations at coastal locations in peninsular India and in Gujarat, so that coal can be transported by large ocean-going vessels to overcome shipment pressures on the Indian Railways (see Chapter Five).

During the Eighth Five-Year Plan, several coastal thermal power stations are to be commissioned in order to meet the growing power demand in the southern and western regions, and to avoid transportation bottlenecks. The CEA has tentatively identified 13 locations, including Visakhapatnam in Andhra Pradesh, North Madras, Cuddalore, Kuticorin and Nagapattinam in Tamil Nadu, Pondicherry, Kayamkulam and Trikaripur in Kerala, Karwar and Nadinkur in Karnataka, Goa, Danhol in Maharashtra and Vadinar in Gujarat.

The Department of Power has envisaged adding 38,369 MW capacity by 1994-95 (Table 6.7). This expansion would comprise 30,230 MW of thermal, 7,434 MW of hydro-, and 705 MW of nuclear power capacity. The ongoing and sanctioned projects would

Table 6.7: **Power capacity additions by regions 1990-91 to 1994-95, in megawatts**

Region	Thermal	Hydro	Nuclear	Total
North	7,270	2,056	235	9,581
West	7,977	2,453	470	10,900
South	6,391	1,515	-	7,906
East	7,300	1,007	-	8,307
Northeast	1,292	403	-	1,695
All India	30,230	7,434	705	38,369

Source: Ministry of Energy 1990-91

contribute about 26,223 MW, while 9,986 MW could come from projects already cleared by the CEA that are awaiting approval of the Planning Commission. The balance of 2,160 MW would come from new projects.

According to the Ministry of Energy, total investments in the power sector during the Eighth Five-Year Plan are to be Rs1,280 billion (US$70 billion) at 1989-90 prices. This includes expenditures on Ninth Five-Year Plan starts, but excludes expenditures on nuclear power, rural electrification, energy conservation and nonconventional energy sources programs. Multilateral aid of US$4,300 million was provided for power projects as of March 1990.

The CEA is aiming for an electricity generation capacity expansion of 28,000 MW in the Eighth Five-Year Plan. This translates into a shortfall of 10,000 MW in 1994-95 when compared to the Department of Power target of 38 GW. The bulk of the shortfall is planned to be met through gas-based power projects. During the Eighth Five-Year Plan period, a total capacity expansion of about 7,485 MW (4,947 in the Central sector and 2,538 MW in the State sector) is envisaged from gas-based power projects. The Central sector projects include Kawas, Kathalguri, Dadri, Anta, Gandhar, Godavari, Rokhia, Faridabad, Tripura, and those of the State sector include Uran, Vijjeshwaran, Lakwah Phase-II, Lakhwa WH, Ramgarh, Vatwa, Utran, Gandhar, Piparvar, Karaikal, Amguri and Desu WH.

ENVIRONMENTAL IMPACT OF POWER PLANTS

Environmental quality standards for thermal power plants are operationalized through various government regulations. Emissions of the precursors to acid rain, such as sulfur dioxide, have tripled since the 1960s. Different regions of India have been under various stages of environmental stress. The montane zone of southwestern India has been vulnerable since the proliferation of thermal plants in the region.

Impacts of coal mining projects associated with thermal power plants include air pollution, acid rain, land degradation, water quality deterioration, demographic and socioeconomic changes and subsequent ecological effects. Land degraded due to overburdened dumps, mined-out, flyash dump sites and waste disposal areas is being reforested. However, there is a greater need for planned environmental management in thermal power generation and in the coal mining districts.

Seven

NUCLEAR POWER

DEVELOPMENT OF THE NUCLEAR INDUSTRY

The Atomic Energy Act of 1948 established India's nuclear energy program with the formation of the Atomic Energy Commission (AEC). The Department of Atomic Energy (DAE) was created in 1954 to implement policies and programs laid down by the AEC. A Nuclear Power Board, which has now become the Nuclear Power Corporation of India, Ltd. (NPC), advises the DAE on nuclear power generation. The NPC was set up in 1987 under the Electricity (Supply) Act to develop India's nuclear power potential on an integrated basis at Central and State levels. In the short period since its creation, the NPC has raised capital of more than Rs1,000 million (US$55 million).

India is a major producer of electricity generated from nuclear power plants. The installed nuclear power capacity is about 1,600 megawatts (MW) (Table 7.1) Gross output accounted for 2.3 percent of India's total electricity generation in 1990-91.

Three nuclear power stations, with six reactors based on heavy water (CANDU type), are located at Tarapur (Maharashtra), Rowatbhata (Rajasthan), and Kalpakkam (Tamil Nadu) (Figure 7.1). The Tarapur reactor is one of the world's four operational chemical-reprocessing plants for uranium production. The three stations have been beset with operational problems in recent years, with long shut-down periods for the Rowatbhata Plant. A fourth nuclear power station at Narora (Uttar Pradesh) was designed with two pressurized heavy water reactor units of 235 MW each, using natural uranium as fuel. It was to be commissioned in 1991.

POWER GENERATION

Nuclear power generation increased marginally after 1980-81 when the nuclear power plant at Kalpakkum (Tamil Nadu) was commissioned. Primary nuclear power generation was

Table 7.1: **Nuclear power generation 1987-1991**

Year	Installed Capacity (MW)	Power generation (billion kWh)
1987-88	1,300	5.0
1988-89	1,300	5.8
1989-90	1,600	4.6
1990-91*	1,600	6.0

* provisional
Source: Economic Survey 1990-91

4.60 billion kWh in 1989-90, a decrease of 9.4 percent from the 5.08 billion kWh produced in 1988-89. For 1990-91, a target of 6.85 billion units was set, implying an increase of 48.9 percent over the 1989-90 production; however, provisional estimates show that only 6.0 billion kWh were produced in 1990-91.

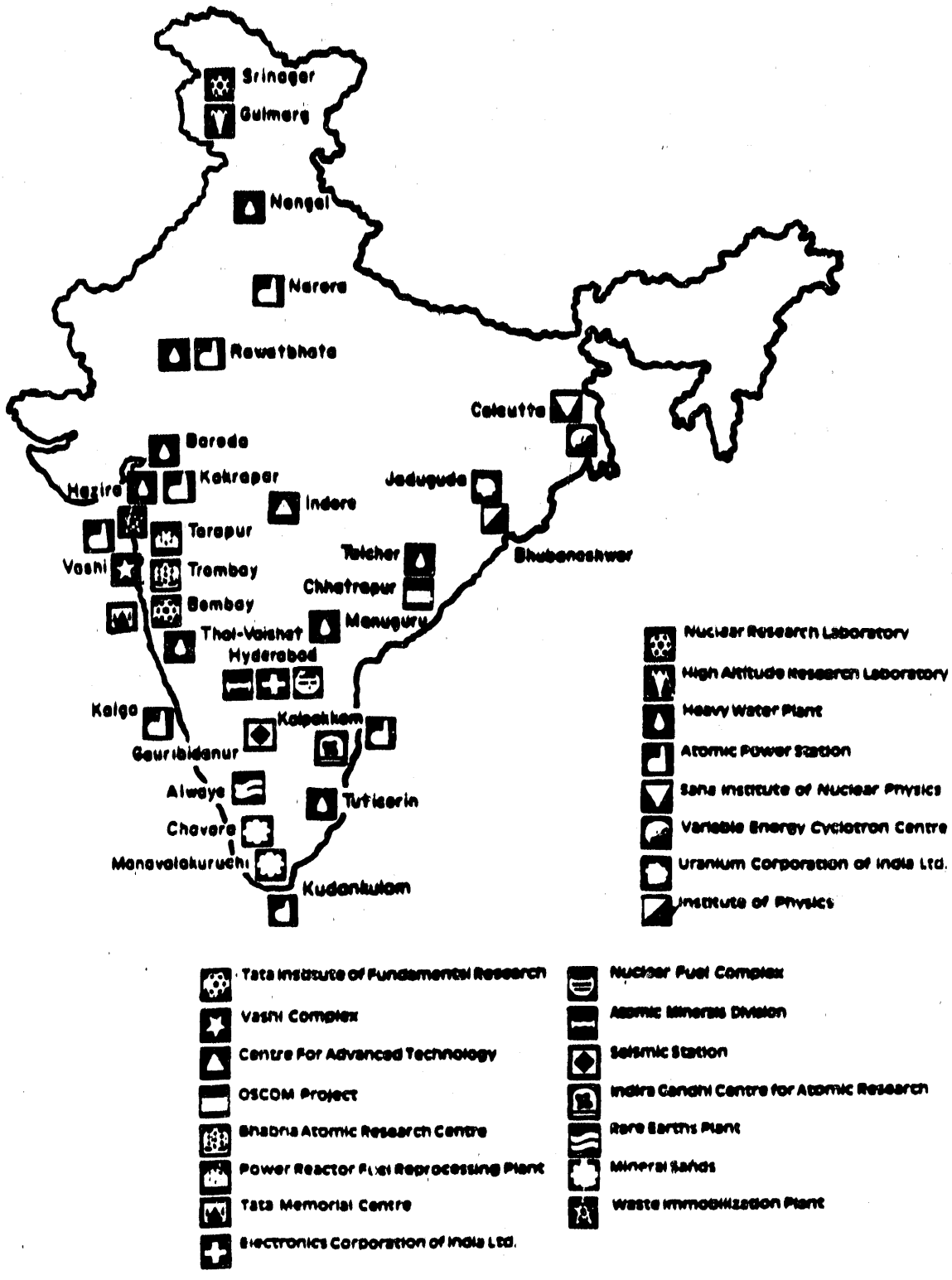
By the year 2000, nuclear power generation capacity is expected to increase five-fold to 8,000 MW. Two new units, with 235 MW capacity, are under construction at the Rowatbhata Plant and are to be commissioned by 1995-96. Two new nuclear power stations are under construction at Kakrapar (Gujarat), and Kaiga (Karnataka), each with two 235 MW units. One of the new plants is expected to be commissioned in 1991-92, while the other is scheduled for 1995-96.

Outlook for nuclear power generation

India has appreciable mineral reserves, including thorium oxide reserves of about 363,000 tonnes, that will be able to supply its nuclear power program for a century. With its indigenous natural uranium reserves, India can support a nuclear power program of about 8,000 MW (Working Group on Energy Policy 1979). Capacity is expected to multiply several times if fast-breeder reactor technology is introduced.

A document entitled "Nuclear Power Profile," prepared by the Indian Department of Atomic Energy, describes the production outlook. The DAE seeks to establish a total installed capacity of 10,000 MW by the turn of the century; however, due to the costs of

Figure 7.1: **Nuclear energy establishment**



Source: Ministry of Energy

the program and delays in implementation, a capacity of 8,000 MW by the year 2000 is more realistic. The total planned outlay for this corporate plan is Rs140 billion (1989 prices), of which Rs120 billion is to be invested during the Eighth Five-Year Plan, and the balance during the early part of the Ninth Five-Year Plan.

NUCLEAR SAFEGUARDS AND ENVIRONMENTAL PROTECTION

India's vast potential for nuclear power generation can be harnessed only if safety, waste and environmental protection issues are addressed. The Atomic Energy Regulatory Board, established in 1983, is empowered to frame rules and regulations related to nuclear safeguards and regulatory requirements. The Board regulates safety standards, environmental protection codes, and guidelines envisaged under the Atomic Energy Act. A Crisis Management Group was set up in 1987 with the responsibility of ensuring that each nuclear installation under the DAE is fully prepared to take necessary steps in the event of an emergency related to radiation hazards of conventional industrial accidents.

Eight

HYDROPOWER

Hydropower is an important source of energy in India. The installed hydropower generation capacity is 18,300 megawatts (MW) (Table 8.1). Hydropower supplied 71.5 billion kilowatt-hour (kWh) units of electricity in 1990-91, 30 percent of total power generation, up from 62.1 billion kWh in 1989-90. On the whole, the 15.1 percent growth rate of hydroelectricity generation in 1990-91 was the highest in the power generation sector. Actual capacity rolled/commissioned in 1990-91 was 446 MW, substantially lower than the target of 1006 MW. Hydropower generation is targeted to increase to 80 billion kWh in 1991-92.

India's hydropower potential has been estimated at 84,044 MW, at a 60 percent load factor. Around two-thirds of the hydropower potential is in the Himalaya mountain ranges, far away from industrial centers. Hydropower projects are location-specific; high costs are incurred as power is transmitted over large distances to the major demand centers.

The development of hydropower in India has encountered a variety of problems that range from delays in clearing forests and geological obstacles to the challenges of operating construction sites in remote locations. As the result of dams being built, land has been submerged and people have had to be resettled and rehabilitated. Hydropower stations, although ideal for meeting peak loads, are adversely affected in years when rainfall is below normal and in winter months when the river flow is minimal.

Another factor that has delayed the development of hydropower is inter-State water disputes. At present, 27 projects with a capacity of 2,584 MW are pending due to non-settlement of inter-State water disputes. For example, projects of 1,000 MW capacity in southern India are being held up as a result of inter-State disputes over sharing of the Cauvery River water.

Table 8.1: **Hydropower generation**

Year	Installed capacity (MW)	Power generation (billion kWh)
1987-88	16,200	53.8
1988-89	17,300	47.5
1989-90	17,800	62.1
1990-91	18,300	71.5

Source: Economic Survey, 1990-91

India possess water resources adequate for numerous small hydropower stations. The establishment of small hydropower stations requires shorter gestation periods and obviates the need to provide major transmission lines, therefore resulting in substantial savings. Against an estimated 5,000 MW of small hydropower station potential, only about 300 MW is reported to have been developed so far. Thus, there is a broad scope for development of this source of energy which can be tapped from small streams and canal falls in hilly terrain.

Current total capacity is just over 18 gigawatts (GW), with an additional four GW of capacity under construction. Given the long lead-times, it is unlikely that total capacity will exceed 20 GW by the year 2000. Nevertheless, in coal-equivalent terms, every 100 MW of hydropower installed reportedly saves three to four mmt of coal per year. In addition, it enables the rest of the power system to work more efficiently by offering peak loads at lower cost.

Nine

RENEWABLE AND NONCONVENTIONAL ENERGY RESOURCES

ALTERNATIVE ENERGY PROGRAMS

Various forms of renewable and nonconventional energy offer environmentally benign alternatives for fuels and electricity. India's rising energy needs can be met by using some of these relatively inexpensive alternatives.

India established the Commission for Additional Sources of Energy (CASE) in March 1981 to develop and promote new and renewable sources of energy (NRSE). In 1982, the Department of Nonconventional Energy Sources (DNES) was established in the Ministry of Energy. The DNES oversees the development, production and application of energy sources, including biogas, solar photovoltaic and thermal power, wind, micro-hydropower plants, geothermal power, chemicals, hydrogen, battery-powered vehicles, and energy from urban residues and wastes.

The entire scheme of DNES activities is planned and executed under different programs, and in all of these activities the DNES serves as a single central funding agency. These activities include the National Project for Biogas Development (NPBD); the National Program on Improved Chullahs (cooking stoves) (NPIC); the Solar Energy (SE) program; the Wind Energy (WE) program; the Biomass Program (BP); the Human and Animal Energy Program (HEAP); the Urjgram Program; the Micro-Hydropower (MHD) program; the Hydrogen Energy Program; and the Ocean Energy Program (OEP).

The DNES has prepared a Perspective Plan for the development of alternative energy sources in India to the year 2001. The Plan envisages using nonconventional and renewable sources of energy to conserve conventional forms of energy and generate power equivalent to 250 mmt of coal annually by the year 2001. This includes the generation of 15,000 MW of electricity. The DNES has created a number of task forces and expert committees to identify

and recommend research and development projects for financial support. These include the organizations Task Force on Biogas Generation from Night Soil; the MHD project Steering Committee; the Technical Advisory Committee on Hydrogen Energy; the Task Force on Chemical Routes for Trapping Solar Energy; the Task Force on Storage Batteries; the Task Force on Fuel Cells; the National Task Force on Water Hyacinths; and the Research and Development Committee on Biogas.

A public sector financial unit, the Indian Renewable Energy Development Agency Ltd (IREDA), was set up in March 1987 for NRSE projects. Its function is to help fund indigenous technologies on new and renewable sources of energy. As of March 1991, the IREDA had sanctioned a total of 125 projects, out of which 49 projects have been commissioned. In 1990-91, the IREDA funded 31 projects at a cost of Rs263 million and nine of these have been commissioned as of March 1991.

The IREDA-funded projects focus on biomass utilization for heat, steam and power generation, solar thermal energy, generation of biogas/power from industrial effluents, battery-powered vehicles, wind energy, and mini-macro hydropower plants, as well as manufacturing equipment needed for various NRSE systems and devices.

Biomass fuels

Because of its location in tropical and subtropical regions and its vast agriculture, India is endowed with enormous potential for production of biomass fuels. Biogas is generated from bovine dung, crop residues, and firewood. Dung fuel supplied annually by the 286 million bovine population is estimated to be 1,197 mmt (84.02 mmtoe). This biomass fuel has a calorific value of 3,290 Kcal/kg. An estimate of the supply of crop residues was 55 mmtoe in 1990-91. The firewood supply was estimated to be about 28.5 mmtoe in 1990-91.

The National Board for Biogas Development (NPBD) was formed in 1981-82. During the Seventh Five-Year Plan (1985-90), about 890,000 biogas plants were set up. It is estimated that 1,402,000 family-sized biogas plants in 1990-91 produced 1,500 million cubic meters of gas, equivalent to five mmt of firewood valued at Rs2 billion. In addition, these plants also produced about 25 mmt of enriched manure valued at Rs2 billion. About 760 biomass gasifier systems, which can replace over 65 percent of diesel use, have also been installed under a demonstration program.

Fuel efficient *chullas* (cooking stoves)

Chullas are cooking stoves in which biomass and other fuels are burned for domestic cooking in rural parts of India. Under the National Program for Improved Chullas, 1.7 million fuel-efficient and smokeless chullas were set up in 1990-91, bringing the total to 10 million chullas. These improved chullas are estimated to save seven mmt of firewood per year, valued at Rs2.8 billion. In addition, the stoves are less polluting. In 1990-91, the utilization of biogas and improved *chullas* saved conventional energy sources valued at approximately Rs7 billion.

Solar thermal energy

An investment-sharing scheme for the installation of low-grade solar thermal systems and devices was started in 1982. About 176,000 family-sized solar cookers were sold by 1989-90. These are estimated to save as much as 84,000 tonnes of firewood per year, worth Rs3,360 million.

Solar photovoltaic systems

About 7,500 villages have been provided with solar photovoltaic street-lighting systems and about 400 kWh capacity has been created through experimental solar photo-voltaic power plants. Solar photovoltaic technology is suitable to rural, remote and isolated areas not served by the conventional power grid. About 100 water pumping facilities, 3,000 street lighting and 100 domestic lighting units, 100 community TV/lighting units, and 100 power plants and other applications were installed in 1989-90.

Windmills

A total of 2,711 windmills, mainly of the 12-pu-500 type, have been installed in various parts of India. Wind farm projects with an aggregate capacity of 37 MW have been set up in seven States. It is estimated that, on an average basis, a windmill can save about 1.28 tonnes of diesel or 2,000 kWh of electricity annually.

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