Chapter 8

# Energy Resources

Energy is an essential input for economic development and improving the quality of life. Energy may be classified into two categories, namely: (i) conventional (coal, petroleum, natural gas, and electricity), and (ii) non-conventional energy (solar, wind, tidal, geothermal, and biogas energy). Energy can also be classified into non-commercial (fuel-wood, charcoal, dried cow-dung, animal waste and animal power), and commercial energy (coal, mineral oil, natural gas, hydro-power, nuclear power wind energy, solar energy). It is the commercial energy which plays a vital role in the economic development of a country. A brief description of the sources of commercial energy, their distribution and production has been given in the following section.

## SOURCES OF CONVENTIONAL ENERGY

### Coal

Coal is the main source of energy in the country and accounts for 67% of the commercial requirement of the country. India has coal reserves of 360 billion tonnes (India 2010).

***Classification***

The coal of India may be classified under two categories: (i) Gondwana coal, and (ii) Tertiary coal.

**Gondwana Coal** The Gondwana coal belongs to the carboniferous period (570 million years to 245 million years back). It is found in the Damodar , Mahanadi, Godavari, and Narmada valleys. Raniganj, Jharia, Bokaro, Ramgarh, Giridih, Chandrapur, Karanpura, Tatapani, Talcher, Himgiri, Korba, Penchghati, Sarguja, Kampte, Wardha Valley, Singareni (A.P.) and Singrauli are some of the important coal mines of the Gondwana formations. The Jharguda coal mine (Madhya Pradesh) is the thickest coal seam 132 metres of the Gondwana Period, followed by the Kargali seam near Bokaro coalfield which is about 30 metres in thickness. Over 98 per cent of the total coal reserves of India belong to the Gondwana Period. The Gondwana coal is mainly bituminous or anthracite in which the carbon content varies between 60 to 90 per cent. The bituminous coal is converted into coke before being used in the iron and steel industry.

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**The Tertiary** Tertiary coal is found in the rocks of the Oligocene period of the Tertiary Era. It is about 15 to 60 million years old. The Tertiary coal is also known as the *'brown coal'*. The Tertiary coal contributes only about two per cent of the total coal production of the country. It is an inferior type of coal in which the carbon varies between 30 per cent in Gujarat and Rajasthan to 50 per cent in Assam. Lignite coal is found in Arunachal Pradesh, Assam, Gujarat (Kachchh) Kerala, Jammu and Kashmir, Nagaland, Tamil Nadu, Uttar Pradesh, and West Bengal (Darjeeling District). The largest lignite deposits of the country are at Neyveli in the state of Tamil Nadu. The different types of coal and their characteristics have been given in the following:

***(i) Peat*** It contains the highest percentage of moisture, gives more smoke, has less than 40 per cent carbon and, therefore, is the lowest and most inferior quality of coal. It represents the first stage of coal formation.

***(ii) Lignite (Brown-Coal)*** Lignite is superior to peat. Under the increasing pressure and heat, with the passage of time, peat is converted into lignite. It contains 40 to 60 per cent carbon. It is mainly found in Neyveli (Tamil Nadu), Palna (Rajasthan), Lakhimpur (Assam), Jaintia Hills (Meghalaya), Nagaland, Kerala, Jammu and Kashmir, Uttar Pradesh, and the union territory of Pondicherry. Lignite deposits in India have been estimated around 38930 million tonnes, out of which 4150 million tonnes are in Neyveli area of Tamil Nadu (2010). Lignite is also found in Assam, Gujarat, Jammu & Kashmir, Kerala, Meghalaya, Nagaland, and Rajasthan.

***(iii) Bituminous (Black-Coal)*** When coal is buried very deep, the moisture gets expelled. The seam subjected to increased temperatures results into the formation of bituminous coal. It is dense, compact and black in colour. The traces of original vegetation from which it has been formed are found in this coal. Containing 60 to 80 per cent carbon, it is the most popular coal in commercial use. The name is derived after a liquid called bitumen released after heating. Bituminous coal is also used in making coke (coking coal), gas coal, and steam coal. Coking coal results from the heating of coal in the absence of oxygen, which burns off volatile gases and is mainly used in iron and steel industry. Most of the bituminous coal is found in Jharkhand, Odisha, Chhattisgarh, West Bengal and Madhya Pradesh.

***(iv) Anthracite (Hard Coal)*** It is the highest quality of coal containing 80 to 90 per cent carbon. It has very little volatile matter and insignificant proportion of moisture. It has short blue flame. Of all the coals, it is the most expensive.

### *Distribution*

The distribution of coalfields has been shown in **Fig. 8.1**, while the state-wise coal reserves and their percentage share have been given in **Table 8.1**.

**Table 8.1** *Coal Reserves in India—2005–06*

| *State* | *Total reserves in million tonnes* | *Percentage of all India reserves* |
|---|---|---|
| 1. Jharkhand | 72,565 | 28.97 |
| 2. Odisha | 61,684 | 24.62 |
| 3. Chhattisgarh | 40,865 | 16.24 |
| 4. West Bengal | 27,495 | 10.98 |
| 5. Madhya Pradesh | 19,672 | 7.85 |
| 6. Andhra Pradesh | 17,595 | 7.06 |
| 7. Maharashtra | 8,635 | 3.45 |

(*Contd.*)

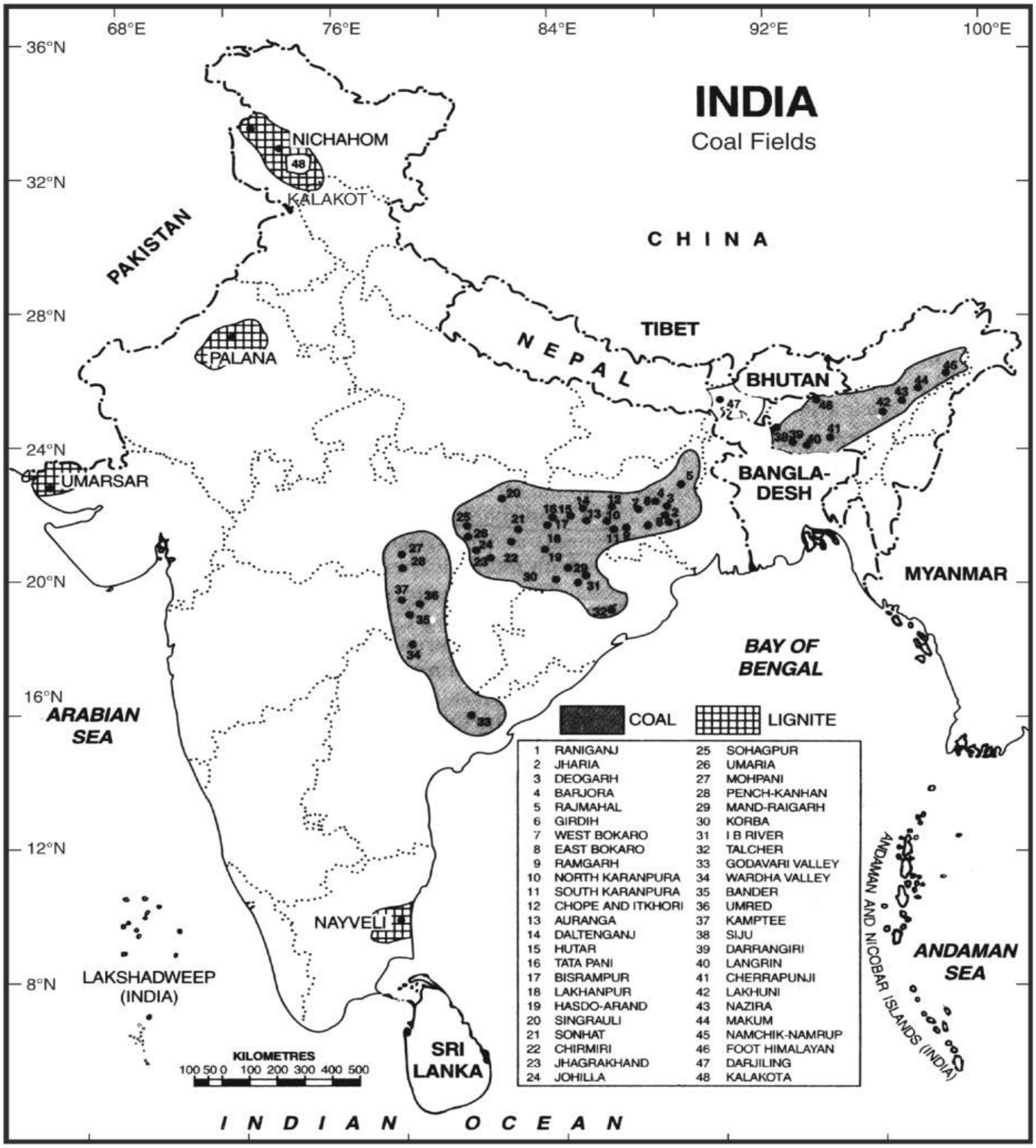


**Fig. 8.1** Coal Fields

(*Contd.*)

| | | |
|---|---|---|
| 8. Uttar Pradesh | 1,135 | 0.49 |
| 9. Meghalaya | 469 | 0.20 |
| 10. Assam | 385 | 0.15 |
| 11. Bihar | 178 | 0.07 |
| 12. Arunachal Pradesh | 95 | 0.02 |
| 13. Nagaland | 22 | 0.01 |
| Total | 250,795 | 100.00 |

Source: ***Statistical Abstract of India,*** 2007.

The major states having large proportion of the coal reserves of the country are Jharkhand, Odisha, Chhattisgarh, West-Bengal, Madhya Pradesh and Andhra Pradesh (**Fig. 8.2**). A brief account of coal reserves in these states has been given in the following:

**(i) Jharkhand** The state of Jharkhand, accounting for about 29 per cent, has the first rank in coal reserves and its production. Most of the coal belongs to the Gondwana period. The districts of Dhanbad, Dumka, Hazaribagh, and Palamu are very rich in coal deposits. The main coal mining centres are Auranga, Bokaro, Daltenganj, Dhanbad, Giridih, Hutar, Jharia, Karanpur, and Ramgarh (**Fig. 8.3**).

***(a) The Jharia Coalfield*** Out of all the coal mines of Jharkhand, Jharia is the largest and most important coal producing mine, which sprawls over an area of about 460 sq km. It contains the best metallurgical coal (bituminous). Nearly 90 per cent of the coking coal is produced from the Jharia mine. Its coal is mainly supplied to the iron and steel plants of Asansol, Bokaro, Durgapur, and Jamshedpur.

***(b) The Bokaro Coalfield*** This coalfield stretches in the valley of Bokaro river in Hazaribagh district, about 32 km to the west of Jharia. The Kargali seam (37 metres) of the Bokaro coalfield is one of the thickest of the Gondwana period in (India). Its coal is mainly supplied to the iron and steel plant of Bokaro.

***(c) The Giridih or Karharbari Coalfield*** The Giridih coalfield stretches in the district of Hazaribagh. Its seams are very close to the surface. It provides one of the finest quality of bituminous coal used for the metallurgical industry. Its coal is supplied to the Bokaro and Jamshedpur steel plants.

***(d) The Karanpur Coalfield*** The Karanpur coalfield is divisible into the North and the South Karanpur coalfields. It lies only about 30 km to the west of Bokaro. The thickness of its seam is about 25 metres. Much of the coal is, however, non-coking.

***(e) The Ramgarh Coalfield*** Stretching over an area of about 100 sq km, the Ramgarh coalfield is only about 9 km to the west of the Bokaro coalfield. The coal of Ramgarh is of relatively inferior quality containing a high proportion of ash (about 30%) and carbon 35 per cent.

***(f) The Hutar Coalfield*** Stretching over about 200 sq km the Hutar coalfield lies in the Palamau district. Its seams are however, thin and the coal is of inferior quality containing about 50 per cent carbon, 30 per cent volatile matter and 20 per cent ash.

***(g) The Daltenganj Coalfield*** Sprawling over 55 sq km, this coalfield lies in the Palamau district. Its coal is either semi-anthracite or non-coking, of inferior quality which can not be used in metellaurgical industries.

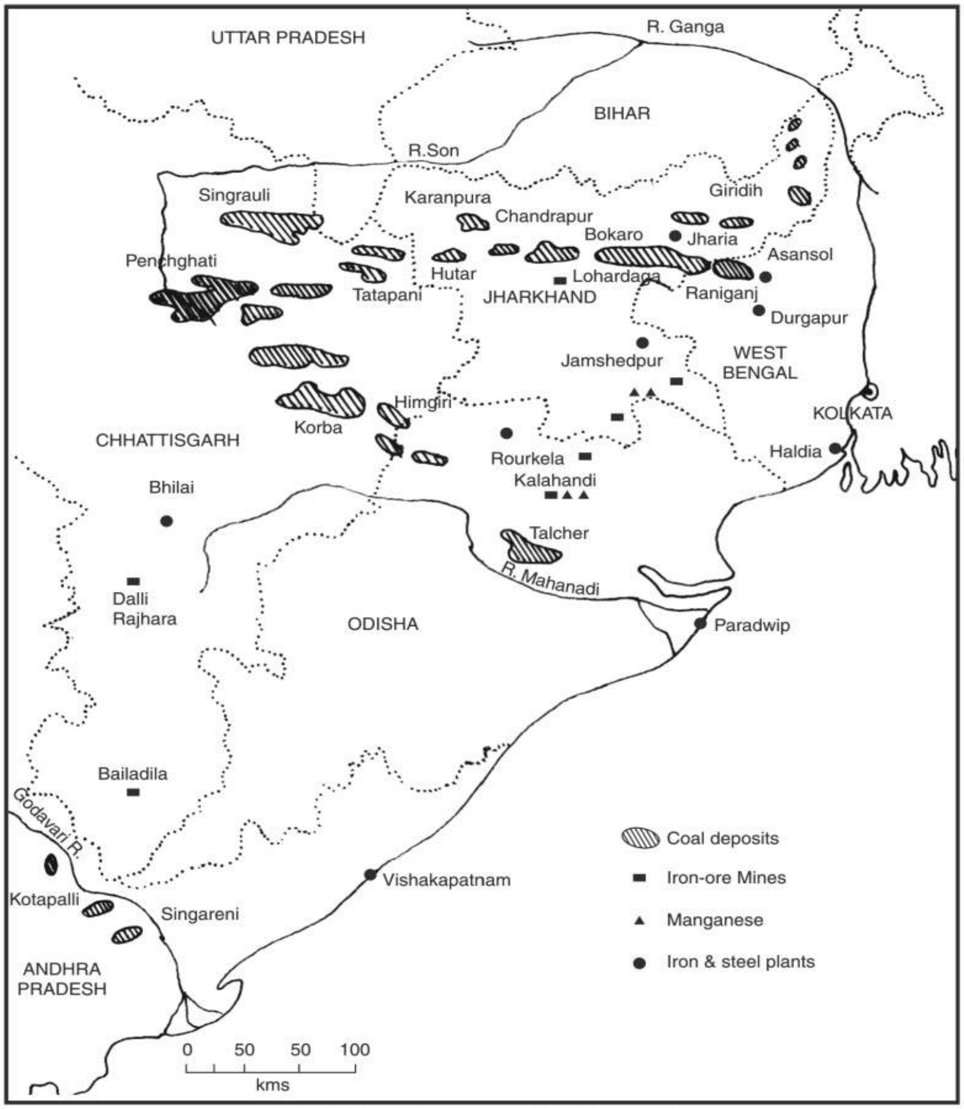


**Fig. 8.2** Gondwana Coal Deposits

***(h) Deogarh Coalfields*** This coalfield lies in the Dumka district and stretches over an area of about 20 sq km. The coal is of inferior quality containing about 40 per cent carbon, 25 per cent volatile matter and 35 per cent ash content. Its coal is mainly used in the brick kilns.

**(ii) Odisha** The state of Odisha has more than 24 per cent of the total coal reserves and produces about 15 per cent of the total coal production of the country. In Odisha most of the coal deposits are found in Dhenkanal, Sambalpur, and Sundargarh districts.

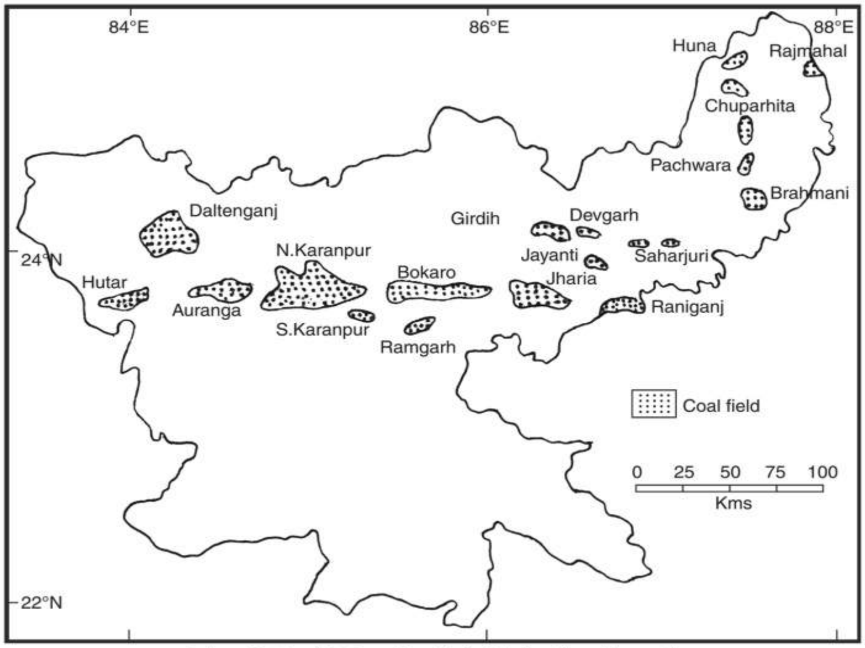


**Fig. 8.3** Major Coal-Fields in Jharkhand

***(a) The Talcher Coalfield*** Stretching over Dhenkanal and Sambalpur districts, the Talcher coalfield covers an area of about 500 sq km. It has the second largest coal reserves in the country after Raniganj. The coal is, however, of lower grade containing only about 35 per cent of fixed carbon, 40 per cent volatile matter and about 25 per cent ash content. The coal is mainly utilised in the thermal power and fertiliser plants of Talcher.

**(iii) Chhattisgarh and Madhya Pradesh** The state of Chhattisgarh has the third largest coal reserves (about 17 per cent of all India) in the country after Jharkhand and Odisha, but it holds the first rank in its production. Coal deposits are found in Bilaspur, Betul, Chhindwara, Narsinghpur, Raigarh, Rewa and Surguja districts. Singrauli, Sohagpur and Umaria (Rewa district), Bisrampur, Jhilmilli, Ramkola, Tattapani (Surguja district), Korba and Sandurgarh (Bilaspur district), Pench and Kanha valley (Chhindwara district), Mand river (Raigarh district), and Patakhera and Dulhara (Betul district) are the main mining centres of coal in Chhattisgarh.

***(a) The Singrauli Coalfield*** Stretching over the Sidhi and Shahdol districts is the largest coal-field of Madhya Pradesh. Its Jhingurda coal seam with a thickness of 132 metres is the thickest coal-seam of the country. The coal belongs to the Gondwana period, which contains 40 to 50 per cent of fixed carbon. Its coal is mainly utilised in the thermal powerplant of Obra.

***(b) The Korba Coalfield*** The Korba coalfield lies in the Bilaspur district. Two of its coal seams are more than 30 metres. The coal is of average quality and is used mainly in the Korba thermal power plant.

***(c) The Pech-Kanha-Tawa Coalfield*** It lies in the Chhindwara district. In quality its coal is of coking and semi-coking category.

***(d) Umaria Coalfield*** This coalfield lies about 60 km south of Katni. The coal contains a higher percentage of ash and moisture. It is used mainly in the generation of thermal power. In addition to these, coal is also mined at Jhilmili, Sonahat, and Tattapani coalfields of Surguja district.

**(iv) West Bengal** West Bengal has about 11 per cent of the total coal reserves of India (**Table 8.1**). The coal deposits of West Bengal lie in Bankura, Bardhman, Birbhum, Darjeeling, Jalpaiguri, and Puruliya districts. The most important of coal reserves and mining coalfield of West Bengal is Raniganj.

***(a) Raniganj Coalfield*** Stretching over 185 sq km in the Bardhman and Birbhum district to the north-west of Kolkata, it is the most important coalfield of West Bengal. It is known for the good quality of coking coal. It contains 50 to 65 per cent of carbon. It is used in the metallurgical industry, especially in the Durgapur iron and steel plant.

***(b) The Darjeeling Coalfield*** The coal of Darjeeling district belongs to the Tertiary Period. It is exposed in the Mana and Mahanadi valleys. The coal is in powder form with coking quality.

**(v) Madhya Pradesh** About 8 per cent of the coal reserves of India are found in Madhya Pradesh. The main coal deposits lie at Singrauli, Muhpani, Satpura, Sohagpur and Pench-Kanhan.

**(vi) Andhra Pradesh** About 7 per cent of the coal reserves of India are found in Andhra Pradesh. Its main coal deposits are found in the Godavari valley. The districts of Adilabad, Khammam, Nellore and Warangal are known for its production. Coal is mainly used in thermal power plants of Kottagudem, Nellore, Ramagundam, Errazada, Husain-Sagar, and the fertiliser plant at Ramagundam.

The Singareni coalfield lying about 185 km to the east of Hyderabad is the main mining area of coal in Andhra Pradesh. Another important coal producing centre is at Kottagudam. Its coal seam is of about 18 metres and the coal is of good quality.

**(vi) Maharashtra** The main coal deposits of Maharashtra lie in the Wardha valley, stretching over the Nagpur (Kampte-coalfield), and Yavatmal districts. The coal from these coalfields is utilised by the railways and the thermal power stations of Trombay, Chola (Kalyan), Khaperkheda, Paras, Ballarshah, Nasik and Koradi.

### *Coal Deposits of the Tertiary Period*

The Tertiary coal deposits came into existence during the Eocene, the Oligocene, and Miocene periods. Coal of this period is found in Arunachal Pradesh, Assam, Meghalaya, Nagaland, and Jammu and Kashmir states. It is also known as brown coal. Containing more moisture, it has less carbon content.

**Tamil Nadu** The state of Tamil Nadu has the largest deposits of lignite at Neyveli in the South Arcot district. The seams are 10 to 12 metres in thickness. Its carbon and moisture contents are 30–40 per cent and 20 per cent respectively, while the volatile matter varies between 40 to 45 per cent.

**Rajasthan** Lignite deposits are found in the districts of Bikaner (Palana and Khari mines). The thickness of Bikaner seams varies from 5 to 15 metres. It is of inferior quality and used mostly in the thermal power plants and railways.

**Gujarat** In Gujarat coal is found in Bharauch district and Kachchh. The coal is of poor quality with about 35 per cent carbon and more moisture.

**Jammu and Kashmir** The Tertiary coal in Kashmir is found at Raithan of the Shaliganga, Handwara, Baramulla, Riasi and Udhampur districts, and the karewas of Badgam and Srinagar. It is of inferior quality with less than 30 per cent of carbon, over 15 per cent moisture and 30 per cent volatile matter.

**West Bengal** In West Bengal lignite deposits of the Tertiary period are found in Burza Hills of Jalpaiguri and Darjeeling districts. Scattered deposits of lignite have also been discovered in Pondicherry.

India is the fourth largest producer of coal in the world, contributing about 5 per cent of the total coal production. An examination of **Table 8.2** shows that in 1950–51 the total production of coal and lignite was 323 and 0.4 lakh tonnes which rose to 3750 and 280 lakh tonnes in 2005–06 respectively. The coal mines were nationalised in 1972, after which there had been a tremendous increase in the coal production (**Table 8.2**).

**Table 8.2** *India: Production of Coal—1950–51 to 2008–09*

| *Year* | *Production (in lakh tonnes)* | | |
|---|---|---|---|
| | *Coal* | *Lignite* | *Total* |
| 1950–51 | 322.6 | 0.40 | 323.00 |
| 1960–61 | 360.00 | 0.65 | 360.65 |
| 1970–71 | 720.00 | 36.50 | 756.50 |
| 1980–81 | 1230.00 | 60.00 | 1290.00 |
| 1990–91 | 2100.00 | 140.00 | 2240.00 |
| 2000–01 | 3280.00 | 230.00 | 3510.00 |
| 2010–11 | 4660.00 | 350.00 | 5010.00 |

*Source:* 1. ***Statistical Abstract and The Economic Survey,*** 2011–12.
2. India–2010, p.690.

**The Talcher Series** It is the series of the Gondwana Systems, named after the Talcher and Dhankenal districts of Odisha. It rests on the glaciated boulder bed of igneous rocks. It is known for its coal deposits. The coal from here is supplied to the Raurkela and Jamshedpur Steel Plants.

**The Damuda Series** It is the most important series of the Gondwana System**.** The Damuda Series is well developed in Jharkhand and West Bengal. The Damuda series is known for good quality coal seams. The Raniganj, Jharia coal seams lie in the Damuda series. The Superior quality coal (anthracite and bituminous) is obtained from this series. The bituminous which has carbon over 60 per cent is used for metallurgy, especiallay the iron and steel plants of Jamshedpur and Bokaro.

**The Panchet Series** It is the youngest series of the Lower Gondwana System. It lies to the south of Raniganj. The series consists of greenish sandstone, shales and iron rich rocks, but is devoid of coal-seams. An outlier of this series is known as Mangli beds in the Wardha valley of Maharashtra.

### *Problems of Coal Industry*

The main problems of the coal mining industry are as under:

**1. Unequal Distribution of Coal** The distribution of coal in India is confined mainly to Jharkhand, Chattisgarh, Odisha, Madhya Pradesh and West Bengal. The transportation cost is consequently heavy which makes this vital source of energy expensive.

**2. Poor Quality of Coal** Most of the mines of India are producing non-coking coal which can not be utilised for metallurgical industries.

**3. Less Efficient Transport System** Most of the coal in India is transported by trains. Adequate number of wagons are not available and railway system is not efficient enough to deliver the coal at distant places in a short time.

**4. Obsolete Method of Mining** The mining technology is outdated and the per worker production is low. The per tonne cost of production is high.

**5. Shortage of Power Supply** The shortage of power supply is a big barrier in the mining of coal.

**6. Fires and Water-logging** There occur heavy losses of coal because of fires and waterlogging in the mines and at the pit-heads.

***Conservation of Coal***

Coal is an exhaustible resource. It needs to be utilised judiciously. The following steps can go a long way in the conservation of coal in the country.

1. The coking and good quality coal should be reserved only for metallurgical industry.
2. Low grade coal should be washed and impurities removed by modern techniques.
3. Selective mining should be stopped by an act of law. All possible grades of coal should be obtained from all the mines.
4. Environmental safety laws should be effectively implemented.
5. The thermal power plants should be located at the pit-heads to enhance power generation.
6. The pilferages and theft of electricity should be minimised.
7. New reserves should be discovered.
8. The non-conventional sources of energy should be popularised.

## Petroleum

Petroleum is an important source of energy which is much in demand to accelerate the economic development. Apart from an important fuel resource, it provides lubricants and raw materials for a number of chemical industries. Its products include kerosene, diesel, petrol, aviation-fuel, synthetic rubber, synthetic-fibre, thermoplastic resins, benzene-methansol, polystertene, acrylates, detergents, aromatics, gasoline, carbon-black, dyes, colours, food-colours, pigments, explosives, printing ink, film-photography, greases, cosmetics, paints, lubricant oils, paraffin, and wax.

Crude oil is obtained mainly from the sedimentary rocks of marine origin. In India, crude oil is found in the sedimentary rocks of the Tertiary period **(Fig. 8.4).** Normally it does not occur at its place of formation. Being lighter than water, crude oil overlain with gas, gets accumulated in the anticlines above the water surface. The geologists propounded two theories about the origin of crude oil.

***Origin:*** The origin of petroleum and natural gas is considered to be organic. According to organic origin, the living organisms (marine life, like fish) and vegetal matter got buried under the accumulated sediments of mud, silt and sand, etc. Due to pressure and heat, this undergoes chemical changes so as to form crude oil and natural gas after millions of years.

Oil in India was discovered near Margherita (Upper Assam); for the first time in 1860 by the Assam Railway and Trading Company. Subsequently, oil was discovered at Digboi in 1889. In the beginning of the 20$^{th}$ century (1917), oil was discovered at Badarpur (Assam). In 1954, production of oil was started in Naharkatiya region. The Oil and Natural Gas Commission (ONGC) was established in 1956. With the efforts of the Oil and Natural Gas Commission (ONGC), oil was discovered in the Gulf of Cambay (Khambat) in 1961 and in Bombay High in 1976.

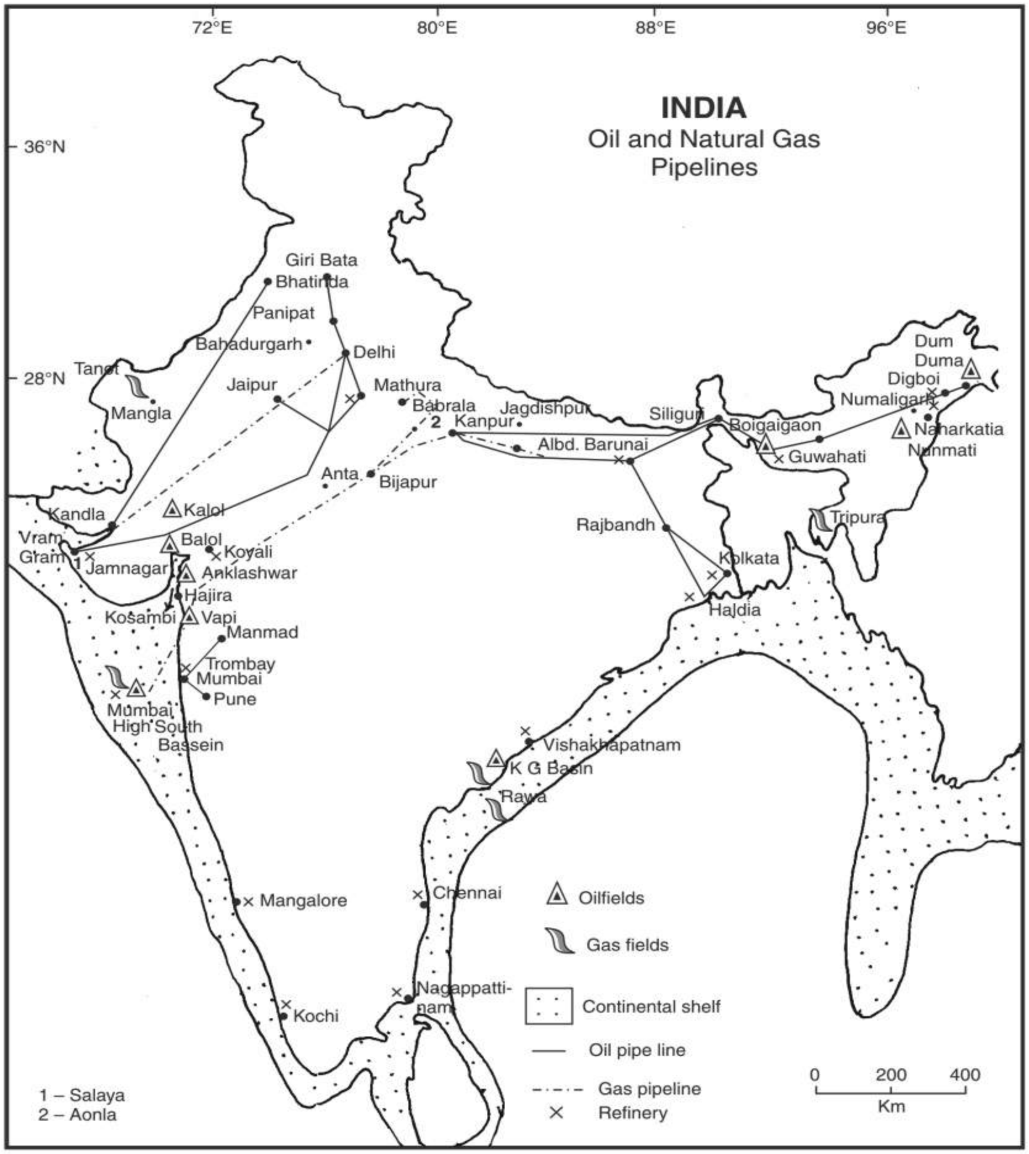


**Fig. 8.4** Oil and Natural Gas Deposits

In India, the petroleum and natural gas has been discovered in the following ten basins:

| | | |
|---|---|---|
| 1. | The Upper Assam Basin | (60,000 sq km) |
| 2. | The Western Bengal Basin | (60,000 sq km) |
| 3. | The Western Himalayan Basin | (100,000 sq km) |
| 4. | The Rajasthan Saurashtra-Kachchh Basin | (95,000 sq km) |
| 5. | The Northern Gujarat Basin | (140,000 sq km) |
| 6. | The Ganga Valley Basin | (385,000 sq km) |
| 7. | The Coastal Tamil Nadu, Andhra & Kerala Basin | (75,000 sq km) |
| 8. | The Andaman and Nicobar Coastal Basin | (2000 sq km) |
| 9. | Offshore of the Khambat, Bombay High & Bassein | (2000 sq km) |

The production trend of oil has been given in **Table 8.3**

**Table 8.3** *India—Production of Crude Oil—1951–2006*

| *Year* | *Production in Million Tonnes* |
|---|---|
| 1950–51 | 0.27 |
| 1960–61 | 0.50 |
| 1970–71 | 7.20 |
| 1980–81 | 15.5 |
| 1990–91 | 33.0 |
| 2000–01 | 32.5 |
| 2005–06 | 34.0 |

Source: ***Economic Survey of India, 2009–10.***

It may be seen from **Table 8.3** that the total production of crude oil in 1950–51 was only 0.27 million tonnes which rose to 34 million tonnes in 2005–06. The produced oil is, however, only about 40 per cent of the domestic need. The production of crude oil from the different regions of the country has been shown in **Table 8.4.**

**Table 8.4** *India: Production of Crude-Oil—2005–06*

| *State/Region* | *Production in Thousand Tonnes* | *Per cent of all India Production* |
|---|---|---|
| 1. Bombay High | 22.10 | 65.00 |
| 2. Gujarat | 06.00 | 17.65 |
| 3. Assam | 05.10 | 15.00 |
| 4. Andhra Pradesh | 00.39 | 1.15 |
| 5. Tamil Nadu | 00.37 | 1.10 |
| 6. Arunachal Pradesh | 00.04 | 0.10 |
| All India | 34.00 | 100.00 |

Source: ***Statistical Abstracts of India, 2007.***

The crude oil production in India has been shown in **Fig. 8.5**. It may be seen from Fig. 8.5 that the crude oil production was about eleven million tonnes in 1980–81which rose to over 34.0 million tonnes in 2005–06.

It may be observed from Fig. 8.5 that over 65 per cent of the total oil production is from the Bombay High. The second and third ranks are that of Gujarat (about 18 per cent) and Assam (15 per cent).

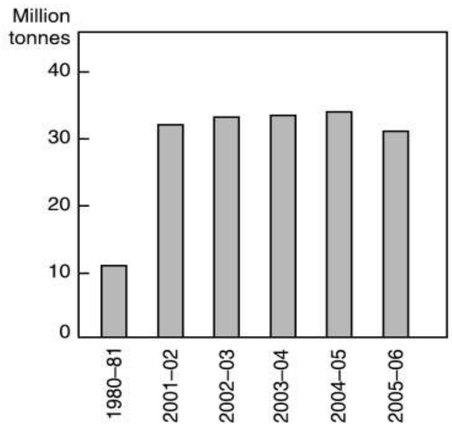


**Fig. 8.5** India—Crude Oil Production

### *Crude-Oil Producing Regions*

The major oilfields of India are as under:

**1. The Western Coast Offshore Oilfields**

***(i) The Bombay High Oilfields*** This is the largest petroleum production oilfield contributing over 65 per cent of the total production of crude oil. This oil field lies about 176 km to the south-west of Bombay. It has about 35 million tonnes of crude oil and about 40,000 million cubic metres of natural gas. Production of oil from this field was started in 1976. Owing to over exploitation, the production of this oil-field is declining fast.

***(ii) Bassein Oilfield*** This oilfield lies to the south of Bombay High. Here oil occurs at a depth of over 1900 metres. It has rich deposits of oil and natural gas.

***(iii) Aliabet Oil-field*** The Aliabet oilfield is located about 45 km to the south of Bhavnagar.

**2. The Gujarat Coast**

This is the second largest oil producing area of the country. Its main oilfields are in Ankleshwar, Cambay-Luni area and Ahmadabad-Kalol region.

***(i) Ankleshwar*** Situated in the district of Bharauch, it stretches over an area of about 30 sq km. The oil of this region belongs to the Eocene period. Oil production in this region was started in 1961. Ankleshwar oil is rich in gasoline and kerosene. The crude oil from this region is sent to the Koyali petroleum refinery.

***(ii) Cambay-Luni Region*** This oilfield lies about 60 km to the west of Vadodara. The drilling operations in this region were started in 1958. The estimated reserves of crude-oil are over 30 million tonnes. The oil of this region is very light with a sulphur content of less than 0.1 per cent.

***(iii) The Ahmadabad-Kalol Region*** This crude-oil region lies to the north of Gulf of Khambat (Cambay) around the city of Ahmadabad and extends up to Mehsana. Kalol, situated about 25 km to the north of Ahmadabad is an important oilfield of the region. Oil production from this region was started in 1961. Crude oil from this region is supplied mainly to the Koyali refinery.

**3. The Brahmaputra Valley** As stated above, crude oil was first discovered in the Brahmaputra valley. The oil-bearing rocks spread from the Dehang Basin up to the Surma valley. The main oil producing wells, however, lie in the Dibrugarh and Sibsagar districts of Upper Assam. Some of the important oil producing centres of this region are given below:

***(i) The Digboi Oilfield*** Stretching over an area of about 15 sq km, the Digboi oilfield is one of the oldest oil-fields of the country. The oil of this region belongs to the Eocene and Miocene periods. There are 85 oil wells in this region. Most of the oil is sent to the refinery of Digboi. Since 1959, the Digboi oilfields are worked by the Oil India Limited (OIL).

***(ii) The Naharkatiya Oilfield*** This oil-field lies about 35 km to the south-west of Digboi. Oil production from the Naharkatiya oilfields was started in 1954. Crude oil from this region is supplied to the refineries of Noonamati, New Bongaigaon (Assam), and Barauni (Bihar).

**4. The Eastern Coast Oil-fields** Petroleum and natural gas have been discovered in marine delta regions of Mahanadi, Godavari, Krishna, and Kaveri rivers. The Rawa field in the Godavari-Krishna offshore is expected to produce about 3 million tonnes of crude-oil annually. Petroleum has also been discovered in the Kaveri delta.

In addition to these, crude oil has been discovered in the Bilaspur Tehsil of Rampur District of Uttar Pradesh, Jawalamukhi area of Punjab, and in the Barmer District of Rajasthan. There are strong possibilities of petroleum and natural gas deposits to be found on the offshore of Andaman and Nicobar, Gulf of Mannar, Baleshwar coast, Punjab, Haryana and Uttar Pradesh.

The Ministry of Petroleum and Natural Gas is entrusted with the responsibility of exploration and production of oil and natural gas including import of Liquefied Natural Gas (LNG), refining, marketing, distribution import, export and conservation of petroleum products.

Oil and Natural Gas Corporation Limited (ONGC) and Oil India Limited (OIL), the two national companies (NOCs), and private and joint venture companies are engaged in the Exploration and Production of oil and natural gas in the country. Crude oil production during 2005–06 was 32190 MMT by ONGC, OIL, and Private/Joint Venture companies.

The natural gas production during the year 2005–06 was 32.20 Billion Cubic Metres (BCM) from ONGC, OIL and Private/Joint Venture Companies.

### *Import*

The total quantity of crude oil and petroleum import during 2004–05 was over 100 MMT, valued at Rs.134,094 crore ($29844 million). In the same year 21.50 MMT of petroleum products valued at Rs.47 crore were exported. Thus, India is not self sufficient in the production of petroleum and over 70 per cent of its demand is fulfilled by imported crude oil and petroleum.

During the year 2005–06, the public sector refineries purchased crude oil on term contract and spot basis. The countries from where term contract purchases were made included Saudi Arabia, Kuwait, UAE, Iran, Oman, Sudan, etc.

### *Pipelines*

Crude oil from oil-wells and finished products from refineries are generally transported through pipelines. Transportation of oil and petroleum through pipelines is cheap, effective and considered to be safe. Looking at these advantages, a network of pipelines has been developed in India. Some of the important pipelines are as under:

**1. Pipelines of North-East India**

(i) Noonmati-Siliguri-Pipeline to transport petroleum products from Noonmati to Siliguri.
(ii) Lakwa-Rudrasagar-Barauni Pipeline, completed in 1968 to transport crude-oil from Lakwa and Rudrasagar to Barauni Oil Refinery (Bihar).
(iii) Barauni-Haldia Pipeline: This pipeline was laid down in 1966 to carry refined petroleum products to Haldia port and bring back imported crude-oil to Barauni refinery.
(iv) Barauni-Kanpur Pipeline: This pipeline was completed in 1966 to transport refined petroleum products to Kanpur city.
(v) Noonmati-Bongaigaon Pipeline: This pipeline was constructed to transport crude-oil to Bongaigaon petro-chemical complex.
(vi) Haldia-Maurigram-Rajbandh Pipeline: This pipeline was completed in 1998.

**2. Pipelines of Western India** Bombay-High Mumbai-Ankleshwar-Koyali Pipeline: This pipeline connects the oilfields of Bombay High and Gujarat with the Koyali refinery of Gujarat. The city of Mumbai has been connected with a pipe line of 210 km length double pipeline to Bombay High to transport crude oil and natural gas. The Ankleshwar-Koyali pipeline was completed in 1965 to transport crude oil to Koyali refinery.

**3. The Salaya-Koyali-Mathura Pipeline** This pipeline, 1075 km in length was laid down from Salaya (Gulf of Kachchh) to Koyali and Mathura via Viramgram to supply crude oil to the Mathura refinery. From Mathura, it has been extended to the oil-refinery at Panipat (Haryana) and Jalandhar in Punjab. It has an offshore terminal and the Sayala-Koyali sector of the pipeline was completed in 1978, while the Viramgram-Mathura sector was completed in 1981.

**4. The Mathura-Delhi-Ambala-Jalandhar Pipeline** This 513 km long pipeline was constructed to transport refinery products of Mathura to the main cities of north and north-west India.

**5. Pipelines of Gujarat** In Gujarat, there are a number of short distance pipelines to transport crude-oil and natural gas to the refineries and the refined products to the market. These include the Kalol-Sabarmati Crude Pipeline, the Nwagam-Kalol-Koyali Pipeline, the Cambay-Dhuravan Gas Pipeline, the Ankleshwar-Uttran Gas Pipeline, the Ankleshwar-Vadodara Gas Pipeline, and the Koyali-Ahmadabad products Pipeline **(Fig. 8.4).**

**6. Mumbai Pipelines** From Mumbai, pipelines have been laid up to Pune and Manmad to distribute petroleum products.

**7. The Haldia-Kolkata Pipeline** Through this pipeline, the Haldia products are sent to Kolkata and neighbouring urban places.

**8. The Hajira-Bijaipur-Jagdishpur (HBJ) Gas Pipeline** Having a length of 1750 km, this is the longest pipeline of India. It crosses 75 big and small rivers and 29 railway crossings. This pipeline was laid down by the Gas Authority of India. This gas pipeline connects Kawas (Gujarat), Anta (Rajasthan), Bijaipur (M.P.) and Jagdishpur (U.P.) and Auraiya (U.P.). It provides gas to the fertiliser plants at Bijaipur, Sawai Madhopur, Jagdishpur, Shahjahanpur, Aonla, and Babrala. Each one of these fertiliser plants has the capacity to produce about 1400 tonnes of ammonia per day.

**9. The Kandla-Bhatinda Pipeline** This pipeline transports imported crude-oil from the Kandla seaport to the Bhatinda refinery.

***Oil Refineries of India***

The oil refineries are the processing factories of crude-oil. The impurities from the crude oil are removed to obtain petroleum, diesel, kerosene, bitumen, and aviation fuel. Petroleum industry contributes about 15 per cent of the GDP (2010-11). The main refineries of India, their year of commission and production capacity are given in (**Fig. 8.6**) **Table 8.5**.

**Table 8.5** *India: Refineries and their Production Capacity*

| *Refinery* | *State* | *Year of Commissioning* | *Capacity (lakh tonnes per year)* |
|---|---|---|---|
| Digboi, IOC | Assam | 1901 | 5.0 |
| Trombay, HPCL | Maharashtra | 1954 | 55.0 |
| Trombay, BPCL | Maharashtra | 1955 | 60.0 |
| Vishakhapatnam, HPCL | Andhra Pradesh | 1957 | 45.0 |
| Noonamati, IOC | Assam | 1962 | 8.5 |
| Barauni, IOC | Bihar | 1964 | 33.0 |
| Koyali, IOC | Gujarat | 1965 | 95.0 |
| Kochi, CRL | Kerala | 1966 | 45.0 |
| Chennai, MRL | Tamil Nadu | 1969 | 56.0 |
| Haldia, IOC | West Bengal | 1975 | 27.5 |
| Bongaigaon, BRPL | Assam | 1979 | 13.5 |
| Mathura, IOC | Uttar Pradesh | 1982 | 75.0 |
| Numaligarh, IOC | Assam | 1999 | 30.0 |
| Jamnagar, RP | Gujarat | 1999 | 270.0 |
| Karnal, IOC | Haryana | 1998 | 60.0 |
| Mangalore, HPCL | Karnataka | 1998 | 30.0 |
| Panagundi, IOC | Tamil Nadu | 1999 | 5.0 |
| Pachpadra HPCL | Rajasthan | 2013–17 | 9.0 |
| Total | | | 913.5 |

The total refining capacity of crude oil was 2 lakh tonnes per annum in 1901 which rose to more than nine hundred lakh tonnes per annum in 2005–06. All the refineries except the Digboi and the Jamnagar are in the public sector, or the joint section.

## Natural Gas

The exploration of natural gas is being done by the Oil and Natural Gas Commission. According to one estimate, India has a total natural gas reserve of about 450 billion cubic metres. Out of the total reserves, about 75 per cent lies in the Bombay High and the Bassein oilfields, about 12 per cent in Gujarat, 7 per cent in Andhra Pradesh and 6 per cent in Assam. Apart from Bombay High, there are rich deposits of natural gas in Ankleshwar and Gulf of Khambat (Gujarat), Godavari and Krishna basins, the Thanjavur and Shingleput districts of Tamil Nadu. Natural gas is also found in Barmar district of Rajasthan, Kangra district of Himachal Pradesh, and Firozpur district of Punjab. The trend of natural gas production in India has been shown in **Table 8.6.**

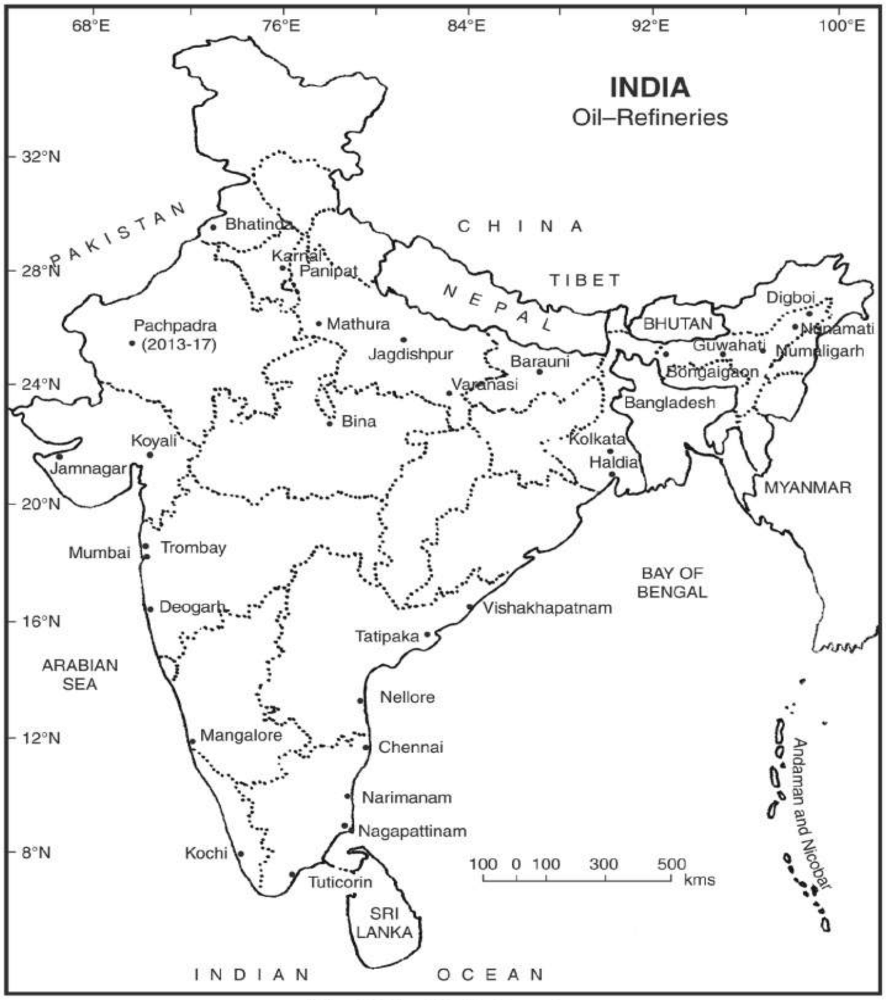


**Fig. 8.6** Oil Refineries

**Table 8.6** *India—Trends in Natural Gas Production*

| *Year* | *Production (in million cubic metres)* |
|---|---|
| 1960–61 | 17 |
| 1970–71 | 76 |
| 1980–81 | 200 |
| 1990–91 | 12,870 |
| 2000–01 | 20,920 |
| 2005–06 | 25,750 |

Source: ***Statistical Abstract, India,*** 2006–07.

The largest share of natural gas is consumed in the production of chemical fertilisers accounting for about 40 per cent, about 30 per cent is used in power generation, and about 10 per cent in L.P.G. (cooking gas).

After 1990, the production of natural gas has increased phenomenally, yet the production falls short of demand. Consequently, natural gas in large quantities has to be imported. Natural gas is imported from Iran, Saudi Arabia, UAE. and the other Gulf countries.

## Electricity

Electricity is a clean source of energy. It is generated from water, coal, mineral oil, natural gas, and atomic minerals. Electricity can also be generated through wind energy, solar energy, bio-gas, sea-waves, geothermal and dry batteries. Electricity is relatively cheap, transportable, pollution free and renewable. Because of these advantages it is increasingly becoming popular day by day. The per head consumption of electricity is often considered an important indicator of socio-economic and human development. It is about 350 kWh which is much below the per head consumption in the world 1000 kWh and USA 7000 kWh

**Table 8.7** *India—Installed Capacity of Electricity (in thousand MW)*

| *Year* | *Hydro* | *Thermal* | *Nuclear* | *Others* | *Grand Total* |
|---|---|---|---|---|---|
| 1950–51 | 0.6 | 1.1 | — | 0.6 | 2.3 |
| 1960–61 | 1.9 | 2.7 | — | 1.0 | 5.6 |
| 1970–71 | 6.4 | 8.0 | 0.4 | 1.6 | 16.3 |
| 1980–81 | 11.8 | 17.6 | 0.9 | 3.1 | 33.3 |
| 1990–91 | 18.8 | 45.8 | 1.5 | 8.6 | 74.7 |
| 2000–01 | 25.0 | 76.0 | 2.9 | 15.2 | 119.1 |
| 2005–06 | 35.0 | 95.0 | 2.8 | 17.2 | 150.00 |

Source: ***The Economic Survey***, 2006–07.

It may be seen from Table 8.7 that the total installed capacity of electricity by different sources was only 2.3 thousand MW in 1950–51 which rose to 150 thousand MW in 2005–06. The highest installed capacity is that of thermal, accounting for over 63 per cent of the total installed capacity.

The electricity production in India was started in 1898 when the Darjeeling hydel power project was commissioned. The first thermal power plant was installed in Kolkata in 1899. Subsequently, the Mettur project in Tamil Nadu and the Sivasamudram project in Karnataka were commissioned. In the initial phase the use of electricity was confined only to the big urban centres. The National Thermal Power Corporation (NTPC) was established in 1975, which established a number of thermal power stations based mainly on coal in different parts of the country.

**Table 8.8** *India—Trends in the Power Sector 2005–2006 (billion kWh)*

| | *2005* | *2006* | *Change over previous year* |
|---|---|---|---|
| Power Generation* | 487.4 | 617.5 | 7.5 |
| Hydro-electric | 84.50 | 80.61 | 13.8 |
| Thermal | 486.1 | 497.20 | 6.1 |
| Nuclear | 16.8 | 17.21 | 3.0 |

* Excludes generation from captive and non-conventional power plants and thermal power plants below 20 MW units and hydro-power plants below 2 MW.
Source: ***Economic Survey***, 2007, p.179.

It may be seen from Table 8.8 that in 2005, the power generation was 487.4 billion kWh in which the share of hydro-power and thermal power was 84.50 billion kWh and 486.1 billion kWh respectively. In 2006, an increase of 6.1 and 13.8 per cent was recorded in the production of hydro- and thermal power respectively.

## Hydro-Electricity

As stated in the preceding paragraph, the first hydro-electric plant in India was commissioned in 1898 at Darjeeling. It was followed by the Mettur (Tamil Nadu) and Sivasamudram (Karnataka) projects which were commissioned in 1899 and 1902 respectively. The fourth hydro-power station was built on the Jhelum river at Mohara in 1909. The real progress in the production of hydro-power took place after independence when a number of multipurpose projects were constructed. Some of these projects are the Bhakra-Nangal Dam, Rihand-Dam, Hirakud-Dam, Nagarjun-sagar, Damodar Valley Corporation, Chambal, Tungbhadra, and Koyna projects.

### *Regional Patterns*

The development of hydro-electricity depends on the perennial and seasonal character of rivers, their monthly regime, undulating topography, suitable rock formations for the construction of dam and the demand for energy. Because of these factors, the development of hydro-power is not uniform. Andhra Pradesh ranks first, followed by Karnataka, Tamil Nadu, Punjab, Maharashtra, Kerala, and Madhya Pradesh. The major Hydro-electric Power Plants have been given in **Table 8.9**.

After Independence, especially in the First Five Year Plan, great emphasis was laid on the development of electricity. To achieve this objective, a number of multipurpose projects were installed. Some of the important multipurpose projects have been described in the following:

**Table 8.9** *State-wise Main Hydro-Electric Power Plants*

| *States* | *Names of the Hydro-Electric Power Plants* |
|---|---|
| 1. Andhra Pradesh | Machkund, Nagarjun-Sagar, Nizam -Sagar, Sileru, Srisalem |
| 2. Bihar | Kosi |
| 3. Gujarat | Akrimota, Sardar-Sarovar, Ukai (Tapi), Hathmati (Sabarmati), Bhadra (Kathiawad) |
| 4. Jammu & Kashmir | Dool-Hasti, Lower Jhelum, Salal, Baghliar |
| 5. Jharkhand | Maithon, Panchet, Tilaiya ( all three under DVC), Mayurakshi |
| 6. Karnataka | Mahatma-Gandhi (Jog Falls), Sivasamudram (Kaveri), Bhadra, Munirabad, Saravati, Tungbhadra, Krishnaraja-Sagar |
| 7. Kerala | Idikki (Periyar), Kallada, Kuttiaddy, Pallivasal, Parambikulam, Poringal, Panniar, Sabarigiri, Periyar |
| 8. Madhya Pradesh | Jawaharsagar and Pratap-sagar on Chambal, Twa (M.P.) |
| 9. Maharashtra | Bhola, Bhatnagar-Beed, Girna, Khopali, Koyna, Purna, Paithon, Vaiterna |
| 10. North-eastern States | Dikhu, Doyan (both in Nagaland), Gomuti (Tripura), Loktak (Manipur), Kopali (Assam), Khandong and Kyrdemkulai (Meghalaya), Sirlui and Barabi (Mizoram), Ranganadi (Arunachal Pradesh) |

(*Contd.*)

(*Contd.*)

| | |
|---|---|
| 11. Odisha | Hirakud (Mahanadi), Balimela, Rengali (Brahmani), Indiravati |
| 12. Punjab and Himachal Pradesh | Bhakra-Nangal on Sutlej, Dehar on Beas, Giri-Bata, Harike Binwa, Andhra, Chamera, Pong, Siul, Bassi |
| 13. Rajasthan | Ranapratap Sagar and Jawahar Sagar on Chambal river |
| 14. Tamil Nadu | Bhavanisagar, Mettur, Periyar, Aliayar, Kodayar, Moyar, Suruliyar, Papnasam |
| 15. Uttarakhand | Tehri-dam and Koteshwar-dam on Bhagirathi |
| 16. Uttar Pradesh | Rihand, Ramganga, Chibro on Tons |
| 17. West Bengal | Panchet |

**1. Bhakra Nangal Project** The Bhakra-Nangal Dam is a joint venture of the Punjab, Haryana and Rajasthan governments. Constructed across the Satluj river near Bhakra gorge, it is one of the highest straightway gravity dam in the world. The dam is 518 m long and 226 m high. Its reservoir is known as the Gobind Sagar (named after Sikh Guru Gobind Singh, the tenth Guru of Sikhs). It is a multipurpose project funded by the Central Government, built to generate electricity, provide irrigation, flood control, soil conservation, silt control, recreation, navigation, pisci-culture, preserving wild-life, and cattle rearing.

**2. Damodar Valley Project** The Damodar River is a tributary of the Hugli River. It used to be called the 'Sorrow of Bengal'. The Damodar flows through Jharkhand and West Bengal. The Damodar Valley Corporation was established on February 18, 1948. Under this project, four dams were constructed namely, Tilaiya, Maithon, Konar, and Panchet Dams.

***(i) Tilaiya Dam*** The Tilaiya dam has been constructed across the Barakar river. It is the only concrete dam in the area. Two power stations of 2000 kW each have been set-up here. The dam provides irrigation to forty thousand hectares of land. It has helped in the reduction of floods. This dam was completed in 1953. Its underground power station with installed capacity of 60,000 kW provides cheap power to the mica mines of Kodarma and Hazaribagh.

***(ii) Konar Dam*** The Konar dam has been constructed across the Konar river—a tributary of the Damodar River in the Hazaribagh District. It was completed in 1955. It is an earthen dam with concrete spill-way . Beside irrigation and power, it provides cooling water to the Bokaro Steel Plant. The hydel station located near the dam generates about 40,000 kW of electricity.

***(iii) Maithon Dam*** Constructed across the Barakar river near the confluence of Barakar with Damodar river, it is a 56 m high dam. The dam completed in 1958, provides irrigation to 50,000 hectares of arable land. The underground power station generates 60,000 kW of electricity.

***(iv) Panchet Hill Dam*** The Panchet dam has been constructed across the Damodar river, about 20 km south of the Maithon Dam. It is 45 m high and 2545 m long. The power station near the dam has an installed capacity of 40,000 kW. It irrigates about 3 lakh hectares of agricultural land.

**3. Dool Hasti** The Dool Hasti Project has been constructed across the Chenab river in the Doda district of the Jammu Division. The main objective of this project was to harness the water of Chenab river and to generate electricity to be supplied to the main cities of the state including the cities of Srinagar and Jammu. It was commissioned in 1986.

**4. Gandhi Sagar** The Gandhi Sagar project has been constructed across the Chambal river. The installed capacity of the Gandhi Sagar Dam is 115 MW. Five generators have been installed at

Gandhi Sagar; four with a capacity of 2300 kW and one with a capacity of 2700 kW. It is providing power and irrigation to the surrounding regions of Rajasthan and Madhya Pradesh.

**5. Hirakud Project** Constructed across the Mahanadi river, this project was funded by the Central Government. It is a 14 km long dam, considerd to be the longest in the world. The project involves the construction of three dams across Mahanadi, at Hirakud, Tikrapara, and Naraj. The Hirakud Project, according to recent study, has increased floods and droughts in the region. Due to increasing siltation , the storage capacity of the reservoir has been reduced, causing floods in the lower catchment area of the Mahanadi.

**6. Nangal Project** Nangal dam has been constructed at Nangal, about 13 km downstream of the Bhakra-dam. It is about 30 metres high, 305 m long, and 121 m wide. Its main function is to generate electricity. It also supplies water to the Bhakra canals.

**7. Jawahar Sagar Dam** This dam has been constructed to the north of Rana Pratap Dam in the state of Rajasthan. It is about 40 km to the north of the Rana Pratap Sagar. It is a multipurpose project constructed to generate electricity, control floods and provide irrigation water to the catchment area.

**8. Kosi Project** The Kosi river, often been called 'the 'Sorrow of Bihar', is an outcome of the joint agreement between the Nepali and Indian governments reached in 1954. Its main objective is to construct a barrage near Hanumannagar in Nepal, to built embankments on both the banks of the river to control floods, to construct canals for irrigation and to generate hydro-power. Kosi in July, 2008 shifted its course about 100 km towards east and caused great damage to life and property.

**9. Koyna Project** It is a multi-purpose project in the Satara District of Maharashtra state. Its installed capacity is 880 MW. Its hydro-electricity is being supplied to the cities of Satara, Sholapur, Sangli, Kolhapur and Pune.

**10. Machkund Project** This is a joint venture of the Andhra Pradesh and the Odisha states. The Machkund Dam is 54 m high and 410 m long. It is mainly a hydro-electric project which shall generate 115 MW electricity.

**11. Mahi Project** This project has been constructed across the Mahi river which originates from the Vindhyan Hills of Madhya Pradesh. The project on completion will generate 40 MW hydro-power and shall irrigate 80,000 hectares of agricultural land.

**12. Mayurakshi Project** Mayurakshi is a tributary of the Hugli. It rises from the Chotanagpur Plateau and flows through Jharkhand and West Bengal. It is a multipurpose project, generating 4000 kW of electricity and providing irrigation water to 3 lakh hectares. Electricity from this project is supplied to Murshidabad, Birbhum (West Bengal), and Santhal Pargana (Jharkhand).

**13. Mettur Dam** The Mettur Dam was built in 1937 across a tributary of the Kaveri river in the Nilgiris. The project has a capacity to produce 240 MW of hydro-electricity. The Mettur Dam is not only generating electricity and providing irrigation water, but it has also helped in the flood control in the basin.

**14. Nagarjun Sagar Project** The Nagarjunsagar project has been constructed across the Krishna river in Nalgonda District of Andhra Pradesh. Its right and left bank canals have been named after Jawaharlal Nehru and Lal Bahadur Shastri respectively. The power plant generates 210 MW of hydro-electricity. The power is supplied to Hyderabad, Khammam, Mahbubnagar, Nalgonda and Vijaiwada.

**15. Pochampad Project** This project has been constructed across the Godavari river in Adilabad District. Its 115 km long canals irrigate about 2.5 lakh hectares in Adilabad, and Karimnagar districts of Andhra Pradesh.

**16. The Periyar Project** Originating from the Cardamom Hills, Periyar is an important river of Kerala. A dam has been constructed across its course in hilly gorge. Its installed capacity is 140 MW. It is a multi-purpose project helping in the prevention of floods, soil erosion and generating electricity being supplied to Ernakulam, Kochi and neighbouring cities.

**17. Rampad Sagar Dam** This dam has been constructed in the lower reaches of the Godavari river, about 30 km to the north of Rajamundry. It is a multi-purpose project designed to check floods, to provide irrigation in the delta region of the river and to generate electricity.

**18. Rana Pratap Sagar Dam** This dam has been constructed across the Chambal river, about 25 km to the north of the Gandhi Sagar Dam in the Kota District of Rajasthan. It is a multipurpose project designed to generate electricity, to control floods and to provide irrigation water to the surrounding agricultural land. Its installed capacity is 99 MW.

**19. Rihand Project** Funded by the Central Government, it is the largest multi-purpose project of Uttar Pradesh. It has been constructed across the Rihand river, a tributary of the Son river, near Pipri village in the Sonbhadra District. The reservoir of this dam has been named after Gobind Ballabh Pant. It is connected with the Obra hydro-power station and the Obra thermal power plant located in its vicinity. The power generated from this project is supplied to eastern Uttar Pradesh, western Bihar and northern parts of Madhya Pradesh. Flood control in Son valley, control of soil erosion in Baghelkhand, tourism and pisci-culture are the other benefits from this project.

**20. The Salal Project** This project has been constructed across the Chenab river in the Riasi District of Jammu Division of Jammu & Kashmir State. The installed capacity of the project is 750 MW. It was inaugurated in 1986. The electricity is supplied to Riasi, Udhampur, Jammu, and other neighbouring urban centres.

**21. Sardar Sarovar Dam** This has been constructed across the Narmada river near Navagaon. The project when completed, will generate 1450 MW of hydro-electricity and will irrigate about 18 lakh hectares of agricultural land. It will also promote dairy farming, livestock keeping, animal husbandry and allied occupations.

**22. Shivasamudram Dam** The Shivasamudram project was built in 1902 across the Kaveri river in Karnataka. The main objective of the project was to supply electricity to the Kolar Gold Mines, the city of Mysore and its neighbouring urban centres. It helped in flood control and became a centre of tourists attraction.

**23. Tawa Dam** This project has been constructed across the Tawa river; a left bank tributary of the Narmada river. It is a multipurpose project which has been designed to provide irrigation water to more than 50 thousand hectares and has the installed capacity to produce 150 MW hydro-electricity.

**24. Tehri Dam** The Tehri Dam is being constructed across the Bhagirathi river just below the confluence of Bhagirathi and Bhilaganga in the Tehri District of Uttarakhand. Conceived by the Planning Commission in 1972, the work on the project was started in 1975. The project is being implemented with Soviet (Russian) technical and economic aid. The project will provide irrigation to 2.74 lakh hectares in Uttarakhand and western Uttar Pradesh and will generate 1000 MW of hydro-electricity. Some serious objections were raised about this project as the environment and ecology may be adversely affected by this project which has been constructed in a highly earthquake prone area of the country.

**25. Tungbhadra Project** Tungbhadra is a right hand tributary of the Krishna river which originates from the Western Ghats (Sahayadri Hills) of the Chikmagalur district of Karnataka. The Tungbhadra Dam has been constructed at Mallapuram near Hosepet in the Bellary District. Three power houses have been constructed in this project to generate 126 MW of electricity. The Tungbhadra canals irrigate more than 4 lakh hectares of arable land.

**26. Ukai Dam** Ukai is a tributary of the Tapi river. The Ukai project was launched mainly to harness the Tapi water. The installed capacity of the Ukai project is 300 MW. Its electricity is supplied to Surat and other neighbouring urban centres.

### Thermal Electricity

Thermal electricity is produced with the help of coal, petroleum, and natural gas. About 65 per cent of the total electricity produced is thermal in character. The main advantages of thermal electricity are as under:

(i) It can be generated in the areas not suitable for the generation of hydro-electricity.
(ii) Coal, diesel and natural gas can be transported to the areas of isolation and relative isolation.
(iii) It can be generated even when the weather is adverse.
(iv) The gestation period of the thermal power stations is short.

The production of thermal energy is, however, not eco-friendly as the release of carbon dioxide pollutes the atmosphere. Moreover, it consumes the valuable exhaustible resources like coal, petroleum and natural gas.

Some of the important thermal power stations of India have been given in **Table 8.10.**

**Table 8.10** *India—Thermal Power Stations*

| *States* | *Thermal Power Stations with Installed Capacity in MW* |
|---|---|
| 1. Andhra Pradesh | Bhadrachalam, Kothagudam (680), Manuguru, Nellore (300), Ramagudam (200), Vijayawada (420) |
| 2. Assam | Bongaigaon (120), Chandarpur (100), Namrup (112) |
| 3. Bihar | Barauni (255), Kahalgaon, DVC (780), Durgapur (285), 1 |
| 4. Chhattisgarh | Korba (750) |
| 5. Delhi | Badarpur (720), Indraprastha (285), Rajghat (350) |
| 6. Gujarat | Ahmadabad (180), Banas, Dhuvaram (534), Gandhinagar (240), Kachchh, Kandla, Mahuva, Porbandar, Sabarmati (110), Shahpur, Sikka, Ukai (640), Utaran (200), Wankbori, |
| 7. Haryana | Faridabad (180), Panipat (220), Yamuna Nagar (150) |
| 8. Jammu & Kashmir | Kalakot |
| 9. Jharkhand | Bokaro (248), Chandrapur (780), Subarnrekha |
| 10. Madhya Pradesh | Amarkantak (3000), Satpura (1142), Singrauli, Vindhyachal (1260) |

(*Contd.*)

(*Contd.*)

| | |
|---|---|
| 11. Maharashtra | Ballarshah (500), Bhusaval(485), Chandrapur (210), Chola (95), Dhobal (350), Khapar-Kheda (250), Koradi (1100), Nasik (810), Paras (95), Parli (240), Trombay (838), Ujjaini, Uran (240) |
| 12.Manipur | Loktak (Imphal) |
| 13. Punjab | Bhatinda (440), Rupnagar |
| 14. Rajasthan | Anta, Banswara, Kota (240), Palana, Sawai Madhopur. |
| 15. Odisha | Balimela, Talcher (470) |
| 16. Tamil Nadu | Ennore (450), Mettur, Neyveli (2300), Tuticorin (630) |
| 17. Uttar Pradesh | Bahraich, Dorighat, Gorakhpur, Harduaganj (215), Jawaharpur, Kanpur (325), Mau, Moradabad, Obra (450), Panki (345), Parichha (240), (565), Tundla. |
| 18.West Bengal | Birbhum, Bundel (540), Durgapur (285), Farakka (1600), Gauripur (350), Kalaghat, Kolkata (250), Murshidabad, Titagarh, Santaldih (480) |

It may be seen from **Table 8.10** that the distribution of thermal power stations is highly unequal. Most of them, however, have been located near the source of inferior coal or lignite mining centres. The state of Maharashtra ranks first in the production of thermal power, followed by Uttar Pradesh, Gujarat, and West Bengal. The rank of Madhya Pradesh (including Chhattisgarh) and Tamil Nadu are sixth and seventh respectively. Arunachal Pradesh, Goa, Himachal Pradesh, Kerala, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura and Uttarakhand are the states which are devoid of the production of thermal electricity. On the zonal basis, the western zone is the largest producer of thermal energy, followed by the northern zone, eastern and southern zones. Thermal power stations have been installed at Raichur (Karnataka) and Loktak (Manipur).

The contribution of National Thermal Power Corporation is quite significant in the generation of thermal energy. The NTPC thermal power stations in the country have been given in **Table 8.11.**

**Table 8.11** *India—Major Thermal Power Stations*

| *Projects/Stations* | *Installed Capacity (MW)* |
|---|---|
| 1. Badarpur | 720 |
| 2. Farakka (West Bengal) | 1600 |
| 3. Kahalgaon (Bihar) | 840 |
| 4. Korba (Chhattisgarh) | 2100 |
| 5. National Capital Thermal Power Plant Dadri (U.P.) | 840 |
| 6. Ramagundum (Andhra Pradesh) | 2100 |
| 7. Rihand /Obra (Uttar Pradesh) | 1000 |
| 8. Singrauli (Madhya Pradesh) | 2000 |
| 9. Talcher (Odisha) | 720 |
| 10. Unchahar (Uttar Pradesh) | 720 |
| 11. Vindhyachal (Madhya Pradesh) | 1260 |
| 12. Gas Based Projects: | |
| (i) Anta (Rajasthan) | 430 |
| (ii) Auraiya (Uttar Pradesh) | 600 |
| (iii) Kawas (Gujarat) | 600 |
| Total | 15530 |


**Fig. 8.7** Thermal Power Projects

## Nuclear Energy

Looking at the exhaustible nature of the fossil fuels, nuclear energy development has become very vital for the economic development of the country. In India, it has a vast potential for future energy development. It is produced from uranium and thorium. At present there are 17 nuclear plants across the country. The atomic power stations are given in **Table 8.12**.

**Table 8.12** *India—Atomic Power Stations*

| *Power Stations* | *Unit* | *Year of Commissioning* | *Capacity* |
|---|---|---|---|
| 1. Tarapur | First | 1969 | 160 |
| (Maharashtra) | Second | 1970 | |
| 2. Rawatbhata | First | 1972 | 200 |
| near Kota (Rajasthan) | Second | 1981 | 200 |
| 3. Kalpakkam | First | 1984 | 235 |
| (Tamil Nadu) | Second | 1986 | 235 |
| 4. Narora (U. P.) | First | 1989 | 235 |
| | Second | 1991 | 235 |
| 5. Kakrapara | First | 1993 | 235 |
| (Gujarat) | Second | 1995 | 235 |
| 6. Kaiga | First | 1993 | 235 |
| (Karnataka) | Second | 1995 | 235 |
| 7. Rawatbhata; | Third | | 235 |
| Kota (Rajasthan) | Fourth | | 235 |
| 8. Tarapur | Third | | 500 |
| (Maharashtra) | Fourth | | 500 |
| 9. Kaiga | Third | | 235 |
| (Karnataka) | Fourth | | 235 |
| | Fifth | | 235 |
| | Sixth | | 235 |
| 10. Rawatbhata | Fifth | | 500 |
| Kota (Rajasthan) | Sixth | | 500 |
| | Seventh | | 500 |
| | Eighth | | 500 |
| 11. Kudankulam | First | | 1000 |
| (Tamil Nadu) | Second | | 1000 |
| 12. Jaitapur | Maharashtra | | |
| 13. Haripur | W. Bengal | | under-construction |
| 14. Bargi-Chutka | Madhya Pradesh | | |
| 15. Kawada | Andhra Pradesh | | |
| 16. Maithi-Verdi | Kathiawad (Gujarat) | | |
| 17. Kumharia or Gorakhpur | Haryana | | |

At present, nuclear power constitutes only less than 4 per cent of the total energy production. It requires highly sophisticated technology and technical knowhow. Moreover, for the cooling of plant there is heavy need of fresh water.

The Atomic Energy Institution at Trombay was established in 1954. This was renamed as the 'Bhabha Atomic Research Centre (BARC), in 1967. The first nuclear power station with a capacity of 320 MW was set up at Tarapur near Mumbai in 1969. Subsequently, the Rawatbhata Atomic Plant (300 MW) near Kota was set up in 1969 which was followed by the establishment of Narora (1989), Kaiga (Karnataka), and Kakrapara in Gujarat in1993. Thus, at present, nuclear energy is produced from eleven units located at six centres (**Table 8.12**). The new sites of nuclear power plants include Bargi or Chutka (M.P.), Haripur (W. Bengal), Jaitapur (Maharashtra), Kawada (Andhra

Pradesh), Kudankulam (Tamil Nadu), Kumharia (Haryana), and Mithi-Verdi (Gujarat).

Development of nuclear energy is imperative for the economic development of the country. But the disaster's like Fukushima and Chernobyl have proved that it is full of risk. Thus it is only a parochial solution of the Indian energy crisis. Unfortunately, in India, in case of nuclear accident, the maximum fine that can be imposed by the regulator on an offending nuclear plant is Rs. 500/-. This amount is too low to serve as a deterrent against such infringements.

## NON-CONVENTIONAL ENERGY

The non-conventional energy is also called as renewable energy. The non-conventional sources of energy include solar energy, wind energy, bio-mass energy, fuel-cells, electric vehicles, tidal energy, hydrogen energy, and geo-thermal energy.

### Solar Energy

Solar energy is one of the most important sources of non-conventional energy. Solar energy is non-exhaustible, reliable, and pollution free. It may be utilised for water heaters, power generation devices, air-conditioning, space heating, development of pisci-culture, and multifarious uses of water and refrigeration.

The average amount of solar energy received in the earth's atmosphere is about 1353 kW per sq metre. It is 1000 times the total consumption of the global energy. Being situated in the sub-tropical latitudes, India receives higher amount of solar energy. The greater part of the country has more than 300 solar days. The total amount of energy received from the Sun is about 5000 trillion kWh per year.

The Solar Photovoltaic (SPV) technology enables the conversion of solar radiation into electricity without involving any moving part like turbine. Over 650,000 solar PV systems have been installed in the country.

In many parts of the country, the solar energy programmes have been implemented. One such example is the Rural Energy Co-operative at Sagar Island in the Sundarban Delta of West Bengal. Similar programmes have been implemented in the other islands in the Bay of Bengal, the desert of Jodhpur (Rajasthan), Kalyanpur (Aligarh), and Coimbatore (**Fig. 8.8**).

### Wind Energy

Wind is an important source of non-conventional energy. It is cheap, pollution free, eco-friendly and can be developed away from the sources of fossil fuels (conventional sources of energy). Since ancient times wind energy was utilised in sailing ships and wind mills. India ranks 5th in the world after U.S.A., Spain, Germany and China.

For the generation of wind energy, a wind speed of more than five km per hour is considered to be suitable. Wind speeds above 10 km per hour are prevalent over parts of the coastal regions of Gujarat, Andhra Pradesh, Karnataka, Madhya Pradesh, Rajasthan, Tamil Nadu, Maharashtra, Kerala, Odisha, West Bengal, Uttarakhand, Jammu & Kashmir, and Andaman and Nicobar Islands

(**Fig. 8.8**). The state of Rajasthan and Ladakh also record suitable consistency of wind speed. Wind mills can be operated there to harness wind energy.

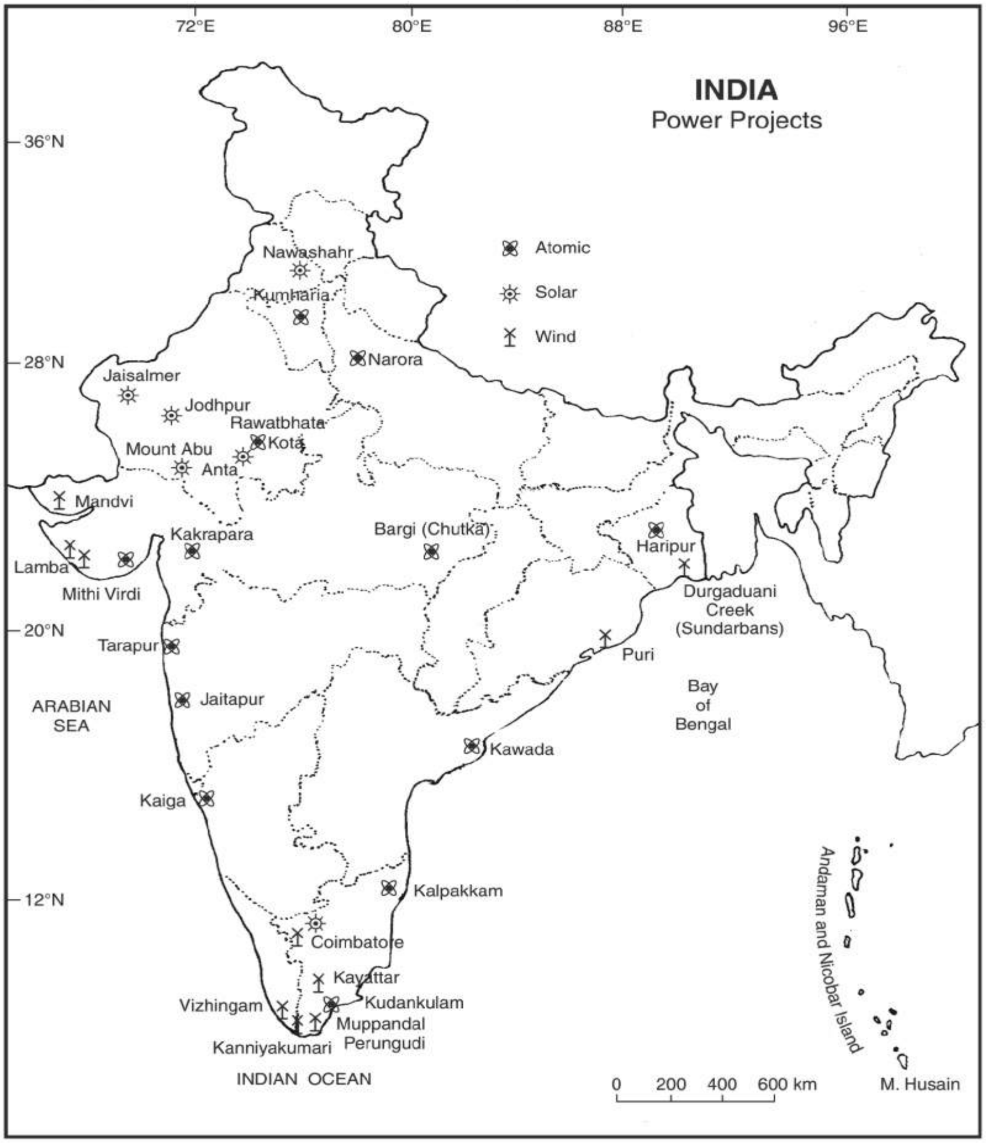


**Fig. 8.8** Power Projects

**Table 8.13** *India—Wind Power Potential*

| *State* | *Total Potential (MW)* | *Technical Potential (MW)* |
|---|---|---|
| 1. Gujarat | 9675 | 1750 |
| 2. Andhra Pradesh | 8275 | 1550 |
| 3. Karnataka | 6620 | 1025 |
| 4. Madhya Pradesh | 5500 | 1200 |
| 5. Rajasthan | 5400 | 0885 |
| 6. Tamil Nadu | 3050 | 1700 |
| 7. Others | 6675 | 4725 |
| Total | 45,195 | 12,835 |

Source: ***Ministry of Non-Conventional Sources of Energy.***

In India, the total potential of wind energy is estimated to be more than 20,000 MW. Wind energy projects have been implemented in 22 states of the country. The maximum potential of wind energy lies in the states of Gujarat and Tamil Nadu. Asia's largest wind farm of 28 MW capacity is located at Lamba in Gujarat. Commercial projects of 1200 MW capacity have been set up in Tamil Nadu, Gujarat, and Andhra Pradesh.

Tamil Nadu has the largest installation of wind turbines in the country in the Muppandal Perungudi area near Kanniyakumari. This is one of the largest concentrations of wind farm capacity at a single location anywhere in the world. A Centre of Wind Energy Technology has been set up in Chennai. The Wind Energy Estates are being set up in the joint sector or in private sector.

## Ocean Energy

The tidal waves and sea-waves are the main sources of ocean energy. India has a very long coastline, more than 6100 km, but the ocean energy production is limited. The suitable areas for the generation of tidal and sea-waves energy are:

(i) The Gulf of Khambat
(ii) The Gulf of Kachchh
(iii) The Estuary of Hugli

According to one estimate, the Indian coasts have the potential to generate over 40,000 MW of electricity. A plant has been established near Thiruvanantapuram (Vizhingam) which is generating about 150 MW of electricity through sea-waves.

The main problem in the exploitation of ocean energy is the high cost involved in the construction of civil works.

## Geothermal Energy

India has very limited potential of geothermal energy. According to one estimate, the total geothermal energy is about 600 MW. There are 115 hot water springs in the country and 350 sites from which geothermal energy can be produced. The Puga Valley in Jammu and Kashmir, the Manikaran area in Himachal Pradesh, the western slopes of the Western Ghats in Maharashtra and Gujarat, the Narmada-Son Valley, and the Damodar Valley are the main areas which have potential for the generation of thermal energy.

## Bio-Energy

Bio-energy is a clean source of energy which improves sanitation, hygiene and the living style of the rural population. The technique is based on the decomposition of organic matter in the absence of air to produce gas. Bio-gas is used for cooking, and lighting fuel in specially designed stove and lamps respectively. According to one estimate, India has a capacity to produce bio-gas to the extent of 25,000 million cubic metres. The left over digested slurry serves as manure. This can meet 50 per cent of the rural domestic fuel requirements. Moreover, it can produce 7 million tonnes to nitrogen, 3 million tonnes phosphate, 5 million tonnes of potassium, and over 50 million tonnes of compost manure.

**Table 8.14** *Bio-Gas Development in Major Selected States of India—2005–06*

| *State* | *Estimated Potential* | *Production* | *Percentage of estimated potential* |
|---|---|---|---|
| 1. Uttar Pradesh | 2,021,000 | 356,300 | 18 |
| 2. Madhya Pradesh | 1,491,000 | 192,950 | 13 |
| 3. Andhra Pradesh | 1,065,600 | 308,520 | 29 |
| 4. Bihar | 939,900 | 119,110 | 13 |
| 5. Rajasthan | 915,300 | 66,025 | 7 |
| 6. Maharashtra | 897,000 | 662,120 | 74 |
| 7. West Bengal | 2,021,000 | 356,310 | 18 |
| 8. Karnataka | 680,000 | 306,845 | 45 |
| 9. Tamil Nadu | 615,800 | 187,265 | 27 |
| 10. Gujarat | 554,000 | 343,700 | 62 |
| 11. Odisha | 605,500 | 171,760 | 28 |

Source: ***Ministry of Non-Conventional Energy***.

It may be seen from **Table 8.14** that Uttar Pradesh has the highest potential in bio-gas, followed by Madhya Pradesh, Andhra Pradesh, and Bihar. The highest production of bio-gas is, however, in the state of Maharashtra (74%) followed by Gujarat (62%) and Karnataka (45%).

The development of bio-gas is adversely affected because of the non-availability of cattle dung, water, labour, space, and low temperatures in certain parts of the country, especially during the winter season.

## ENERGY CRISIS

With the rapid growth of population and increase in the per capita income, there is an increasing demand for energy, especially that of conventional sources of energy. The consumption of energy in the country is increasing at the rate of more than 12 per cent per annum. In the absence of energy, there are frequent power failures, load-shedding, closure of factories, etc., resulting in a decrease in industrial and agricultural production.

In comparison to the developed countries, the per head consumption of electricity in the country is very low. For example, the per capita consumption of electricity in India is 350 kWh as against the world average of 1000 kWh and 7000 kWh in U.S.A. According to one estimate, the country's peak demand projected for 2010 is 175,500 MW against the actual installed capacity of 90,000 MW. This requires an additional installed capacity of 85,500 MW.

Since the coal resources are highly unequally distributed, the transportation cost of coal to the distant thermal power stations is quite expensive.

Mismanagement of power sector, low efficiency of power houses, power theft, labour problem, pilferage, and power wastage are also aggravating the power crisis in the country.

## ENERGY CONSERVATION

The conventional sources of energy (fossil-fuel) are fixed and exhaustible and the non-conventional sources of energy are not adequately developed. Energy conservation is, however, imperative for our survival and for the survival of the future generations. Some of the steps which can go a long way in the conservation of energy are as under:

(i) Emphasis on the development of non-conventional sources of energy. This will conserve the fossil fuels (coal, petroleum and natural gas).
(ii) Reduction in the consumption of energy.
(iii) Use of latest technology for cooking stoves and heating lamps.
(iv) Privatisation of electricity.
(v) Reduction in pilferages.
(vi) Severe punishment for power theft.

All these steps, if taken collectively, can ease the power crisis substantially.

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