# PART I

# 1
# *Resources and Development of Power in India*



## 1.1. INTRODUCTION

The availability of electrical energy and its per capita consumption is regarded as an index of national standard of living in the present-day civilization. The flourishing power generation industry is a sign of growing gross national products which reflects prosperity of the people. Energy has become synonymous with progress. The lack of it and inadequate measure can throttle the entire economic activity and well being of the country. Therefore energy is considered a basic input for any country for keeping the wheels of its economy moving.

Next to the food, the fuel and power are the most important items on which national standard of life depends. Therefore, every stride has been made to increase the power potential of the nation once the requirement of food is fulfilled. The production of food also increases with an increase in power. Therefore, the increase in power potential of a nation is considered most important among all.

The energy in the form of electricity is most desired as it is easy to transport, easy to control, clean in its surroundings and can be easily converted in heat or work as per requirements. The share of the electricity in the total energy consumption of the country has shown a consistent increase and it stands now 28.7% (1985) as against 12.6% in 1953. This percentage electricity in the total energy would have been more but for the recurring power famines, we have been witnessing in almost every state in the country.

India is one of the youngest and yet largest democratic republic in the world, having an area of 1.27 million square miles with a population around 1000 millions. There are 5.76 lakh villages in India and cover a population of about 70% of total population. The history of power development in India dates back to 1897 when 200 kW hydro-station was first commissioned at Darjeeling. In the early years, most of the electricity supply facilities were privately owned and catered to the needs of large towns and cities. The majority of the earlier power stations comprised diesel generating sets. The first steam station was commissioned in Calcutta in 1899 with a total installed capacity of 1000 kW. During the first two decades of the twentieth century, steam power stations at Kanpur, Madras and Calcutta of 2170 kW, 9000 kW and 15,000 kW capacity respectively were commissioned. Similarly, hydro-plants of 4,500 kW at Sivasamud in Karnataka in 1902, 3000 kW at Mohora in J and K in 1907, 500 kW at Simla in Himachal Pradesh in 1911, 1550 kW at Gokak falls in 1914 and 40,000 kW at Tata Hydro (Bombay) in 1915 were installed. By the end of 1920, the total installed capacity was 130 MW comprising hydro 74 MW, thermal 50 MW and diesel 6 MW. By 1940, the total installed capacity rose to 1208 MW. The period from 1941 to 1950 was full of stress and strain as a result of the Second World War and the partition of the country. The installed capacity in utilities by March 1951 was 1710 MW comprising, hydro 560 MW, thermal 1000 MW and diesel 150 MW. The installed capacity in self-generating non-utilities was 590 MW.

Efforts for organising the power supply in industry in a rational manner began only after independence. Planned power development in a systematic manner began in 1951 with the launching of the First Five Year Plan. During the first plan (1951-56), the installed gernerating capacity increased by 1100 MW bringing the total capacity to 3400 MW at the end of the plan. During the five years period covered by the plan, the generation increased from 7514 million kWh to 11872 million kWh. In the second plan period (1956-61), the investment made in power sector was three times the investment made in the preceding plan. The total installed capacity in the country increased to 5700 MW by the end of the plan, comprising 3800 MW of thermal and 1900 MW of hydro, against the total target of 6900 MW. The total generation rose to 20123 million kWh during this plan period. The first 220 kV line in the country was commissioned during this period. Third five year plan was characterised by two important developments. The first was the recognition of the importance of rural electrification as a key infrastructure for economic development. The second development was the recognition of the importance of interconnecting power stations so that the available generating capacities could be pooled and used to the best advantage. This logically led to the demarcation of the country, for system operation purposes into five regions, namely, Northern Region (U.P., Haryana, Punjab, Rajasthan, Himachal Pradesh and JK) ; Western Region (M.P., Gujarat, Maharashtra, Goa, Daman and Diu) ; Southern Region (A.P., Karnataka. TN, Pondichery and Kerala) ; Eastern Region (Bihar, Orissa, West Bengal) and North-Eastern Region (Assam, Meghalaya, Manipur, Tripura, Nagaland, Arunachal Pradesh and Mizoram) and establishment of Regional Electricity Board in each of these five regions. Additional generating capacity of 4500 MW was added during this plan period making the total national capacity of 10200 MW. The total power generation by the end of the plan was 36825 million kWh. The total investment in the power sector was nearly three times the investment in the second plan and about eight times the investment in the First plan. In the mid-sixties, the country experienced successive droughts. This experience influenced the planners to re-orient the emphasis on rural electrification with a bias towards energisation of irrigation pump sets so that assured irrigation facilities could be provided quickly to farmers for increasing agricultural production. During the three year period (1966-69), the installed capacity increased by 4100 MW and total generation increased to 51,642 million kWh. Three years after the end of the Third plan, the Fourth Five Year Plan (1969-74) was launched in April 1969. The additional investment made in power sector during this plan was Rs. 29,830 million, more than the total invested during the preceding two Five Year Plans and three Annual Plans. Nevertheless, the total addition to generating capacity was only 4150 MW as compared to 4500 MW added during the Third Plan. During this period, the first nuclear power station was commissioned at Tarapore with an installed capacity of 420 MW. The total power generation by the end of plan was 72796 kWh. With the number of difficulties as drought, lack of foreign exchange, available funds and non-availability of technical personnel, the total installed capacity by the end of the Fourth Plan was 18600 MW against the expected target of 21000 MW.

The per capita consumption in 1947 was only 12 kWh which gradually increased to 26 kWh by the end of First Plan, 38 kWh by the end of second plan, 61 kWh by the end of Third Plan, 78 kWh by the end of 1969 and 97 kWh by the end of Fourth Plan. The level of per capita consumption is still being low compared to other more advanced countries (USA 8100 kW/capita and world average consumption : 1000 kW/capita).

In 1980 per capita consumption (97 kW-hr) represents an eight-fold increase since independence. We are still a long way from what is required to provide a decent standard of living for the people. The country is very much behind the advanced countries in this respect *e.g.* USA—7013 kW-hrs, UK—3700 kW-hrs, Russia—2628 kW-hrs, France 2408 KW-hrs and world (average)—nearly 1000 kW-hrs per capita as per the data available in 1980. The total power generated in 1947 was 4930 GW-hr which increased to 49,250 GW-hr in March 1969 and it was expected to reach 80 TW-hr in March 1974. Even in one of the lowest developed countries like Spain, the per capita consumption is about 2500 kWh. (1980). We would need not less than 500,000 MW installed capacity (in 1980 38000 MW) for attaining anywhere near that standard. At the present level of additions to the installed capacity, it is very doubtful whether we could meet even the estimated energy needs of about 400,000 M kWh by the year 2000. This requires an installed capacity of 110,000 MW or an annual average addition of about 4000 MW.

The total investment in the power supply industry was Rs. 190 crores in the preplan period and Rs. 302 crores in the first plan. Rs. 525 crores in the second plan and Rs. 1381 crores in the third plan, Rs. 1253 crores during the three Annual plans (1966-69) and Rs. 2533 crores during fourth plan thus making total of Rs. 6176 crores at the end of fourth plan. The proposed investment in the Fifth plan was Rs. 6190 crores on the basis of 1975 prices. With the successful planning of the fifth plan the minimum per capita consumption will be of the order of 150 kW-hr, to 200 kW-hr, and at the end of the decade (in 1981), the maximum per capita consumption was expected to be only between 250 to 300 kW-hr—one-twelfth of the consumption in U.K. and one twenty-fourth of the consumption in USA in 1969.

As in all advanced countries in the world, the electricity has been the most preferred form of energy in our country also. Its growth rate remained faster than all other forms of energy. The demand for electricity grew at a rate of 12% per annum corresponding to a doubling period of about 6 years. The peak demand in the country has increased from 3.8 million kW in 1960-61 to 11.8 million kW in 1971-72 and the corresponding increase in energy consumption being 17 billion units to 52 billion units against the estimated demands of 16900 million kW-hr in 1960-61 to 74000 million kW-hr in 1970-71 (about 4.3 times). The estimated demand in 1980-81 was about 204,000 million kW-hr, twelve times of the 1960-61. The demand for electricity can be expected to grow faster than in the past (132 billion kW-hr per year at the end of 5th plan) and provision must be made in the planning to provide sufficient capital to meet the increasing demands. The Ministry of Irrigation and Power has reviewed recently the power generation programme and has concluded that it is essential to augment the installed generating capacity in the country to about 35 million kW (40000 MW) by 1978-79 to ensure power supply with an acceptable degree of reliability and quality. However, a plan for increasing the installed capacity to 38000 MW has been drawn up at the end of 5th plan taking into account the availability of financial and other resources. In short, the electricity must be carried to every house and to every development activity to make it clear to the people that they are living in a true welfare-state. We Indians, have still a long way to go in this respect compared with advanced countries.

The main sources of electricity generation in India are hydro-power plants, thermal power plants based on coal and nuclear fuels. Diesel generation is also used to feed isolated localities. Natural gas has been also used in Gujarat and Assam where this source is available to a limited extent.

The increase in power capacity in the 5th plan had been met by using hydel, thermal and nuclear sources of the nation. It is not possible to plan the development on an all India basis due to wide disparity in the growth rate in the different parts of the country. The national growth rate as per the data of 1968-69, was 14% whereas the growth rate in U.P. and Andhra was 35% and 29% and the growth rate in Bihar and West Bengal was hardly 8.7%.

Therefore, it is necessary to plan the development on region-wise basis according to requirements keeping in view the industries likely to be developed in different areas.

Keeping this in view, the irrigation and power ministry has suggested the developments in the different regions as tabulated ahead :

| *Region* | *Total installed capacity required in 1980-81 in M.W.* | *Anticipated demand in 1980-81* | *Additional capacity to be provided in 5th plan period* |
|---|---|---|---|
| Northern | 14400 | 10450 | 6600 |
| Western | 12000 | 8300 | 6300 |
| Southern | 13000 | 9000 | 5800 |
| Eastern | 10000 | 7000 | 5300 |
| North Eastern | 1000 | 550 | 660 |
| Total | 50400 | 36700 | 24600 |

The growth of power generation during various five year plans has been 10.5% (first plan), 4.9% (second plan), 14.3% (third plan) and 6.9% in the fourth plan. This shows that the power industry in the country had been facing serious problems at the end of the Fourth Plan due to shortfalls in the achievement of generation targets. This was due to lack of proper maintenance of plants leading to sub-optimum utilization of installed capacity, organisational weakness and scarcity of funds. Since the beginning of the Fifth Plan, concentrated efforts have been made to reorganise the power industry for a more effective performance and concentrate on developing generation capacity to match the requirements to the maximum extent. The national generating capacity was expected to raise to about 38,000 MW by the end of Fifth Plan. In 1974-75, the additional installed capacity was of the order of 1720 MW which was roughly four times more than the capacity added during 1973-74. New addition to the installed capacity was of the order of 1800 MW in 1975-76 and 2380 MW in 1976-77 show that the growth is well in phase with planning. The growth in the power generating capacity has to be achieved by all three conventional sources of power *i.e.* hydel, thermal and atomic. The limitations of foreign exchange resources and lack of proper know-how in case of atomic stations causes restraints with regards to this source and thus main dependence has to be on the first two sources. Special attention has been given towards a balanced development of peaking and base load stations in each region. The optimal use will be made of these stations both by an integrated operation within the region and where necessary by co-operation between the regions. With these considerations in mind, provision has been made for a number of new starts in the thermal and hydel projects. The power generation in Northern and Eastern regions will continue to be comfortable but Western and Southern regions are expected to face both peaking and energy deficits.

Region-wise breakup of the installed capacity at the end of Fourth and Fifth Plan period are shown in Table 1.

**Table 1. Regionwise Breakup of the Installed Capacity at the end of 4th and 5th plans.**

*Capacity in MW*

| *Region* | on 31-3-1974 | | | *Total* | on 31-3-1979 | | | *Total* |
|---|---|---|---|---|---|---|---|---|
| | *hydro* | *thermal* | *nuclear* | | *hydro* | *thermal* | *nuclear* | |
| Northern | 2200 | 1759 | 220 | 4179 | 4005 | 4379 | 440 | 8824 |
| Western | 1037 | 2612 | 420 | 4069 | 1760 | 5042 | 420 | 7222 |
| Southern | 3080 | 1437 | — | 4517 | 4738 | 2387 | 235 | 7360 |
| Eastern | 580 | 3102 | — | 3682 | 977 | 4452 | — | 5439 |
| North-Eastern | 67 | 147 | — | 214 | 138 | 177 | — | 315 |
| Other U.Ts | — | 3 | — | 3 | — | 3 | — | 3 |
| Utilities Total | 6964 | 9060 | 640 | 16664 | 11618 | 16450 | 1095 | 29163 |
| Non-Utilities Total | — | — | — | 1792 | — | — | — | 1732 |
| Grand Total | — | — | — | 18456 | — | — | — | 30955 |

An additional power generating capacity of 22310 MW had to be added over the next five years, 1980 to 1985. Of this, 16708 MW has to come from thermal units, including nuclear and 5600 MW from hydro.

The total installed capacity at the beginning of 1979-80 was 29200 MW. A capacity of 1799 MW was added during 1979-80 bringing the installed generating capacity to about 31000 MW. The total capacity at the end of next five years was thus to be 53310 MW.

According to the present status of work on various thermal and hydro projects under construction, an additional capacity of 2687 MW is expected to be commissioned during the current year (1980-81). Thermal and nuclear will account for 2280 MW and hydro for 407 MW.

The power generation during 79-80 was 105519 million units as against 103328 million units in the previous year making an increase of 2.12%. Thermal generation recorded an increase of 7.27% and nuclear generation went up 3.78%. The hydro generation was less by 3.81% as compared to the previous year. This was due to monsoon failure in 1979 and consequent reduced water availability.

Last year the *northern-region* recorded an increase of 6.63% in energy generation over the previous year and *western* and *southern* regions were up by 2.4% and 2.34% respectively. The *eastern region* and *north-eastern* region showed a decrease of 6.47% and 3.03% respectively.

Short term measures have been taken to improve power availability in the country. Short-term measures include maximising generation from the existing installed capacity, monitoring of coal stocks at thermal power stations, transfer of power from surplus to deficit areas and arranging supply of spare parts from indigenous and foreign sources.

Specical attention has been given by the Government to the speedier commissioning of the new thermal porjects for a total capacity of 4230 MW in the southern and western regions. The capacity expected to be commissioned during 1979-84 plan period is 1760 MW. These include 210 MW set in the Neyveli super thermal station, the first 210 MW unit of the Ramagundam super thermal stations with ultimate total capacity of 1130 MW and first 210 MW unit of the Raichur thermal station in Karnataka sanctioned for total capacity of 420 MW. The other three new thermal projects which are in the western region, are the Satpura, the Trombay and the Korba super thermal station.

**Energy in the VI-plan-period of 1980-85.** The development perspective presented in the VI-plan projects the growth in the consumption of commercial energy according to the pattern given in the following table.

| *Form of Energy* | *Growth in Consumption* | |
|---|---|---|
| | *(1984-85)/(1979-80)* | *(1984-85)/(1984-85)* |
| Petroleum | 9.1 | 5.8 |
| Coal | 9.8 | 7.0 |
| Electricity | 11.3 | 7.5 |

To achieve the target, the output of coal has to be raised to 165 million tons in 1984-85 and 325 million tons by 1994-95. The corresponding figures for lignite would be 8 million tons and 20 million tons respectively. The domestic crude production had to be stepped up from 11.3 million tons in 1979-80 to 21.6 million tons in 1984-85. (8.4 million tons from onshore and 13.2 million tons from offshore fields.)

Electricity generation is to go upto 191 billion units in 1984-85 and 395 billion units in 1994-95. In terms of installed capacity, the target is to add 19666 MW (thermal 13846, hydro 5130 and Nuclear 690 MW) during the VI-plan period making total capacity of the country 50691 MW. In the choice of new projects, priority is to be assigned to the hydro-electric projects. Acceleration of nuclear power development is also planned which includes 3 new atomic projects (each of $2 \times 235$ MW).

## POWER DEVELOPMENT IN VII (1986-90) AND VIII (1991-95) PLAN PERIODS

The public sector outlay in VIII-plan for different developments is shown in Fig. 1.1 (*a*). This clearly shows that the energy sector requires highest capital among all. Therefore it is necessary to provide huge capital as well as planning for the regional power development as per requirements. This is necessary for overall development of the country.

The power sector has responded well registered remarkable growth. In the last 37 years, the installed capacity has increased by about 32 times (1700 MW in 1951 to 54000 MW in 1988) and generation increased over 39 times (5.1 billion units in 1951 to 202 billion units in 1988) *i.e.* annual growth rate of 9.8%.

It is well known that power resources of the country are unevenly distributed among the states and regions of the country. There are several states which do not have any major untapped energy resources located within their territory but are also situated far away from the major source of energy available in the country. This makes power development extremely complex under the present planning concept of central-state distribution of functions and responsibilities.

The Central Electricity Authority expected the power deficit of 10370 MW (21%) peaking power and energy deficit of 22777 million units (8.5%) by the end of the VII-plan (1985-90) on the national basis.

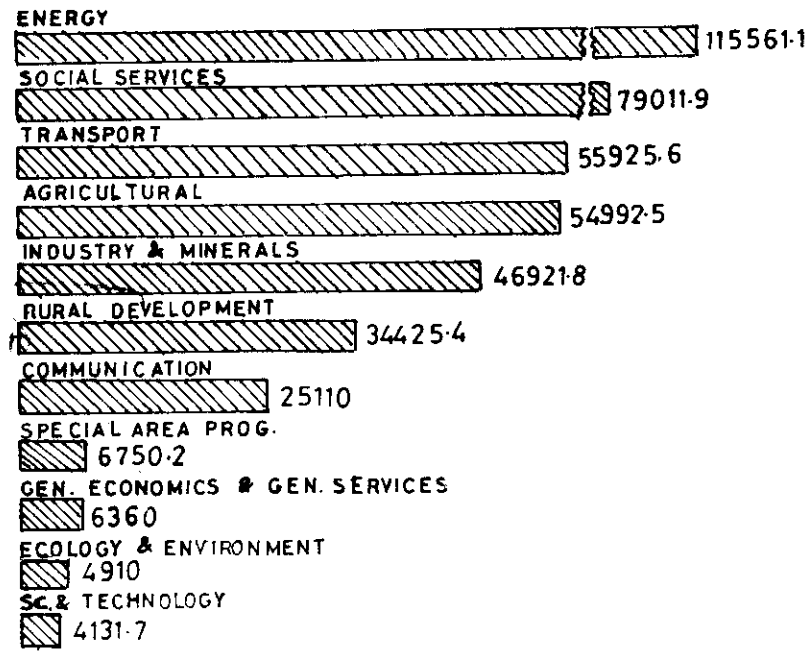



**Fig. 1.1.** (*a*) Public sector outlay in the 8th Plan (1992-97) as per the prices in 1991-92 (Rs. in crores)

The power capacity additions planned during VII-plan are 22500 MW against needed 30000 MW. Funds allotted are 34270 crores against 67500 crores. The additional power needed is only for meeting new demands arising during VII-plan period and do not cover the requirements needed to wipe out the prevailing shortages at the end of VI-plan period for which almost 20% more power would be needed. The funds actually needed are much more than what is provided, therefore serious shortages of funds would result in concentrating on "**On Going Schemes**" without taking up new projects that will yield benefits only during VIII-plan. Hence shortages will continue without any reduction in percentage.

It was estimated that 22245 MW (H – 5541 + T – 15999 + N – 705 MW) will be added during VII-plan period and all India installed capacity would rise to about 65000 MW but due to non-availability of funds, the generation capacity was only 58000 MW.

The peak demand and energy requirement during the last decade are listed below :

| *Year* | *Peak demand (MW)* | *Energy Requirement (million units)* |
|---|---|---|
| 1980 – 81 | 27488 | 135965 |
| 1990 – 91 | 69535 | 388052 |
| | (10% increase per year) | (12.2% increase per year) |

The energy shortages are gradually declining as shown in Fig. 1.1 (*b*). The shortage of energy was about 12.6% in 1987-88 which has come down to 9% in the year 1988-89. During the VIII-plan period (1990 – 1995), the growth rate will further decline and this trend will continue in future. No energy shortage was experienced in the country during 1988-89 atleast 8 to 10 hours a day.

The country is meeting at present a net peak demand of 28000 MW with a peak shortage of 7000 MW. The availability of thermal stations at peak time is about 18000 MW which is only 45% of the total installed capacity of 38000 MW whereas the contribution by hydro-stations is 11000 MW which is 65% of the installed capacity of 17000 MW. The peak shortages and load factors of different regions are listed below as per data available in 1988.

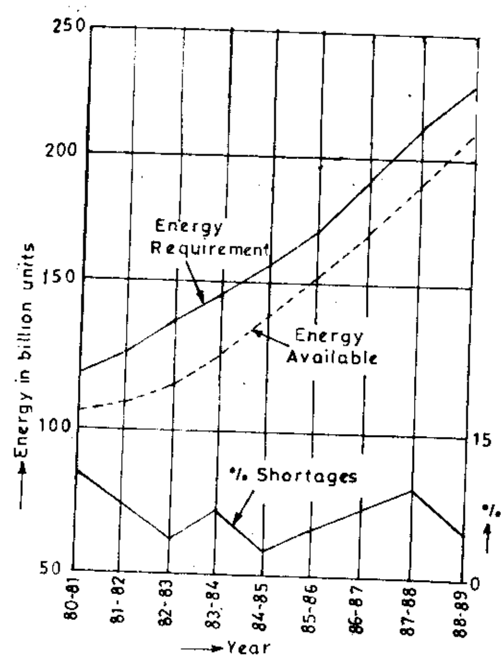



**Fig. 1.1.** *(b)*

| *Region* | *Northern* | *Western* | *Southern* | *Eastern* | *North Eastern* |
|---|---|---|---|---|---|
| Peak demand (MW) | 2000 | 2500 | 1500 | 1000 | 250 |
| Load factor | 0.73 | 0.65 | 0.60 | 0.64 | 0.57 |

A total capacity addition of 35000 to 38000 MW is being estimated for the VIII-plan period (1990 – 95). This capacity addition would enable the country to meet the energy demands. There would be shortages to meet the peak demands as creation of additional generation and associated transmission facilities to required extent may not be available to due constraints of financial resources. Taking this into account, the planning commission has assessed a capacity addition of 34960 MW during VIII-plan period. (H – 9360 MW + T – 24880 MW + N – 700 MW). In addition to this, Government proposes to install gas turbine projects with a capacity of 3000 MW.

Considering that during the VII-plan about 16000 MW of thermal generation is being added and taking into account the future development programme of coal mining industry and railway transport facilities, a program of thermal generation addition of 23000 MW during VIII-plan has been drawn up.

The costing, Rs. 16,230 crores for hydel, Rs. 25,100 crores for thermal and Rs. 28,700 crores towards transmission and distribution totalling Rs. 71,000 crores are estimated. This expenditure accounts for 22% of the VIII-plan outlay of Rs. 3,20,000 crores.

Adequate advance action has already been initiated to ensure realisation of the capacity addition program in VIII-plan. Steps have been also taken to ensure availability of adequate funds during the VII-plan period for taking advance actions on VIII-plan schemes as 5 – 6 years are required for thermal, 6 – 10 years are required for hydel and 8 – 10 years for nuclear plants. About 8000 crores over and above VII-plan outlay of Rs. 34,300 crores are being provided for advanced action on VIII-plan schemes during the VII-plan. In addition to the efforts of finding the power projects from internal sources, schemes of 10,000 MW capacity have already been tied for multilateral assistance. This is in addition to 22 schemes aggregating to about 10,800 MW which have been identified for external assistance due to constraint of domestic financial resources

In spite of the achievements made so far and future plans envisaged for power development, the country is likely to face power shortages. This is on account of the fact that the developing countries often face the dilemma of having an electric power demand growth rate much higher on one hand and constraint in resources on the other. The problem gets further aggravated due to the fact that the investments required to finance the power development programme keep on increasing considerably both on account of the growing size of the power programme and escalating capital intensity. The rate of growth of installed capacity has not been able to keep the pace with increase in power demand and the country is presently facing a power shortage of 10,000 MW (1988). The peaking power demand and energy requirements to be met by the end of VIII-plan have been assessed as about 69,000 MW and 395 TWh respectively. Even with as high as 20% investment of the total plan, the country experienced peaking shortage of 9,300 MW (21.6%) and energy shortage of 15,000 million units (6%) at the end of VII-plan period. During VIII-plan period, there would be peaking shortage of about 11,000 MW (15.5%) and energy shortage of the order of 3000 million units (0.8%). The necessity of providing strong inter-regional links for taking care of the regional power and energy imbalances is essential.

The installed capacity of thermal by the end of VIII-plan would be 63,000 MW and hydro 22,000 MW making the total of 85,000 MW. The centre sector generating corporations are adding thermal and nuclear power stations in a big way without considerations for peak requirements. These plants would work as base load plants at high load factor (LF) and the power stations of SEBs would work on varying loads at low load factor to provide peaking loads.

The energy demand may be met by the end of VIII-plan but peak load demand cannot be met with the present planning of power development. It is not possible at this stage to commission peaking power stations and therefore the only option left is to operate gas power stations to provide maximum peaking. At present, various gas power stations are designed to work at high load factor (0.7). These gas turbine plants will be further converted into combined cycle stations. Some of the gas turbines will have to be operated round the clock so that steam turbines at lower end of the cycle are operated at minimum load. Such a system will be very useful and backing down of power stations during night can be avoided to a great extent and the overall generation is optimized.

The pump storage system is another economical alternative to overcome the problem of peak power demand. But this should be considered when other cheaper options are not available. The overall efficiency of such system is 70% and 30% energy is wasted in conversion. The coal requirement of 1,000 MW pump storage plant to provide 30% loss comes to one million tons of coal. The country cannot afford to waste this much of coal which is to be conserved and properly used. This is the cause, such systems are not taken up in India to provide benefits on the regional basis. There is no national grid and, therefore, transfer of energy from one region to another is not possible. For country like India, pump storage system may not be viable except on certain locations on regional basis.

The Gujarat State is embarking on a tidal power plant to augment its power generation during IX and X plans. A 900 MW tidal plant is proposed to be set up by NHPC during IX and X plans.

Indian Renewable Energy Development Agency (IREDA) has drawn up plans to give a broader thrust for exploration of non-conventional energy sources with wind energy system figuring prominently in the VIII-plan.

Facilities to generate 35 MW of electricity using the wind-power are installed by the end of 1989 under the wind energy programme, 2,400 pumpsets had been installed and small power units had fed 16-million units of electricity into the various grids during 1989. During the period 1985–90, the total investment in renewable energy had been Rs. 435 crores and saving of fuel and organic manure amounted to Rs. 473 crores.

Out of total installed plants to generate energy by wind (35 MW), about 50% of this will be installed in Saurashtra and Kutch region of Gujarat. Gujarat plans to install 100 MW wind power by the end of VIII-plan. The estimated power generation from 120 wind farms is expected to be over 30 million units of power per year.

The first wind farm in the country was setup at Mandvi in Kutch district of Gujarat with a power generating capacity of 1.1 MW. The project Pavanshakti, with a generating capacity of 10 MW through wind power, the biggest in India, was set up at Lamb near Porbander in Saurashtra. It has already supplied 1.75 million units of power to the state grid upto May 1989.

**VIII-Plan**

**Region-wise peak demand and energy requirement (TWh) by the end of VIII-plan**

| *Region* | *Energy Requirement (TWH)* | | | |
|---|---|---|---|---|
| | *1987 – 88* | *1994 – 95* | *Annual load factor* | *Calculated Peak demand* |
| Northern | 59.8 | 112.2 | 62 | 20740 |
| Western | 63.0 | 118.7 | 69 | 19640 |
| Southern | 55.7 | 104.8 | 64 | 18670 |
| Eastern | 28.2 | 54.2 | 64 | 9670 |
| North-Eastern | 2.2 | 5.4 | 53 | 1160 |
| **Total** | **209.5** | **395.3** | **64.6** | **69880** |

**Region-wise Capacity Additions During VIII-Plan**

| *Region* | *Spillover from VII-plan (MW)* | *New schemes (MW)* | *Total (MW)* |
|---|---|---|---|
| **Northern Region** | | | |
| Hydro | 2620 | 2131 | 4751 |
| Thermal | 1420 | 3615 | 5035 |
| Nuclear | — | 470 | 470 |
| **Total** | **4040** | **6216** | **10256** |
| **Western Region** | | | |
| Hydro | 753 | 2011 | 2764 |
| Thermal | 1490 | 4420 | 5910 |
| Nuclear | — | 470 | 470 |
| **Total** | **2243** | **6901** | **9144** |
| **Southern Region** | | | |
| Hydro | 871 | 1140 | 2011 |
| Thermal | 2310 | 3210 | 5520 |
| Nuclear | — | 470 | 470 |
| **Total** | **3181** | **4820** | **8001** |
| **Eastern Region** | | | |
| Hydro | 770 | 110 | 880 |
| Thermal | 2680 | 3155 | 5835 |
| Nuclear | — | — | — |
| **Total** | **3450** | **3265** | **6715** |
| **North Eastern Region** | | | |
| Hydro | 274 | 135 | 409 |
| Thermal | 180 | 302 | 482 |
| Nuclear | — | — | — |
| **Total** | **454** | **437** | **891** |
| **All India (Total)** | | | |
| Hydro | 5287 | 5528 | 10815 |
| Thermal | 8080 | 14702 | 22782 |
| Nuclear | — | 1410 | 1410 |
| **Total** | **13367** | **21640** | **35007** |

**Region-wise Installed Capacity by the end of VIII-Plan**

| *Item* | *Hydro* | *Thermal* | *Nuclear* | *Total* |
|---|---|---|---|---|
| **Northern Region** | | | | |
| VII-plan end | 6101 | 12180 | 910 | 19191 |
| VIII-plan addition | 4751 | 5035 | 470 | 10256 |
| VIII-plan end | 10852 | 17215 | 1380 | 29447 |
| **Western Region** | | | | |
| VII-plan end | 2600 | 17181 | 420 | 20201 |
| VIII-plan addition | 2763 | 5910 | 470 | 9143 |
| VIII-plan end | 5363 | 23091 | 890 | 29344 |
| **Southern Region** | | | | |
| VII-plan end | 8375 | 7258 | 470 | 16103 |
| VIII-plan addition | 2010 | 5520 | 470 | 8000 |
| VIII-plan end | 10385 | 12778 | 940 | 24103 |
| **Eastern Region** | | | | |
| VII-plan end | 1608 | 7006 | — | 8614 |
| VIII-plan addition | 880 | 5385 | — | 6715 |
| VIII-plan end | 2488 | 12841 | — | 15329 |
| **North-Eastern Region** | | | | |
| VII-plan end | 448 | 622 | — | 1070 |
| VIII-plan addition | 409 | 482 | — | 891 |
| VIII-plan end | 857 | 1104 | — | 1961 |
| **All India (Total)** | | | | |
| VII-plan end | 19132 | 44247 | 1800 | 65179 |
| VIII-plan addition | 10815 | 22782 | 1410 | 35007 |
| VIII-plan end | 29947 | 67029 | 3210 | 100186 |

**Average Generation of Thermal and Hydro Power Stations per kW of Installed Capacity**

| *Year* | *1978-79* | *1979-80* | *1980-81* | *1981-82* | *1982-83* | *1983-84* | *1984-85* | *1985-86* | *1986-87* | *1987-88* | *1988-89* | **Average of 10 years* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Units generated per kW of Thermal | 3649 | 3734 | 3626 | 3817 | 3762 | 3817 | 3632 | 3733 | 3873 | 4103 | 4239 | 3817 |
| Units generated per kW of Hydel | 4379 | 4136 | 3970 | 3728 | 4094 | 3798 | 3623 | 3751 | 3346 | 3368 | 2816 | 3728 |

**All India Peak Demand & Energy Requirement**

| *Period* | *Peak Demand in MW* | *Energy Demand in GWH* |
|---|---|---|
| End of VIII-plan (1990-95) | 78438 | 428613 |
| End of IX-plan (1995-2000) | 125400 | 684973 |

**Power & Energy Availability in the VIII-plan Versus Anticipated Requirements**

The position regarding expected peak power demand versus availability and anticipated energy requirements versus availability is summarised in the following tables :

*The average is excluding auxiliary consumption, if this is taken into account, then it comes to 3435 units.

**Note.** Highest thermal generation recorded is 4500 units per kW capacity.

**TABLE I**
**Peak Demand Vs. Availability**

| *Region* | *Peak Power Demand (MW)* | *Peak Power Availability (MW)* | *Surplus/Deficit (MW)* | *% Surplus/Deficit* |
|---|---|---|---|---|
| Northern | 20740 | 19340 | ( – ) 1400 | ( – ) 6.8% |
| Western | 19640 | 18890 | ( – ) 750 | ( – ) 3.8% |
| Southern | 18670 | 15820 | ( – ) 2850 | ( – ) 15.3% |
| Eastern | 9670 | 10220 | ( + ) 550 | ( + ) 5.7% |
| N. Eastern | 1160 | 1200 | ( + ) 40 | ( + ) 3.4% |
| **All India (Total)** | **69880** | **65470** | **( – ) 4410** | **( – ) 6.3%** |

**TABLE II**
**Energy Requirement Vs. Availability**

| *Region* (*TWh*) | *Energy Requirement (TWh)* | *Energy Availability (TWh)* | *Surplus( + ) Deficit( – )* | *% Surplus/Deficit* |
|---|---|---|---|---|
| Northern | 112.2 | 135.6 | ( + ) 22.8 | ( + ) 20.3% |
| Western | 118.7 | 145.2 | ( + ) 26.5 | ( + ) 22.3% |
| Southern | 104.8 | 109.9 | ( + ) 5.1 | ( + ) 4.9% |
| Eastern | 54.2 | 78.3 | ( + ) 24.1 | ( + ) 44.5% |
| N. Eastern | 5.4 | 8.2 | ( + ) 2.8 | ( + ) 51.9% |
| **All India (Total)** | **395.3** | **477.2** | **( + ) 81.3** | **( + ) 20.6%** |

It is obvious from the above two tables that Western region would face a marginal peaking power shortages of about 4% in the terminal year of VIII-plan, the corresponding peaking shortages to be faced by Northern & Southern regions would be of the order of 7% and 15% respectively. Eastern & North-Eastern Regions would have surplus peaking capacity ranging from 3 to 5%. As regards the energy position, by and large, it will be seen that, all the regions will be fairly comfortable. The energy surpluses in the Eastern & N. Eastern regions would be in the range of 40 – 50%.

The above power supply position likely to prevail in the VIII-plan terminal year leads to some important conclusions in regard to strategies to be adopted for power development planning as suggested below :

(1) In the Northern region, it is necessary to expedite the hydel projects in order to take care of the large peaking power deficit and substantial energy surplus.

(2) In the Southern region, efforts should be made to expedite Neyveli & Manuguru Projects (both are under central sector) so as to commission full capacity of 2100 MW by VIII-Plan end.

(3) Strong inter-Regional tie lines between Eastern & Southern regions and Eastern & North regions should be developed so that the power and energy surpluses in the Eastern region could be optimally used.

(4) Effective load management measures by way of staggering of loads have to be taken in order to cope up with the peaking shortfall and energy surplus situation.

**Financial Requirements of VIII-Plan**

According to the capacity addition programme of about 36200 MW is likely to be added during 8th plan, the estimated requirements are listed below :

| *Type of Power Plant* | *Capacity (MW)* | *Estimated Cost Rs. Crores* |
|---|---|---|
| Hydel | 11507 | 17300 |
| Thermal | 24640 | 27100 |
| Associated T & D Works | — | 26600 |
| **Total** | **36147** | **70400** |

The above costs are on the basis of 1989 prices. The above capacity addition is exclusive of 1410 MW nuclear generation programmed for VIII-plan.

It is also assessed that during 8th plan, retirement of old generating units would account for reduction of 3000 MW generating capacity.

The estimated benefits and fund requirements for the above works are listed below :

| *Type of Power* | *Benefits (MW)* | *Estimated Cost (Rs. crores)* |
|---|---|---|
| T & D loss reduction (4%) | 3000 | 1500 |
| Updating Hydel units | 500 | 280 |
| **Total** | **3500** | **1780** |

The above investment would be of a very cost effective nature since the cost works out to be about Rs. 5,000/kW only as compared to Rs. 15,000/kW for Hydel and Rs. 11,000/kW for Thermal.

All these costs are based on the prices in 1989.

Apart from the above, a provision of Rs. 935 crores is required to be made for the Renovation and Modernisation of Thermal Units. It is also expected that about 1400 MW to the grid would be retained which would otherwise be lost due to their obsolence.

To overcome the above-mentioned difficulties, one first important step is to form national integrated system for energy transfer as suggested by NCPU. (National Council of Power Utilities). Proposals have been mooted from time to time for the formation of national grid corporation entrusted with the task of construction and operation of transmission lines and substations (400 kV and above). Therefore, a national policy in this regard requires to be finalised on priority basis as suggested by Rajadhyaksha Committee on power.

**Hydro-Thermal Generation Mix**

Through NCPU, in the early fifties, hydro generation component comprised about 49% of the total generation. However, over the years, due to the strategy adopted for according a higher priority to thermal generation in the country's overall power programme, there has been a steady decline in the contribution of hydel generation and corresponding increase in the thermal generation. On an All-India basis, Hydro-Thermal (including Nuclear) Mix-ratio which was of the order of 49 : 51 about 36 years ago fell to 34 : 66 level by Sixth Plan end, and is likely to fall further to 32 : 68 (including 3% Nuclear) by the end of 8th Plan. This decline in Hydel generation component is rather disturbing as Hydel generation has many advantages over Thermal generation. Hydel generation is based on renewable sources of energy and it is totally pollution free. The region-wise picture of the mix varies a great deal from Region to Region. At the end of Sixth Plan period, Southern Region led with over 60% Hydel Power and hydel contribution was the least in the Western Region being about 14% only.

## NHPC (NATIONAL HYDRO-ELECTRIC POWER CORPORATION) AND ITS ROLE IN THE NATIONAL POWER DEVELOPMENT

The NHPC also was incorporated in Nov. 1975. The main objectives of the NHPC are to plan, promote and organise integrated development of hydroelectric power. The progress of NHPC is not as satisfactory as NTPC because, the hydel plant capital cost is very high and the time period required (10 – 20 year) to develop the project is also large compared with thermal plants (5 – 6 years).

NHPC has developed the following hydel projects :

| *Name of the Project* | *State* | *Installed Capacity (MW)* |
|---|---|---|
| 1. Salal | J. & K. (Commissioned in 1987) | 690 |
| 2. Dul Hasti | J. & K. | 390 |
| 3. Koel Karo | Bihar | 710 |
| 4. Chamera | Himachal Pradesh | 540 |
| 5. Tanakpur | U.P. (Commissioned in 1992) | 120 |

Baira Stul – 180 MW (H.P.), commissioned in April 1982, Loktak – 105 MW (Minipur), commissioned in June 1983, Salal-I (J & K) totalling 630 MW projects are developed by NHPC which were most difficult and vulnerable.

The NHPC is operating, on agency basis, the Devighat project – 14.1 MW in Nepal which is commissioned in Dec. 1983. NHPC has completed the investigations of the Dhaleswari project in Mizoram and submitted the report to Central Electricity Authority. NHPC is also conducting investigations of Dhauliganga project in U.P. with Swedish assistance.

Its perspective plan seeks to add 1815 MW during VIII-plan and achieve 5500 MW by 2000 AD and 7525 MW by the end of X-plan.

**The (NEEPCO) North Eastern Electric Power Corporation**

NEEPCO was established in Oct. 1976 for developing power infrastructure in North-Eastern region. NEEPCO developed Kopili hydel plant of 150 MW and Khandeng plant of 50 MW. It has also undertaken two hydel projects, Ranganadi hydel project and Damine project of 1000 MW capacity.

**Damodar Valley Corporation (DVC)**

It was established in July 1948. The functions of the corporation are to develop schemes for irrigation ; power generation, flood control and navigation in the Damodar river and its tributaries.

The corporation has developed four multipurpose projects at Tilaiya (4 MW), Konar, Maithon (60 MW) and Panchet (40 MW). Power generation in DVC system is shared between Bihar & West Bengal in the proportion of 60 : 40 respectively.

## 1.2. HYDRO-POWER DEVELOPMENT

The role of water in the task of nation-building needs no emphasis. The power developed by the water source in the world plays a very important role in the development of the world and nations. The ocean of the world holds 317 million cubic miles of water which contains 97.2% of the total water that exists on earth. The salty water of the ocean gets evaporated by sun rays and precipitates on the surface of the earth either in the form of rain or as snow. The total water at any given instant in this hydrological cycle is only 0.005% of the entire water storage on the earth.

Hydropower is a commercial source of energy which supplies 22% of total electricity of the world in 1980. It has been estimated that currently a merely 17% of world hydel potential is tapped. Even with doubling of hydro capacity by the year 2000, we would be tapping merely one-third of the world's hydro-potential. Although the hydro-potential of the developing countries is far greater than that of the developed countries, resource constraints have inhibited the growth of the capital intensive hydro-projects.

According to recent estimates, the world's total potential water power is probably equivalent to 1500 million kW at mean flow. This means that the energy generated at a load factor of 50% would be 6.5 million-million kWh, a quantity equivalent to 3750 million tonns of coal if generated in coal fired steam stations at 20% efficiency. Of $6.5 \times 10^{12}$ kWh, 10% are available in Europe, 13% in North America, 10% in South America, 40% in Africa, 21% in Asia and 3% in Australia. The actual installed capacity in the world (as per the data available in 1963) only amounts to 65 million kW or 4.3% of the potential mean flow. India, with high mountain ranges and major river systems, has colossal water power resources. India's total mean annual river flows are about 1675000 million cubic metres of which the usable resources are estimated to be 555000 million cubic metres. Out of total river flows, 60% contribution comes from Himalayan rivers (Indus, Gangas and Brahmputra), 16% from the central Indian rivers (Narmada, Tapti and Mahanadi) and the remaining from the rivers draining the Deccan plateau (Godavari, Krishna and Cauvery).

One of the largest potentials is in the U-bend of Brahmaputra just before it enters India from Tibet which may be exploited with mutual collaboration. The river falls 8000 ft (2400 m) over a distance of 125 miles (200 km) and has a minimum unregulated flow of 30,000 cusecs.

The Indian rivers can be divided into two categories as rainfed and rain as well as snow-fed rivers. The rainfed rivers are characterised by heavy discharge during the monsoon months (June to September) but the flow dwindles to a mere trickle during the summer. In the rain and snowfed rivers originating in the Himalayas, the perennial feed of snow reduces the wide variation of inflow to some extent.

Prior to independence, Mr. J.W. Meares (Electrical adviser to Government of India) made a rough assessment of a minimum potential of 3500 MW and a maximum of 8500 MW for India from hydro-potentials. A systematic assessment undertaken by the commission has shown that India possesses a water potential of 41500 MW. The installed hydro-electric capacity was 1300 MW befor independence and now has been raised to 15000 MW in about two decades. This being a renewable source of energy, we need to give the highest possible priority for the development of hydel potential in the country.

In 1930, the total hydro-electric capacity was 287 MW—48% of total installed generating capacity of 598 MW in the country at that time. In 1951, at the beginning of the first plan, the total installed capacity of the country was 2300 MW of which 588 MW came from hydro-stations using 93000 million cu.m. (17%) of usable water for power generation. The aggregate installed generation capacity of hyro-stations increased from 940 MW to 4097 MW during the period of 1956-1966, the corresponding increase in total installed generating capacity being from 3418 MW to 10173 MW. By the end of 1969, the major, medium and minor projects had harnessed about 193000 million cu.m of water which is 36% of the usable resources. The total hydro-power capacity was 5900 MW out of total nation's capacity of 14300 MW by the end of 1969. The hydro-electric generation has increased from 35% to 43% of total during 1965-66 and 46% to 1969. The abundant availability of water resources, the fairly even distribution of these sources and the overall economy enhanced its development in this country more rapidly.

Apart from being perennial and inexhaustible source of energy, it represents the cheapest source of energy in our country. Its development is based on the use of indigenous technological skill, material and labour and can be achieved with the least strain on the national economy. The cost of hydro-electric project (capital and running) is comparatively smaller than thermal as well as nuclear project based on natural uranium reactor technology as the foreign exchange components required are comparatively less. The capital cost of hydro-project was Rs. 1500/kW installed capacity and energy production cost was 1.5 to 2.5 N.P. per kW-hr against Rs. 2000/kW installed capacity and generation cost of 7 N.P./kWhr at 85% load factor for thermal power plant and Rs. 3000/kW installed capacity and generation cost of 6 N.P./kW-hr at 90% load factor for nuclear power plants on the basis of prices in 1969. These economic advantages and other advantages from the point of view of system operation clearly indicate the need for greater tempo of hydro-electric development in the country.

As foreign exchange in hydro-electric power generation is comparatively smaller than the thermal or nuclear generation, therefore, it is necessary to harness every drop of water and utilise every meter of head to develop maximum amount of hydro-power. With the present day cost, the hydro-electric power generation is considered more economical compared to either thermal or nuclear power. The cost of hydro-power should not be based on the cost per kW installed but on the cost of energy that can be produced.

At present stage, the primary role of hydro-stations in most areas of the country is to provide peaking capacity operating in coordination with the base load thermal or nuclear stations.

India, with its vast geographical expansion, varying climate and topographic features faces a challenging era in the field of water resources development. The major difficulty in the development of hydro-electric projects is that it takes relatively longer time for its hydrological, topographical, geological, and economical investigations as well as the time required for its construction is also large.

Among the topographical, geological and seismological limitations, lack of suitable surface storage sites in Himalayan rivers is a major problem. In the Brahmaputra basin, the problem is one of affording enough protection against flood to the developed regions. In case of west flowing rivers, the narrowness of the region and the limitations mentioned above largely affect the developmental possibilities.

The region-wise distribution of hydro-potential of the country and potential developed and under-development are shown in table 2.

**Table 2. Region-wise Distribution of Hydro-potential**

| *Region* | *Total potential in MW* | *Total potential in thousand million kW-hr (TW-hr)* | *Potential developed and under development* | |
|---|---|---|---|---|
| | | | *in MW* | *% of total* |
| Northern | 6348.9 | 56.4 | 1470.0 | 22.8 |
| Western | 4301.3 | 37.68 | 564.9 | 13.12 |
| Southern | 4858.2 | 42.56 | 1932.3 | 39.8 |
| Eastern | 1616.2 | 14.16 | 344.4 | 21.3 |
| North-Eastern | 7478.6 | 65.51 | 22.5 | 0.3 |
| Total | 24603.2 | 216.31 | 4334.1 | 17.60 |

At the beginning of fifth plan, the hydro-plant capacity is expected to be 7000 MW out of total installed capacity of 18900 MW. During the fifth plan, out of total proposed addition 16500 MW ; the contribution by hydro-plant was expected to be 4000 MW.

The hydro development in the country is caught in the web of short planning horizon, rising costs, constraints of financial resources, organisational deficiencies, long construction periods and lack of sophisticated equipments. Constraints associated with obtaining environment and forest clearances for hydro and transmission projects have further added to the existing problems. Because of these factors, the share of hydro power in the national total has been declining over the years as listed below.

**(Hydro : Thermal) Ratio**

| | *End of VI-plan 1984 – 85* | *End of VII-Plan 1989 – 90* | *End of VIII-Plan 1994 – 1995* |
|---|---|---|---|
| Northern Region | 42 : 58 | 32 : 68 | 35 : 65 |
| Western Region | 14 : 86 | 13 : 87 | 17 : 83 |
| Southern Region | 61 : 39 | 54 : 46 | 46 : 54 |
| Eastern Region | 15 : 85 | 18 : 82 | 14 : 86 |
| Norther-Eastern Region | 39 : 61 | 41 : 59 | 37 : 63 |
| All India basis | 34 : 66 | 30 : 70 | 29 : 71 |

This needs to be arrested, particularly when the country has large hydro-potential. The country has hydro potential equivalent of 473 TWh units annually corresponds to 84000 MW at 60% load factor out of this, the developed and under-development is 15700 MW which is only 18.7% of the total available potential.

Out of total hydro-potential, 33.4% is located in Northern Region, 35.5% in North-Eastern region. The balance 31.1% comprises 7.8% in Western Region, 14.4% Southern region and about 8.9% in the Eastern region which indicates very uneven distribution of the hydel power in the country.

While at the issue of accelerated hydro-development, related issue of developing mini/micro hydro-projects gains importance in the context of our national policy to extend the facility of electricity even to remotest areas where the cost of taking electricity to thin population density areas (particularly hilly) becomes prohibitive due to long transmission and distribution network involved. To overcome this problem, greater emphasis should be given for developing mini/micro hydro projects which can meet the power requirements of local people in such remote areas. The country has 5000 MW mini/micro potential, which is equivalent to 25 TWh per year. 117 mini/micro hydro projects aggregating to about 207.5 MW are under operation and 176 schemes aggregating to 430 MW are under various stages of execution and 333 schemes with 735 MW capacity are under investigation. Detailed investigations on large number of schemes are also underway. The future plans should take this renewable source of energy generation into consideration and earmarked funds provided for development of mini/micro hydro-projects.

The Govt. of Himachal Pradesh invites entrepreneurs to harness the Micro-Hydel Power potential present in various rivers in the state. This is estimated at 500 MW, of which 200 MW have already been identified by H.P. Electricity Board. The H.P. Govt. has invited applications for developing the power in this region upto 15th Feb. 95 as Govt. of India also has offered more incentives as income tax holiday for 5 years and subsidies for surveys and investigations. The promising site in H.P. is shown in Fig. 1.1 (*c*).

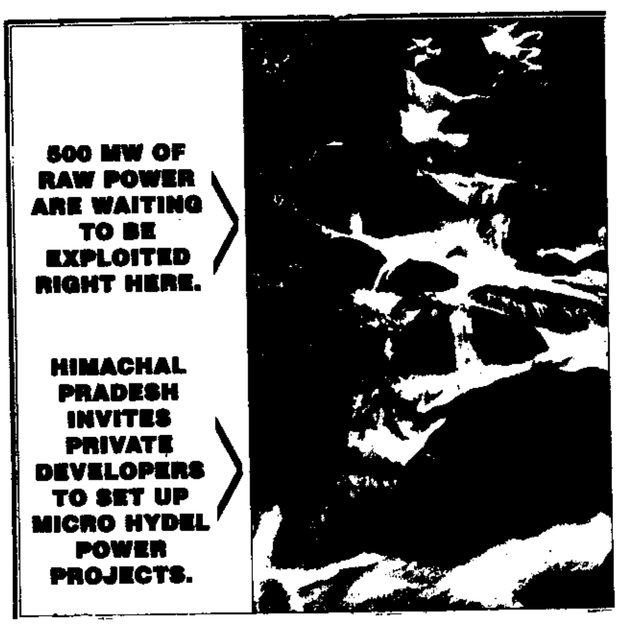



**Fig. 1.1** (*c*).

Keeping view on economic considerations, the developed countries (USA and Switzerland) are already using almost all their potential water power and it is expected that this source of energy will be main survival for all under-developed countries in 21st century. Unfortunately, the mountains and rivers of the world can only provide less than a quarter of the power that will be required on our optimistically low predictions.

With the power development programme, the population becomes a key factor in planning. The available natural resources (gross water) remains constant whereas population keeps on growing. The per capita availability of natural water dwindles with the growth of population. The per capita availability of natural water in 1971 is highest in Brahmaputra basin (28300 $m^2$/year) and lowest in the Krishna and Pennar river basins (410 $m^2$/year). With all the regions in the country reporting a fairly equal rate of population growth and with an estimated total of about 666 millions in 1978, 795 millions in 1990 and 919 millions in 2000 against 547 millions in 1971, the problems of the less fortunate regions and economic implications must be visualized before planning the hydro-power in the different regions.

The worldwide demand for electric energy is increasing by 9 to 10% per year and it appears that hydro-power will have a progressively less important share in the total demand. The role of hydro-power in future moves towards that of providing capacity for peak load. Growth in peak demand thus seems likely to be more significant for hydro-electric development than the growth of demand for energy.

The generation of hydel power is towards increasing trend but it is slow because of huge capital requirements and difficult sites. The expected hydel capacity by the end of VIII plan in shown in Fig. 1.2.

## 1.3. THERMAL POWER DEVELOPMENT

The known resources of coal in India are assumed to be 81,000 million tons which are fairly localised in the four states, West Bengal, Bihar, M.P. and Andhra Pradesh. Most of the resources are of inferior quality (non-coking variety). The limited resources of higher grade coking coal confined to the mines of Bihar and West Bengal are conserved for metallurgical industries. The present day annual production of coal is 90 million tons (as per data available in 1978) of which the thermal stations consume about 30 million tons which is mainly low grade coal with high ash content (as high as 40%).

The recent estimates of coal reserves are of the order of 111878 million tons, out of which 73% are in Eastern Region, 19.5% in Western and about 8% in the Southern Region. This shows that the coal reserves are concentrated mainly in the Eastern Region and to some extent in the Central India. There are some areas like Western part of Northern and Southern regions which have little or no coal and supply of coal to these areas becomes uneconomical as it involves haulage over long distances of 1000 km and above.

Presently, India's largest imports from Australia is coal which stands million $ 489 in 1993-94. According to new guidelines prescribed by the ministry of environment, all coal-based power plants with an installed capacity of 500 MW or more will be granted environmental clearance only when the plants have a linkage with mines which supply washed coal.

This is the area where Australian expertise will be impossible to ignore. All exported coal (150 million tons per year) is washed one (out of 200 million washed coal). More large scale black coal and lignite fired power stations are built in Australia than any other country.

Coal production has made steady strides during last 30 years and production has reached to 140 million tons (1985) presently as compared to 35 million tons in 1951. India is now at the top of the developing countries contributing 3% of coal of the world production. The total coal production in 1994-95 is 190 million tons and is likely to go up in 1995-96 as shown in Fig. 1.3.

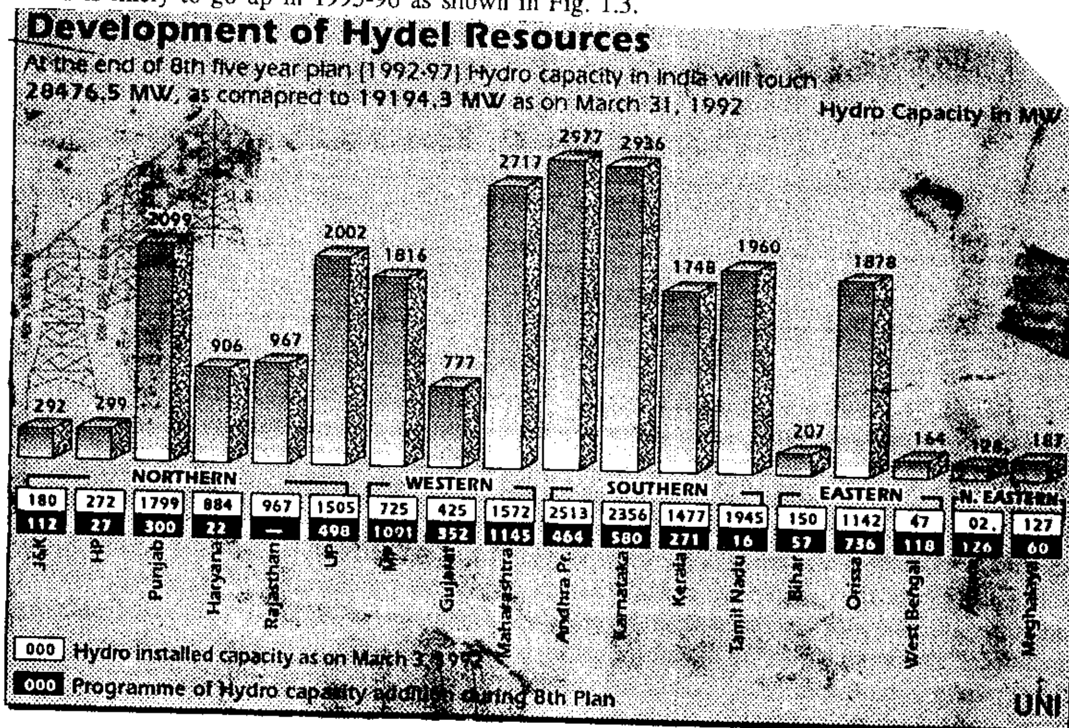



Fig. 1.2.

Oil and natural gas resources are smaller in our country and India has to import large quantities of oil and increasing such imports for power generation is not desirable due to difficult exchange situation.

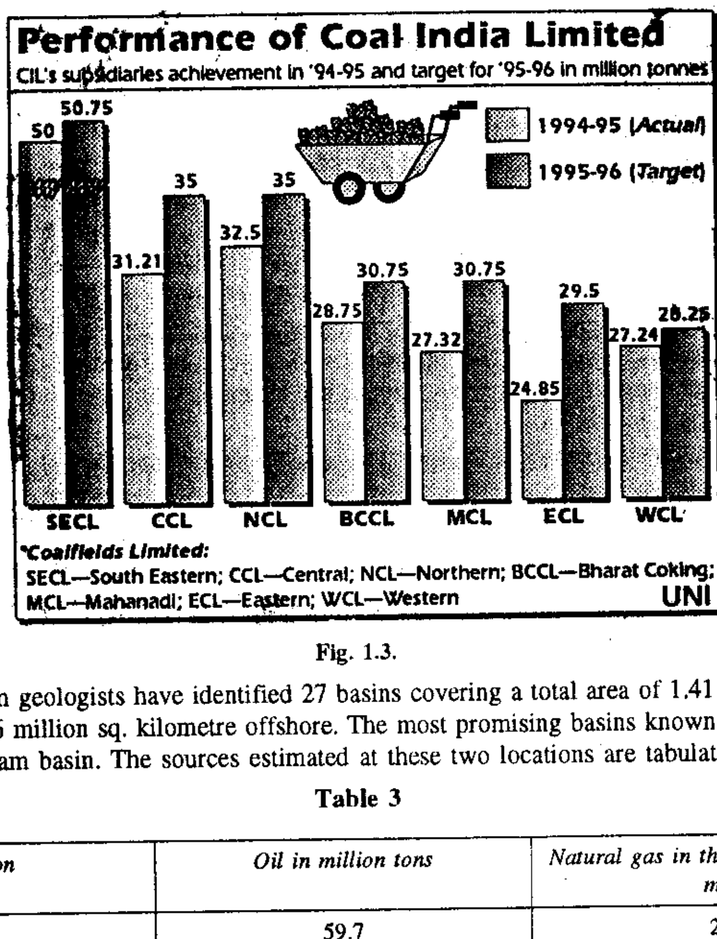



Fig. 1.3.

The petroleum geologists have identified 27 basins covering a total area of 1.41 million sq. km. on land and about 0.26 million sq. kilometre offshore. The most promising basins known today are Cambay in Gujarat and Assam basin. The sources estimated at these two locations are tabulated below.

**Table 3**

| *Region* | *Oil in million tons* | *Natural gas in thousand million cubic metres* |
|---|---|---|
| Gujarat | 59.7 | 23.50 |
| Assam | 70.36 | 42.71 |
| Total | 130.16 | 66.21 |

In spite of the vigorous steps taken to locate additional oil fields, the use of this production cannot be considered for power generation as this will be required for other sectors like transport and industry which must be given first priority. A strange feature about our industrial development is the lack of stress on supply of fuel gas for domestic, industrial and power generation purposes. It is natural gas more than anything else that has brought the post-war prosperity in U.S.A. Today more than a million kilometres of pipeline carries gas upto 4000 miles from the source of its production in U.S.A., whereas India has yet to start in this field. Only in recent years, the country has embarked upon a systematic programme of oil exploration. These explorations have met with success in several parts of the country and crude oil and gas have been brought to the surface. The crude oil during its refinement gives rise to the residual fuel oil. The residual fuel oil and the gas are both capable of being used as fuels for the thermal stations. At present stage, their availability in the country cannot be regarded as blessing.

Oil which has been the world's principal source of energy for the past two decades, is expected to continue for the next two decades. However its future is increasingly clouded by supply limits imposed by nature and by political uncertainties. The world market for oil today is very different from that in 1970. World is rapidly approaching the limits of extracting oil from the vast pool which nature had provided.

Natural gas has many advantages over both coal and oil. It is cleaner and more convenient to transport and use. As a result, it has risen rapidly since world war II and expanding at a faster rate than oil. A rapid increase in natural gas production appears feasible, at least for next half century.

The sudden increase and escalation in the international prices of crude oil from \$ 2.5 a barrel in 1973 to \$ 32 a barrel in 1980 has shaken the world economy at its roots. This impact of price rise has sallowed Rs. 5000 crores against estimated Rs. 1800 crores which is 70% of our export earnings. If such a large chunk goes for the import of oil, finding resources for other necessities become difficult.

The Bombay High has almost peaked and indigenous production has been stagnant and consequently, internal production is making a declining contribution to consumption. The demand for oil is constantly increasing. In 1989-90, the consumption of crude oil was 51.94 million tons compared with 33 million tons in 1980. The indigenous production accounted only 66% in 1990 compared to 33% in 1986. But the demand in 1991 was 20% higher than 1980, so it looks as if we used Bombay High only to meet the increase in our consumption and dependence on imported oil remained same.

With an increase in production from Bombay High, the yield which has been declining because of the ageing wells, is being upped through **an enhanced oil recovery project.** The total output from the Western offshore field will increase from 15 million tons to 24 million tons in the next two years. ONGC has obtained loans of \$ 450 million from World Bank and \$ 300 million from Asian Development Bank for the same. Completion of various oil and gas process platforms in the Bombay High (costing Rs. 4500 crores) would enhance the oil handling capacity by 288475 barrels/day (1 ton = 7.6 barrels) and gas capacity by $25.32 \times 10^6$ $m^3$/day.

The other projects being implemented are the second Bassein Hazira trunk pipeline, the BE-well in the Bassein field will agument the gas handling capacity of this giant field. Heera trunk pipeline project which will create an alternate gas pipeline from Bombay High to shore and South Heera Phase-I will bring the oil from newly discovered reserves (one million tons of oil a year).

The enhanced oil recovery project for L-III reservoir in Bombay High at a cost of Rs. 4952 crores (Rs. 3668 crores in foreign exchange) will augment production of oil by 3.53 million tons a year and gas by 5.15 million $m^3$ a day.

Development of L-II reservoir at a cost of Rs. 2272 crores (Rs. 1783 crores foreign exchange) will produce oil of 1.84 million tons a year and 2.99 million $m^3$ of gas per day. Reservoir simulation studies indicated that cumulative additional production of 16.5 million tons of oil and 8 million $m^3$ of gas from Bombay High is feasible over a period by drilling additional wells. With this objective, ONGC has formulated the L-II development program.

Neelam field, the most promising one in the Western Offshore after Bombay High, is among major projects currently undertaken by ONGC at the cost of Rs. 9725 crores to increase production of oil and gas. The production was 3.24 million tons in 1994-95 and will be 4.5 million tons in the year 1995-96.

ONGC planned to invest Rs. 600 crores in Mahesana area of North Gujerat for the production of oil. It is estimated that $22 \times 10^6$ tons of oil will be available from this area in 20 years period. It is also further estimated that an industry around this area will develop investing 13000 crores of capital.

In addition to above, ONGC and IOC (Indian Oil Corporation) are also planning to set up big refineries in the country.

A grass-roots petroleum refinery, promoted by a group of non-resident Indians at an estimated cost of Rs. 4000 crores, is coming up near Visakhapatnam in A.P. **Black Gold Refineries Ltd.**, the 100% export-oriented unit, would have a capacity to process 2,00,000 barrels of crude per day or 10.5 million tons per year. It would import crude oil from middle east and manufacture high octane petrol, high speed diesel, diesel, kerosene, liquefied petroleum gas, light and heavy naphtha and furnace oils.

Indian Oil Corporation (IOC) and Kuwait National Petroleum Corporation (KNPC) have signed an agreement in Sept. 1995 to set up a six-million tons refinery in Orissa costing 40-billion rupees. KPNC will supply 50% of the crude oil roughly 3 million tons annually. The crude will be received by tankers at Orissa's Paradip port, where new facilities would be set up for handling crude and its transportation to the refinery through pipelines.

The country's import bill for oil and petroleum products was Rs. 6400 crores in 1990 accounting 23% of our total exports. However, every $ 1 per barrel increase in the international oil prices is estimated to increase Rs. 400 crores to our import bill and increase in price in 1991 is $ 7.5 per barrel. Our oil imports may account for 60 – 70% of our exports.

These are two main reasons for uncontrolled growth of oil consumption. Diesel consumption is growing because of increase in the total volume of freight traffic coupled with its shift from rail to road. Kerosene consumption is increasing because the number of non-electrified homes is increasing in addition to the rapid population increase. This is further added by shifting the rural population to urban area.

**Diesel Consumption.** The transport sector consumed about 48% of the total oil used in the country in 1988 and diesel accounted for 76% of the oil used in the transport sector, in comparison with petrol which is only 18%. The bulk of the diesel consumption in the transport sector is by trucks in 1986-87, trucks consumed 42% of the diesel. Trucks hauled 48% of the country's freight in comparison with 31% carried by diesel locomotives. But to carry 1.6 times more freight, trucks consumed about 9 times more diesel than railways (for freight). This definitely confirms the energy efficiency of railway haulage.

Despite this, the share of total freight transported by trucks has increased enormously, both in relative and absolute terms. In 1950-51, trucks carried only 6% of the total freight of 105-billion tons kilometers and it has risen to 433 billion-tons-kilometers in 1989-90. This is all because of inefficient working of the rail transport (as no door to door service, delays and unreliability).

The success of trucks is primarily because the price of diesel in India is subsidised and pegged at the price of kerosene. Thus, the diesel prices could not be increased without roughly equal increase in kerosene prices. Because, if the kerosene price was much lower than that of diesel, trucks operators adulterate their diesel with kerosene and would create a kerosene shortage. This causes great hardship to the poor because kerosene is used almost wholly in the household sector, about 33% for lighting and 67% for cooking. Therefore, kerosene prices cannot be increased under present conditions.

**Electrifying Homes**

In 1986-87, about 100 million households (88% rural and 20% urban households), *i.e.* 68% of the country's 142 million households, depended wholly on kerosene for lighting. Out of about 6.6 million tons of kerosene used in the country in 1986-87 (in comparison with 16.4 million tons of diesel) about 2.2 million tons was used for lighting. The average consumption for lighting is about 2.2 litres/month/household.

Kerosene lamps have an extremely low luminous efficiency (efficiency of electric bulb is 50 times greater than the kerosene lamp). Therefore, electric lighting will result in a dramatic improvement in the quality of life. Despite this, the number of unelectrified homes in the country is increasing at the rate of about a million households a year. This is because, the number of households is increasing at the rate of about 2.9 millions a year whereas the number of electrified houses is increasing as the rate of 2.1 millions a year. Therefore the country has been forced to increase kerosene requirement at the rate of 7.8% a year.

**Petrol Problem**

The diesel and kerosene requirements of the country account for the bulk of our imports of petroleum products. In contrast, petrol represents only 6.6% of the total oil consumption. Therefore, an increase in petrol consumption is not the major problem in the country. However, petrol which in 1980 accounted for only 12% of the oil used in our transport sector, has increased to 18% in 1991. Thus petrol may be a small problem today but it is also rapidly growing problem.

There is rapid growth (4%) of the urban population which is double the growth rate of the total population. The growing urban population increases the load on local transportation. There are two ways to meet the need (*i*) public transportation as trains and buses and (*ii*) personal two or four wheelers. The decision makers have failed to provide local transportation and in other way they have encouraged the personal transportation by extending the automobile industry at large. And due to inefficient and inadequate local transport, the people have preferred personal vehicles. Therefore, the petrol consumption has increased from 1.5 million tons (1979-80) to 3 million tons (1989-90). This has further increased the import of the oil and dependance of the Indians.

The strategy for reducing the country's oil demand must be based on reducing the demand. The strategy for resolving India's oil crisis is :

(*i*) Shifting freight traffic from road to rail.

(*ii*) Replacing oil with alternative fuels.

(*iii*) Shifting passenger traffic from personal to public transportation.

(*iv*) Providing more electrification to the rural areas.

The above details of the oil requirements show that there is hardly any scope to develop electric power using oil as a fuel. Therefore, whole thermal power industry must be dependent on coal-based power plants only.

The gas-based power plants are coming up in the country as the Govt. of India has decided to allow the foreign companies to enter in this industry. Uran at Bombay is already using gas as a fuel. The combined power cycle has an advantage of high efficiency, therefore, most of the gas based plants will be converted into combined cycle. A pact between India and Oman has been signed to provide gas through pipe line which will supply 56.6 million cubic metres of gas per day for coming 25 years. Therefore, many gas based plants are planned by the Govt. of India in the IX plan period. The details about all this are given in respective chapter.

**Oil & Gas Position in the World**

The oil market in the world is very uncertain and that is because of heavy damage to Kuwait and how long the embargo on Iraqi oil will remain. In addition to this, Gulf's oil policies (specially Saudi Arabia) will play an important role in future.

The 70s decade saw the first oil shock. After 1973 crisis, it was clear that multi-national oil companies could not manage future crisis by themselves, it was upto the Govt. to take on that role. The decade of the 1980s started in spectacular fashion. Between 1979 to 1981, the oil price went from $ 13 to $ 34 a barrel which was a shock to the world power industry.

The world has experienced another hike in oil prices in Aug. 1990 which went on a roller coaster —a random walk (first went to $ 37/barrel and came down to $ 20/barrel within 3 months). After August 1990, the oil prices in the world market are randomly fluctuating and has big impact on the power industry.

**Present Demand & Supply of Oil**

The oil prices are expected to remain in the $ 20 to $ 25 a barrel in long term scenario, although, the prices could move outside this range for the short term.

Energy demand worldwide has grown by over 3% per year an average since 1980s. Within that total, oil demand rose by 1.8% per year from 1983 to 1986 by just over 2% per year from 1986-89. The growth of oil and energy demand was of course geographically uneven. In Western Europe, oil demand has grown by only 0.6% a year over the last 6 years and in Japan and the U.S, just by 2% a year. But in the new industrializing countries of South East Asia, oil demand has grown by 6.8% a year. At this rate, the use has doubled in 10 years.

In areas where growth has been fastest per capita consumption is still very low. Asia is 1/10 of the level in the U.S. If economic structures keep changing and prosperity keeps spreading through society, the scope exists for continued growth in oil demand. Demand could be pushed on by population growth which is over 1.5% per year is 3 times higher than in Western Europe or the U.S.

The mixture of energy demand is changing fast. In the period 1980-84, 42% of incremental energy supply world-wide was met by nuclear power. Oil's share of total energy demand fell from 45 to 40%. The percentage energy supply from different sources in different countries is shown in Fig. 1.4.

Primary Energy
Regional Consumption Patterns 1989

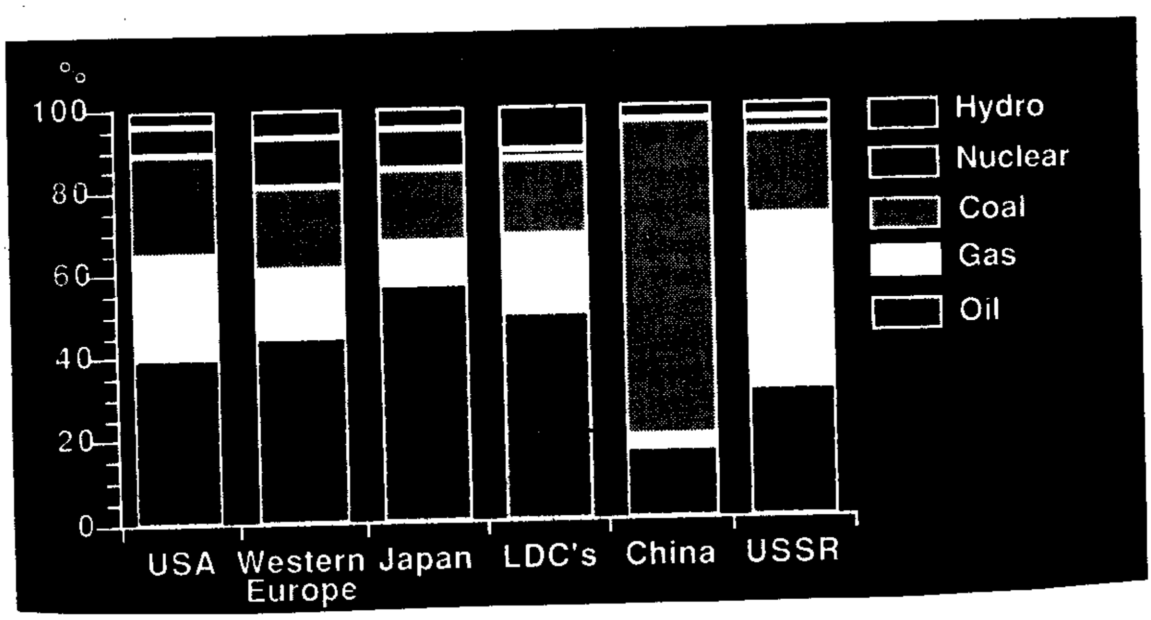



Fig. 1.4.

During the period 1983-89, oil demand grew again in absolute terms. In 1993-95, oil has been the largest contributor to incremental demand. This is partly the consequence of lower prices (as shown in Fig. 1.5)

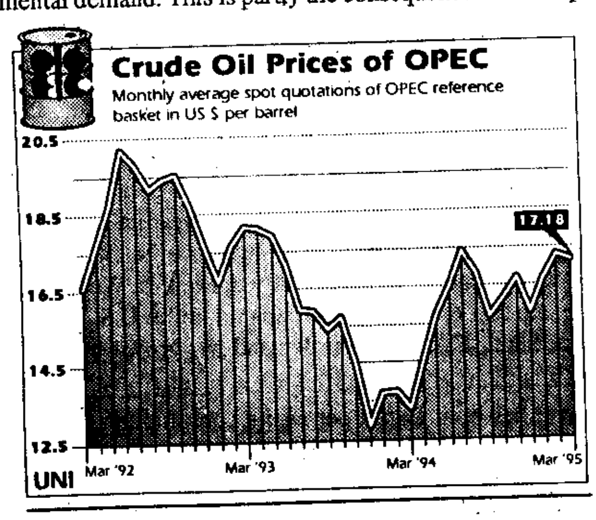



Fig. 1.5.

of oil, partly also the effect of the slow-down in the world-wide nuclear programme and more recently, the aversion to coal on environmental grounds. The net result of all this is that oil demand has been rising and is rising with disproportionate speed in the areas where economic activity and overall energy demand are rising fastest. Demand in those areas could continue to grow. For example, world-wide growth of 2% per year would add more than 12 million bpd (barrels per day) to the current level of demand by the end of century. This is 24% increase.

World oil demand is increasing, mainly in less developed countries, with a very small growth of just 1% per year for the period of 1990-95 and then accelerate to 2% by the end of 2000. This number suggests an absolute increase of around 10 million bpd. The world-wide consumption of oil for the period 1970-89 is shown in Fig. 1.6.

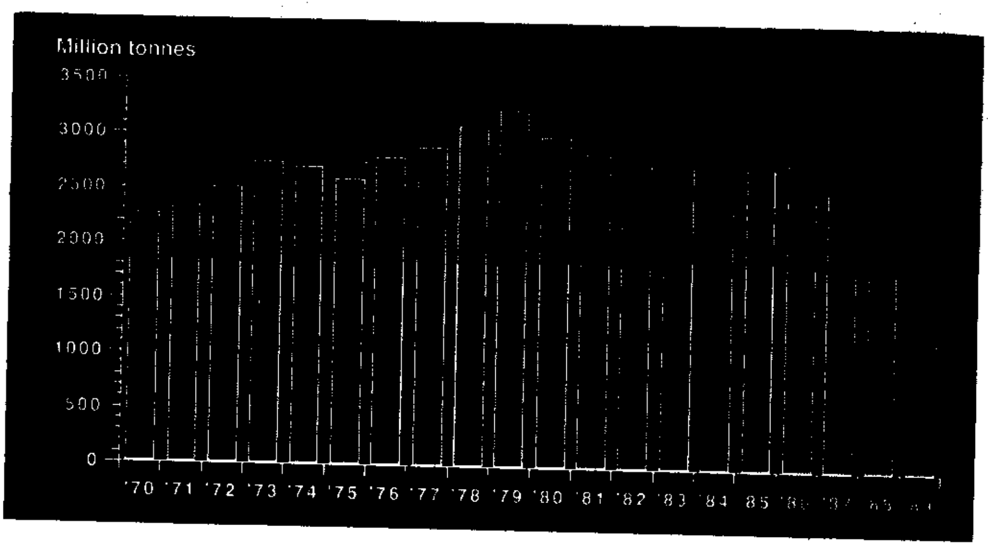



**Fig. 1.6.**

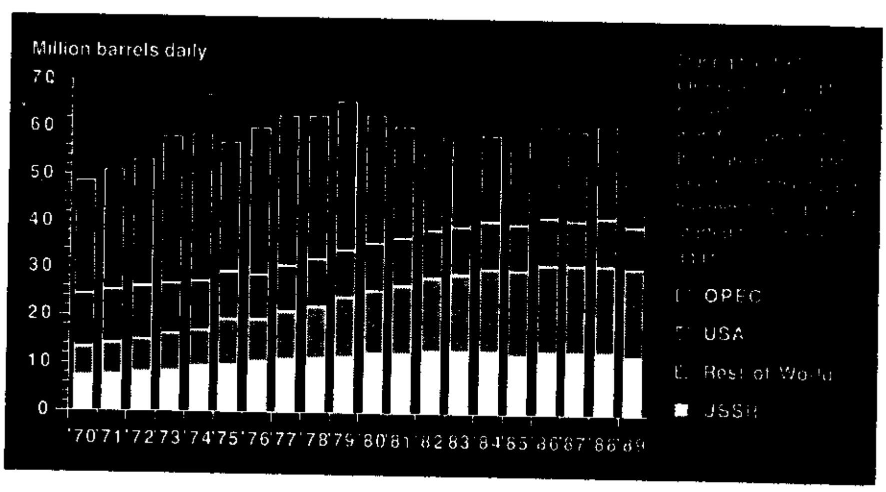



**Fig. 1.7.**

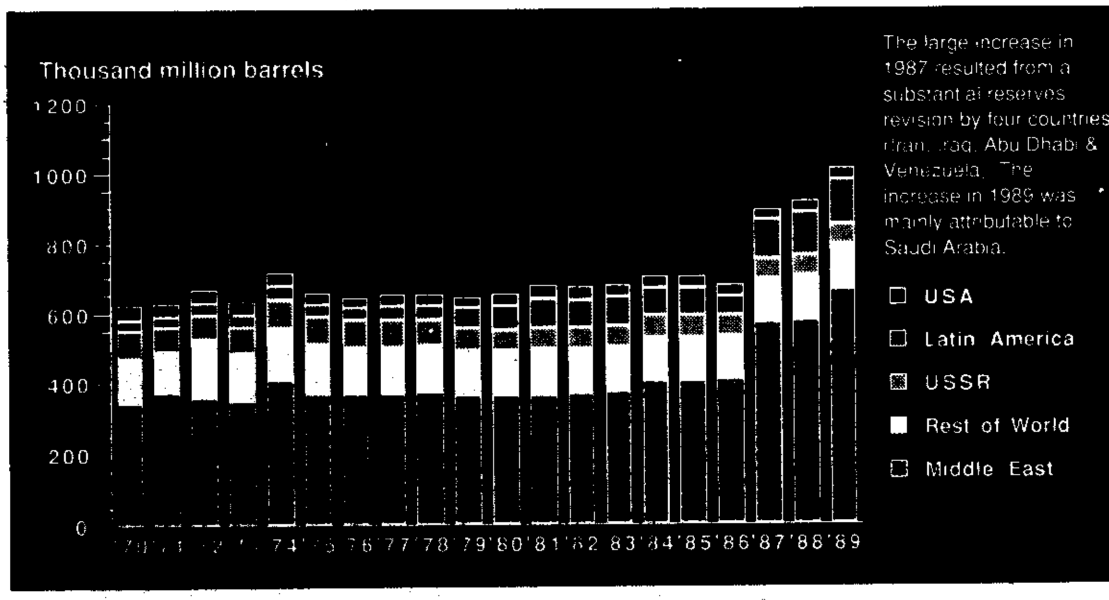



**Fig. 1.8.**

The world supply from Organisation of Petroleum Exporting.Countries (OPEC) in 1989 accounts for 25 million bpd of crude and NGLs, out of this, 3 million bpd are supplied by former Soviet Union States. Since then, supplies from Iraq and Kuwait have been cut by 4 million bpd while other OPEC producers and the few non-OPEC producers with spare capacity moved swiftly towards their full short-term production limits.

The fields in OPEC as well as in the North Sea, and Alaska do reach a natural plateau and then decline. No field can sustain plateau production on an indefinite basis. It is the decline of very large field which will have the most serious impact on the world market. World-wide, 30 fields have provided one-third of total production over 1980-90 and have accounted for almost all the variance in response to fluctuating levels of demand. But there is clear evidence that a number of the largest of those fields are in decline. For example, Prudhoe Bay in Alaska, Samatlor in the former Soviet Union and Super giant Ghawar field in Saudi Arabia have entered their decline phase. The OPEC has shown decline in 1982-83 but again picked up in 1989 as shown in Fig. 1.7.

Now the question arises, is the world replacing its production ? Between 1970-80, the answer was yes. Average oil and gas production world-wide was 81 million bpd oil equivalent (that is 290 billion barrels over the 10 years). But since 1980, a significant gap has opend up. In 1990, the average production was around 90 million bpd oil equivalent (60 million bpd oil and 30 million bpd barrel oil equivalent of gas) in five years. In those five years, only 50 billion of oil and 33 billion barrels of oil equivalent of gas were found—a replacement ratio is hardly 50%.

The reason for this failure to replace production is the failure to locate new fields except Alaska and the North sea are the only new provinces discovered in the last 20 years. The oil production by different countries to make up an increased demand is shown in Fig. 1.8.

Considering extensions and new discoveries only, the average replacement is only 40% but as a group, the majors have succeeded in replacing their production upto 90%.

There are atleast 1500 billion barrels of oil equivalent of reserves of oil and gas already discovered but not yet produced. Developing this huge potential reserve must now be a priority for this industry. Beyond that, there is a further substantial volume of oil and gas remaining to be found. Our best estimate is that there are some 850 billion boe including perhaps 375 billion barrels of oil world-wide. This is equivalent to 6 years of oil production at present rates. Of the 1300 recognised sedimentary basins, 350 remain to be seriously explored. History suggests that one in twelve will contain a field with reserves of over one billion barrels, one in five, a field of over 250 million barrels.

Kuwait, one of the major oil producing country, has drawn up a ten-year plan to raise its oil production to 3.5 million bpd. Present Kuwait production ceiling is fixed at 2 million bpd. Under the future plan, output would reach between 2.5 to 2.7 million bpd in the next 5 years and it will touch to 3.5 million bpd by the year 2005. This will help a lot to fill up the gap of demand and supply of the world consumers.

**Demand and Supply of Gas**

World proven gas reserves are vast and still increasing. It is believed that there are 475 billion boe of gas yet to be found. That is more gas than oil and amounts to 16 years worth at current production level. The proven gas reserve for the period 1978-89 in main 5 countries are shown in Fig. 1.9.

The gas consumption is rising at a rate of 4% per year, with growth rates of the Far East & Australasia running at two and four times this average rate. Western Europe is net importer of natural gas with indigenous production generally declining and Soviet Union, Algeria, Norway and Netherlands being the exporters.

The major gas supply to UK is from North Sea which is constantly supplying the required gas for the last 25 years (from 1965 onwards). But current trend in the new discoveries and production is growing. In the last 5 years (1985-90), gas has accounted for 38% of the hydrocarbons discovered in the North Sea. The North Sea is considered as a gas glue, there is an excess in the ground waiting for development. The present U.K. demand for gas is 5 billion $ft^3$ per day and expected to increase 7 billion $ft^3$ per day in 1995 which is massive increase of 40% in 4-years period which will be used for power generation. Western Europe among the world is lucky enough to have the most balanced energy consumption portfolio in the world.

The world gas consumption for the period 1970-89 is shown in Fig. 1.10.

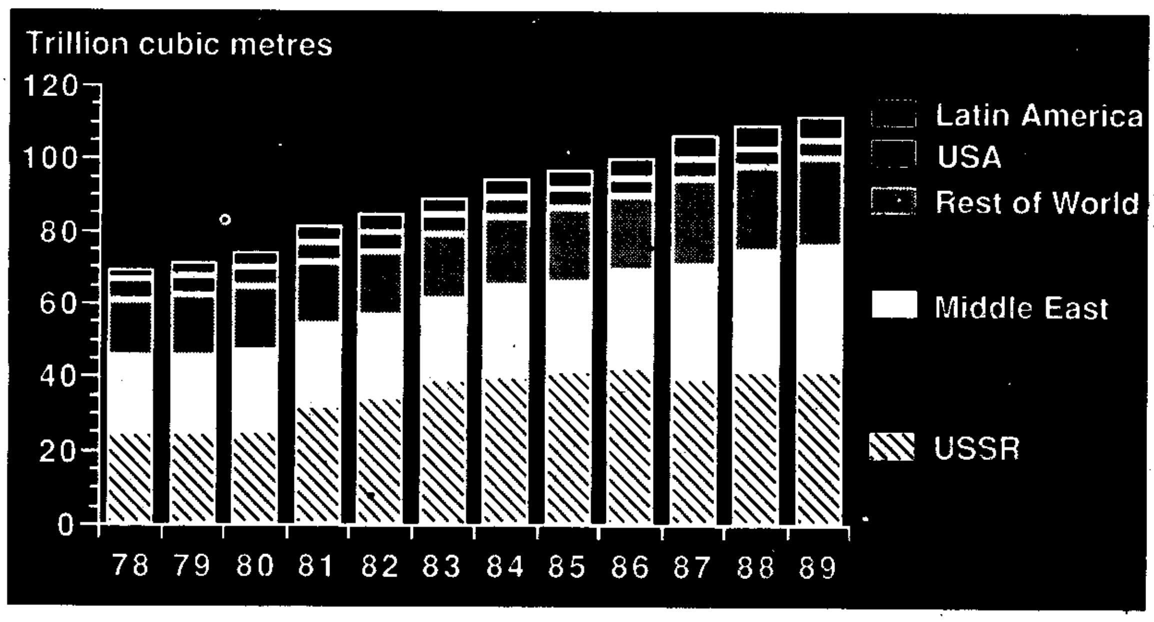



**Fig. 1.9.** The proven gas reserves.

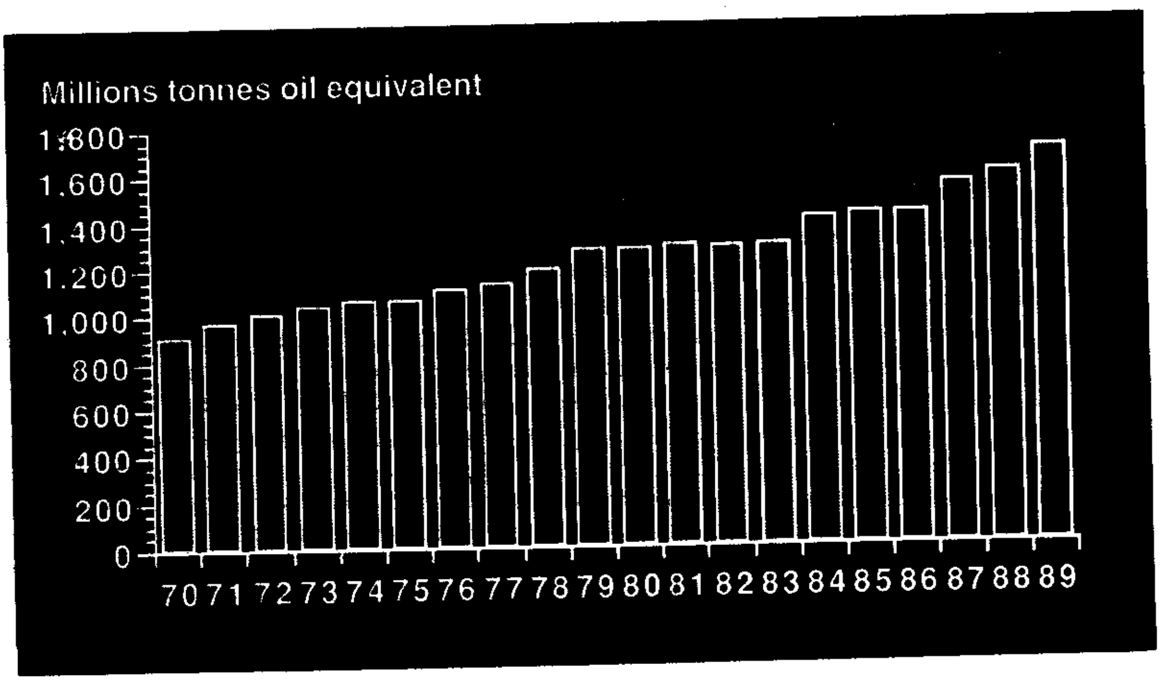



**Fig. 1.10.** World gas consumption.

A thought was given presently to gasify the coal and supply the same to the thermal power plants to avoid the coal haulage problems for fulfilling the mammoth programme of thermal power developments. Every 1000 MW generated by the gas would save the mining and haulage of nearly 2.2 million tons of coal each year.

## 1.4. NUCLEAR POWER GENERATION

Nuclear power provided about one percent of the world's commercial energy and 8% of all electricity produced. Twenty-three countries, including seven developing, depended on nucler energy for part of their electricity requirements. This number will increase as plants now under construction will start operating.

Nations dependent on foreign sources of fossil fuels look to nuclear power as a means of reducing that dependency. It is seen as a leading alternative to dwindling supplies of oil. Originally viewed as a clean, cheap source of energy and virtually inexhaustible, the nuclear option is now subject to serious challenge on grounds of safety and environmental effects.

So far as siting of hydro-power is concerned, we cannot choose any site except those which lends to generation of hydro-electricity. In case of thermal power plants, we have a few alternatives as well as problems also. So far nuclear power is concerned, we can choose any site paying due consideration to safety and available load. India has to consider nuclear generation in places far remote from coal reserves and water power sites. The choice of nuclear power plants has been restricted to areas where they are likely to be competitive on the basis of the present technology of their development. The states which are poor in their natural resources and which are also remotely located from the natural resources (coal and water) ; and those which have very little untapped conventional resources left for future development (Gujarat and Rajasthan) should consider the development of nuclear power. The total nuclear power proposed in the 5th plan was 3000 MW.

The only nuclear fuel which is at present in commercial use is uranium which exists in the form of $U_{238}$. The deposits of uranium have been located in Bihar, Rajasthan and Madras. The amount of uranium available only from Bihar ores is estimated to be 12000 tonnes. It is indicated that the present reserves of uranium available in the country (50,000 tons) may be in position to sustain 10,000 MW of nuclear power for its life time (20 years). It is also estimated that 30,000 tons of uranium can be recovered from the monasite sands of Kerala. The facilities are created to treat about 1000 tonnes of ore per day and yield about 200 to 300 tonnes of uranium metal per year (the ore contains 0.07 to 0.1 per cent of uranium only). The other nuclear fuel is thorium which is a fertile material. The commercial use of thorium for nuclear power generation is tied up with development of fast breeder reactor technology. Our country is highly reputed to have the largest thorium reserves in the world. There are some 5,00,000 tonnes of thorium mainly in two deposits. About 200,000 tonnes are contained in the monarite beach sands of Kerala and about 300,000 tonnes are available in Ranchi Plateau, Partly in Bihar and partly in Bengal. The 500,000 tonnes of thorium has been described as equivalent to all world's known uranium resources. Indian energy economy must await for the development of economic methods for using thorium which is expected to be available by the end of 2000. The nuclear power generation in India will be ultimately based on the utilization of thorium as fuel and this would have to be developed in three stages. The first stage will utilise reactors fuelled by natural uranium producing plutonium as a by-product. (1 to 3 kg of plutonium are generated per ton of uranium fuel depending on burn-up levels). The plutonium will have to be separated from the burnt fuel if one wishes to use as nuclear fuel. The separation process is very difficult because extremely high radioactivity levels present call for complete remote handling of the operations. Such process is prefected in the Department of Atomic Energy and a prototype plant is operating at Trombay. Recently, large capacity plant has been constructed and commissioned at Tarapur. In the second stage, the intention is to utilise plutonium with throrium in fast beeder reactors to produce $U_{233}$. while in the third stage reactors operating with $U_{233}$ are envisaged. One of the factors affecting the choice of nuclear generation in India is the required foreign exchange. The required foreign exchange for coal fired plants is two or three times higher than that required for hydro-stations and it is still higher for nuclear plants. The energy derived from hydro-power and backed by the conventional thermal power will continue to play an important role in the power development in India although the beginning of nuclear power development generation has been made.

The working power plant at Tarapur, north of Bombay (400 MW capacity), and the projected nuclear power stations at Ranapratap Sagar in Rajasthan (400 MW capacity) and Kalpakkam near Madras (200 MW capacity initial) have been influenced by the compelling circumstances of inadequate conventional fuel in the areas and the vital need for firming up of hydro-power.

A considerable portion of electrical energy can be met by nuclear energy in future. Countries like France are envisaging as much as 80% power generation by nuclear source by the turn of the century. The program in India is more modest and our target is fixed between 10 to 20% of total power by the year 2000 A.D.

As nuclear generation is concerned, India could support a natural uranium reactor programme of about 8000 MW. However, recent explorations have indicated reserves as capable of sustaining a much larger nuclear generation programme. In addition to the present six reactors of 1230 MW capacity (Tarapur 2 × 160 MW, Ranapratap 2 × 220 MW and Kalpakkam 2 × 235 MW), eight more reactors of 235 MW each are under construction at four locations. Two are at Narora (U.P.) and they are completed. Two similar are under construction at Kakrapar in Gujerat. During 1988, work had been started for two reactor units, one at Kota in Rajasthan and one at Kaiga in Karnataka. These will be operational in VIII plan as their operation scheduled in 1990 had prolonged.

The target of the nuclear power is 10,000 MW by the end of century which is 10% of the total power generation in the country. Besides 10,000 MW target, two more units of 1000 MW each would be setup in Kudumkulam in Tamil Nadu. Another two units of 235 MW would be completed in Rajasthan and one in Kaiga by 1995 and another two units of 500 MW at Tarapur and four units of 500 MW at Rajasthan are planned in IX-plan period and expected to be completed by 1997.

Once, Indian scientists are able to achieve a break-through in power generation by fast breeder reactor, the country would be in position to sustain a much larger nuclear generation programme, since it is estimated that our thorium reserves are the largest in the world.

The share of the power generation through nuclear source in the world is expected to be reduced by the end of 2000 A.D. due to mounting resistance by the people after Chernobyl nuclear disaster on 26th April 1986. The World-watch Institute in its new report says that a decade of increasing costs, mounting nuclear waste and frequent plant break-downs has crippled most nuclear power programmes. Some countries have decided to stop further development and others are poised to abandon nuclear power altogether.

The nuclear cloud emitted from Chernobyl exacted a heavy toll on the ecology and agriculture of USSR and Europe. As estimated, 7000 kg of radio-active material were released (over 1000 times of what was released at Three Mile Island). Health threatening levels of radioactive materials were deposited more than 2000 km from the plant and in at-least 20 countries. The Chernobyl disaster killed 31 Soviet citizens, and caused acute radiation sickness in 237. Authorities evacuated 135000 people. Farmland has been abandoned, forests razed and the trees buried. The total cost of Chernobyl disaster could exceed $ 10 billion. The effects outside of former USSR were less drastic but still serious. For several weeks, 100 million Europeans reduced their routine consumption of fresh vegetables. As far away as Brazil and Thailand, the sale of powdered milk from Europe was banned.

Anti-nuclear protest also occurred in eastern Europe and former USSR. Public opinion in most countries oppose new nuclear power plants. Chernobyl showed that the effects of nuclear accident can cross borders. In Europe, 119 nuclear plants are located within 100 km of a national frontier. Since Chernobyl calamity, Danish have objected to Swedish plant, German to French plant, Austrian to German plant and Hong Kong to a Chinese plant. Therefore, nuclear power is fast becoming an international question.

If nuclear power generation continues to expand, the frequency of accidents is likely to increase. Three Mile Island accident occurred after 1500 years of worldwide reactor operation and Chernobyl after another 1900 years. If this accident rate continues, there will be three traditional accidents by the year 2000.

Nuclear plants in most nations are plagued by serious mishaps. France which gets 65% of its electricity from nuclear power, has highest rate of forced shut-downs while the Japanese nuclear industry has lowest shut-down rates. In USA, there were 764 emergency shut-downs in 1985. Therefore, France, which had the world's last unrestrained expansion programme, new orders have slowed to less than one per year and state utility is sagging under a $ 32 billion debt.

The future progress in nuclear power industry will be slow because of accident dangers and large numbers of forced shut-downs.

Thus, there are ample resources available in the country to meet the power requirements of the country even for one more century. The states like Kerala, Mysore, Jammu and Kashmir, Assam, Himachal Pradesh and NEFA have sufficient large hydro-resources and these are also located away from collieries. The future power development in these states would be based on exploitation of the hydro-power resources. States like Andhra Pradesh, Madhya Pradesh, Maharashtra, Bihar, Orissa and U.P. have both hydro and coal resources, therefore, the power development in these states must come from an optimum hydro-thermal co-ordination. West Bengal and South Bihar have large resources of coal which can sustain the large scale thermal generation in this area. States like Tamil Nadu, Punjab and Haryana have very little resources left for further development and they would have to depend upon the neighbouring states which have abundant and surplus resources to meet their future demands. Gujarat and Rajasthan are the only states in India which are poor in water and coal resources and are also located far away from coal collieries. Nuclear power generation would be the only solution to meet the future demands in these states. It is also estimated that the nuclear generation is only economical in the places which are situated 800 km or more from the coal fields, when the generation is done with single unit of 200 MW capacity. It has been estimated that by 2000 A.D., the 50% of the power required by the world would be generated by fast breeder nuclear plants. Plans for setting up nuclear plants afloat far off-shore to minimise danger of pollution or accidents are afoot.

The major problem in any electric system, there are variety of needs. The power required usually fluctuates during the day reaching peak at the evening hours and the load is lowest in the middle of the night. The thermal plants find it uneconomical to keep the running during the lean periods. Nuclear plants are more sensitive to fluctuating demand than thermal plants and require a high percentage of base load at high load factor for efficient operation. On the other hand, hydro-plants have the advantage of easy adjustment of generation to the demand. Another point in favour of hydel-plants is the recurring cost per unit of generation is lower than thermal plants. Apart from developing the available resources, in each region according to requirements, it is also necessary to derive maximum benefits through integrated operation of hydro, thermal, and nuclear stations. For economic operation, thermal and nuclear plants must operate at base loads at high load factors and hydro plants may be used to take the peak loads as hydro-plants are ideally suited for such operations due to their inherent flexibility. The suitable mix of hydel and thermal and nuclear is necessary for most economic operation and this is only possible if generation is organised without regard to state boundaries. This concept of mixed operation has been introduced in many power systems. The hydel plants as Idikki in Kerala, Koyna-III stage in Maharashtra and Yamuna-II stage in U.P. have been designed as peaking stations. Another development is the pump-storage plant. In pump storage plant, the water from the lower reservoir is pumped into higher reservoir using the off-peak energy of thermal or nuclear power at night. The stored energy (potential) is then used during peak hours to provide the peaking capacity. This provides most economic working of hydro and thermal among all the systems. There are number of sites in the country where such developments can be introduced. The pump-storage developments with reversible pump turbine installation at Nagarjunasagar dam in Andhra Pradesh, Kadana dam in Gujarat and Kadamparal project in Tamil Nadu are proposed in the fifth plan. The pump-storage plant at Nagarjunasagar would add 100 MW to Andhra Pradesh grid.

It has also become necessary to exploit other natural resources such as geothermal, tides, wind and solar power in the present energy crisis in the world. Detailed proposals for the development of such sources were included in the fifth plan. The prospects of power generation from geothermal energy in certain areas like Manikaran in Himachal Pradesh, Puga in Ladakh and Coastal-area in Maharashtra are found quite bright. A scheme for exploration of such plants is also included in fifth plan. In regard to the tidal power, although the possibilities exist near Cambay in Gujarat, Kutch and Sunderban area in Bengal, the projects involve very high cost on account of the construction of civil engineering structures in deep water. CWPC has proposed to carry out surveys for locating promising project sites.

## 1.5. NTPC'S (NATIONAL THERMAL POWER CORPORATION) ROLE IN THE DEVELOPMENT OF POWER IN INDIA

The development of power in the country was achieved through State Electricity Boards (SEBs) during first three decades after independence. The outlay for power during VIII-plan was Rs. 34270 crores against Rs. 393 crores during the first plan period. The outlay for power remained 19-20% during all plan periods out of total outlay.

With significant achievements since independence, power shortage has persisted because the demand has always been outstripping the supply. This was because, financial resources were not available to the extent required to create the necessary power supply capacity.

Due to the shortages of power in different regions and imbalance power generation, and non-availability of inter-regional grids, it was decided to install generation capacity in the central sector. Two central companies, the National Thermal Power Corporation (NTPC established in Nov. 1975) and the National Hydroelectric Corporation (NHPC) were set up in 1975 and NEEPC (North Eastern Electric Power Corporation) to serve North Eastern region thus was considered a major stride in the establishment of an integrated grid at the national level through inter-connection of regional grids. A third central generation company, the Nuclear Power Corporation (NPC) has been formed to develop nuclear power potential.

The NTPC is executing a number of super thermal power projects and associated transmission systems at an approved investment of Rs. 13568 crores. During VI-plan, NTPC alone accounted for 20.2% of the total thermal capacity additions in the country (and 15.5% of total generating capacity addition). During VII-plan it has contributed nearly 40% of the total thermal capacity additions and would be nearly 24% of the total thermal capacity in the country. It is expected that NTPC would have an installed capacity of about 29500 MW at the present cost of Rs. 40,000 crores by the end of the century.

The first super-thermal power station of 2000 MW capacity was set up at Singrauli in U.P. by NTPC. The power generated is fed to U.P., Rajasthan, Punjab, Haryana, H.P. and Delhi through Northern grid. NTPC ushered the era of 500 MW unit in the country commissioning the first 500 MW unit at Singrauli in Dec. 1986 and another 500 MW unit at Korba super-thermal station in M.P. in May 1987.

The NTPC's projects spread over the different parts of the country include Singrauli (U.P.) with installed capacity of 2000 MW, fully operational, the Korba (M.P.) in the Western region, the largest power station in the country, of 2100 MW capacity, the Ramagundam (A.P.) of 1600 MW capacity in Southern Region, and Farakka (West Bengal) of 600 MW capacity in the Eastern Region. The Vindhyachal Project in M.P. has achieved a generating capacity of 630 MW. Two units of 500 MW each at Richard Project in U.P. have been commissioned. The Kahalgaon Project in Bihar comprises four units of 210 MW each, which is to be setup with Russian assistance. The four units, each of 210 MW are located at Dadri in U.P. In addition to this, NTPC is also managing Badarpur Thermal Power station of 720 MW generating capacity on behalf of Govt. of India since 1st April 1978.

Govt. of India has drawn a programme to set-up six more super thermal power stations in the central sector. These will be taken up at Waiden of 3000 MW in M.P., Pench of 840 MW in M.P., Kahalgaon of 2800 MW in Bihar, Manguru of 3000 MW in A.P. & Singrauli-II of 3000 MW in U.P.

Coming to the Gas Projects, three gas turbines of Anta Project each 88 MW capacity have been commissioned. At Auraiya in U.P., two gas turbines of 112 MW capacity have been synchronised and another project at Talchar (1000 MW) is coming up in Orissa. The gas turbine power plants at Kawas, Anta & Auraiya will be converted into combined cycle plants in future.

By the end of 1988, the NTPC had commissioned a capacity of 8418 MW. NTPC has contributed substantially towards capacity addition program in the country. During VII-plan, the NTPC has added 7718 MW till March 1989 against anticipated target of 7152 MW. Total capacity installed by NTPC by 1990 would be 9352 MW which will be 21.8% total thermal installed capacity of the country.

During VIII plan, NTPC has a program of capacity addition of around 11150 MW which contributes 39.7% of the total thermal capacity addition in the country. The new projects during VIII plan include North Karanpura (1000 MW), Chandrapur (2 × 500 MW), Manuguru (2 × 500 MW), Dadari gas (817 MW), Faridabad (800 MW), Kayamkulam (420 MW), Yamunanagar (840 MW) and Mangalore (320 MW). A long-range plan till the end of century, capacity addition of about 28000 MW is proposed at the cost of 30000 crores.

NTPC has also pioneered the introduction of new technologies in the generation and transmission fields in the country like *merry-go-round* rail transportation system, data acquisition system, and micro-processor based distributed control system, satellite communication and computerisation.

The NTPC energised the following 400 KV transmission lines during 1984-85.

(*i*) Bhilai-Koradi—273 km (*ii*) Muradnagar-Panipat—86 km and (*iii*) Hyderabad-Nagarjun sagar —150 km. The transmission system associated with Rihand super-thermal power station (3000 MW) includes construction of 910 km of high voltage direct current (HVDC) line. The HVDC technology in transmission is being introduced in the country for the first time by NTPC.

To combat the acute power shortage in the South, the NTPC has planned to shift the focus to the Southern states, where the mismatch between demand and supply is quite alarming.

**The bulwork of NTPC in the South would be 2100 MW Ramagundam super thermal power station (226 km from Hyderabad) which is to be upgraded to 2600 MW making it the country's largest single**

thermal power station. The other southern projects of the NTPC are only in the conceptual stage now. The states where the projects are planned are Andhra Pradesh, Tamil Nadu and Karnataka.

Kayamkulam power project of 1300 MW in Kerala, gas based power station using naphtha in the beginning and switch over to natural gas later, 500 MW station in Karnataka (being located Chamrajanagar near Mysore), the expansion of Tuticorin thermal plant and power station at Cuddalore in Tamil Nadu are in the future plan of NTPC.

The NTPC has planned to add over 5000 MW in IX-plan period where these projects will involve an investment of Rs. 16000 crores at today's prices (Aug. 1995).

The NTPC has installed 16085 MW generating capacity (Aug. 10, 1995) during last two decades and navigated from the construction to operation stage. The corporation operates presently 11-coal based and 5-gas based combined cycle plants including Bharat Aluminium Captive Power Project in M.P. and Badarpur in Delhi.

The power projects of NTPC generated 79093 million units which is 23% of the total generation of the country during 1994-95. The corporation netted profit in the same year was Rs. 1112 crores.

For the next 8 years (1995 – 2003), NTPC has chalked out an ambitious capacity addition programme of 10,000 MW by installing several coal and gas based power plants. This will take the total installed capacity of NTPC to more than 25000 MW (20%, 25% of total national capacity).

The future development programme includes the second stage Vindhyachal thermal power station in M.P. where first stage with 1260 MW is already under operation. The work on expansion of the Unchaher stage-II of 420 MW plant in U.P. has also been undertaken with the completion of second-stage, Unchaher capacity will go up to 840 MW. Rihand expansion in U.P. will add a capacity of another 1000 MW. Expansion of the Talcher super thermal project in Orissa will add another 2000 MW. Also, the expansion of Kawas, Anta, and Auraiya gas projects located in Gujarat, Rajasthan and U.P. are in the pipe line. Work on the Kayamkulam project of 400 MW capacity in Kerala is expected to start soon. The cabinet committee on economic affairs had cleared this project with estimated cost of Rs. 1310 crores (Aug. 1995). The first gas turbine would be ready by the middle of 1998. The whole power will be supplied to Kerala in view of the heavy power stortage faced by the state. The 400 MW gas based project at Faridabad is yet to be cleared by Public Investment Bureau (PIB). The A.P. Government has allocated two projects to NTPC, 1000 MW thermal project at Simhadri near Vishakhapatnam and 650 MW naphtha-based Hyderabad Metro-Power project near Hyderabad.

Recognising and anticipating the emergings cenario in the power sector with particular reference to private sector participation, NTPC is seeking alliances with companies having complementary strength. After successful joint venture with a private company for setting up 208 MW unit in A.P., a memorandum of understanding (MoU) has also been concluded with Bombay Suburban Electricity Services to take up construction, erection and project management activities in power sector as a joint venture.

For an environment friendly growth, NTPC has developed a comprehensive environment action plan. Keeping in view, the environmental regulation and need to utilise the ash effectively, an ash utilisation division has been formed. During the year 1994-95, about 1.8 MT of ash has been utilised for various productive purposes. Agreements have already been signed with a couple of parties for making bricks and other products from fly-ash.

NTPC is also executing transmission lines and substation packages at Nepal & Dubai. Recently (Aug. 1995) an order has been secured from Tanzanian Govt. for the preparation of feasibility and project reports for a power station.

The story of NTPC is the story of two powerful and successful decades of excellence in power generation. In a short span of two decades, NTPC has installed 16085 MW, contributing 23% of total power generating capacity in the country, lighting one-fifth of the nation. Another outstanding feature is, plant load factor during 1994-95 was 0.766. It employs 22500 people, with a net profit of Rs. 1125 crores in 1994-95.

**Super-Thermal Power Station at Neyveli.** It has been decided by the Govt. of India to establish pithead super thermal power stations not because they are load centres but because generating power at the pitheads and transmitting electricity to load centres is considered economical because bulk transport of very large tonnages of fuel is avoided. Higher the inner matter and lower its thermal value, higher the cost of transport of coal. This further provides great relief to the Indian railways which is already overloaded.

To alleviate the critical power situation in the country and to exploit its vast reserves of lignite Neyveli Lignite Corporation (NLC) have undertaken a new super thermal power station and also a new open cast mine at Neyveli.

The lignite deposits of the order of 3300 million tons spread over an area of 480 $km^2$ in and around Neyveli are available for exploitation. With a view to attain the annual target of 6.5 million tons against 3.5 million tons per year, specialised mining equipments of higher capacity have been introduced.

Neyveli alone supplies about 40% of the power need of Tamil Nadu. Taking note of the continuing power deficits in the Southern region, the Govt. of India have sanctioned the opening of second mine of 4.7 million tons in 1978 linked to a power station of 630 MW.

The proposals for expansion of second thermal power station from 630 MW to 1470 MW and stepping up lignite raisings in the second mine from 4.7 to 10.5 million tons per year are already sanctioned by the Govt. of India.

**Weak distribution may cripple NTPC units.** An ominous situation is emerging in which the massive power generation capacity being created in the eastern region may lie unused, though the eastern as well as other parts of the country will continue to starve for power. The culprit will be the weak and inadequate transmission and distribution system in the eastern region.

Over the next three years, about 1,500 MW of power generating capacity will be added per year in West Bengal, Bihar and Orissa. Most of this capacity will have to remain unutilised as the transmission and distribution system in these states is not up to the mark. Given that it takes around Rs. 3.5 crore to set up a megawatt of power capacity, this would mean that Rs. 5,250 crore of investment will remain hopelessly locked up.

During the past six months, West Bengal has not picked up any power from the 600 MW Farakka thermal power station of National Thermal Power Corporation (NTPC) on the plea that there is no demand for power in the state. The state is entitled to 35 per cent of the generation at Farakka.

Problems are compounded by the fact that there is no national power grid connecting all the four regions of the country. Efforts are now being made by the NTPC to market this power to Nepal and Bangladesh. NTPC is the main sufferer in this case because 3,000 MW of the 4,500 MW capacities that will come up in this region over the next three years will be through new projects of this public sector company. NTPC is also trying to persuade the public sector transmission company, (Powergrid), to quickly set up additional transmission links so that the surplus power can be wheeled away to the southern region. But these links will take years to complete.

If the transmission and distribution system in the eastern states is strengthened, the consumption of power in the region could go up substantially. At 146 kilowatt-hour per person per year, consumption in the region is much below the all-India average of 253 kilowatt-hour per person per year and far below the 374 kilowatt-hour per person per year average consumption in the western region.

"At first glance, this situation in the eastern region would seem to be an instance of low demand because of the flight of capital and due to the fact that no industry is being set up in this area. But this is not the case," says a power expert. He points out that since there is not enough power being distributed (as distinct from generated), industry is not coming up in the region.

**NTPC's Role in the Development of Gas Based Power Stations**

The NTPC is presently executing 9 super thermal power stations and 4 gas based combined cycle projects. Out of four, Anta, Auriya have achieved their phased operational capacity. The other two at Kawas and Dadri are at different stages of completion.

Seventh plan period witnessed the introduction of gas based power generation. First gas-based unit at Anta was commissioned in 1989.

NTPC has established itself as a pioneer in setting up and operating combined cycle gas based plants. This is going to be beneficial to the nation as substational power generation in future is anticipated through gas based plants. With the recent indications of increasing availability of natural gas in the country, gas based power plants offer major growth opportunities. NTPC has taken up to instal gas based plants at Gandhar (650 MW), Faridabad (800 MW), Dadri (1200 MW), Anta (430 MW), Godawari (800 MW) and Tripura (500 MW). The commissioning of NTPC's gas based units not only marked heralding of the era of gas-based combined cycle plant but also created history in terms of shortening the generation period.

The recent discoveries of significant gas reserves in the country (Western, Southern and North Eastern Regions) have come at a very opportune time and would help to bridge the gap between energy supply and demand over the shorter time horizon.

NTPC has decided to add 5000 MW in the VIII-plan period (1992-97), 3260 MW from coal based plants (65%) and 1740 MW from gas based plant (35%).

It is fortunate that the country has gas reserves of 1200 billion cubic metres. But the Govt. is yet to firm up its policy on use of natural gas for power generation on long term basis. But, in view of the advantages of gas-based generation, it is anticipated that power generation based on gas would continue to increase in the next decade and even beyond.

## 1.6. POWER GENERATION IN PRIVATE SECTOR

Irrespective of all measures taken by Govt. of India to control the population growth, the trend is to increase the population rapidly. Rapid industrial growth has been experienced during last decade. The living standard has also gone high as per capita electric consumption has gone 100 kW/person in 1975 to 300 kW/person in 1995. This clearly shows that the power demand in this country is on the path of increase. The requirement of power may increase still rapidly in future due to population and industrial growth.

The country had failed to keep pace with the demand. Shortages started in 1947. Even today (May 95), there are villages without power, which is essential need as drinking water.

Central Electricity Authority (CEA) is most competent to make assessment about country's power needs. An additional generating capacity of 48000 MW was needed (if plant load factor = 0.6). Based on resources availability, the planning commission had provided only 30,000 MW during VIII-plan period. The CEA had assessed that the on-going projects would be able to add only 20,000 MW by March 1997, causing more than 20,000 MW shortage of power.

The position in the country in the next few years presents a grim scenario with no private sector power project taking off during 1994 due to procedural problems. The peaking shortage touched to an alarming average rate of 25% with energy storage of 10% as both state and central sectors slipped in target capacity by about 10,000 MW during VIII-plan.

The peaking shortage is already on the high side in both Eastern and Southern States, where it hovered between 16 to 42% during 1994. The peaking shortage was highest in Bihar at 41.5%, followed by Orissa with 34.8%, A.P. 31.5% and Karnataka 24.4%.

During the first 3 years of the VIII-plan period (1991-95), fresh capacity of 9348 MW have come up considering Central and State Sectors as against the target of 13715 MW. The state sector spent Rs. 15000 crores on power project against approved of Rs. 17500 crores whereas, the central sector has spent Rs. 11000 crores against an outlay of Rs. 14000 crores.

Not a single private sector power project has taken off during 1991-93, though both Central and State Governments have initiated several measures to promote their development because of numerous clearance difficulties from Govt. Agencies. Therefore, Central Govt. was forced to offer counter guarantees to the first batch of seven private sector power projects despite stiff resistance from the Union Finance Ministry as an incentive in view of the poor finance record of State Electricity Boards.

In 1994, power had been the major constraint for economic growth in the country and situation by the end of 1995 is likely to be further aggravated by witnessing over 30% peak shortage of power and the Northern states might be severely affected by the worst ever power crisis by the turn of the century. A gap of over 25000 MW is expected due to the delay in commissioning of ongoing power projects and slow progress towards renovation and modernisation of old units due to fund constraints.

Based on the targeted 30538 MW capacity addition in VIII-plan, estimated power requirement would be over $416.2 \times 10^3$ (M kWh) as against the availability of $379.2 \times 10^3$ (M kWh), thereby leaving a shortfall of $37 \times 10^3$ (M kWh).

The energy requirement of Northern region is likely to increase from 110.84 billion kWh in 1995 to 162.95 billion kWh by 2000 creating huge gap between demand and supply, whereas India's energy requirement might touch 520 (B kWh) as against 360 (B kWh) at present.

According to the Advisory Board of Energy, demand for power was likely to shoot up to a range between 510 billion and 610 billion kWh by the year 2005 assuming 4 to 5% gross domestic product growth. To meet this demand, an installed capacity of 1,60,000 MW to 1,90,000 MW will be required as against the current capacity of 77,000 MW. The anticipated installed capacity by the end of 2005 is of the order of 1,15,000 MW only. This demands more than double the increase in the present capacity. This addition of power capacity would require 3,50,000 crore worth of investments in the next ten years. The required capacity would be more if higher growth rate of about 6-7% per annum is assumed. This is physically impossible with the present resources with the Govt.

The Prime Minister (May 1995) said that the Govt. wanted private investment in the power sector because it wanted to divert its limited funds to social welfare areas like education, health, roads and welfare. If the available funds are released from infrastructure heads (like power), they could be used on welfare as none would come forward to spend money on welfare of the country as Prime Minister said in inauguration of **India 1994.**

There is resistance by the people to the private sector to enter in the Power Industry as there is fear of high cost of power selling (Rs. 2.5 to 3/kWh against present Rs. 1 to 1.5/kWh). The energy minister Mr. Salve said it is wrong to say that the cost of power would go up with the entry of the private sector. There is no comparison between the cost of power generation by the old plants of the public sector with that of power produced by the private sector plants. The tariffs of the public sector had been deliberately kept low, as a result of which the State Electricity Boards had suffered a loss of Rs. 5000 crores annually.

Recently Haryana Electricity Board (Dec. 1994) has hiked the power tariff in the State, 20% increase for domestic consumers, 10-25% increase for industrial and 30% to the agricultural sector. The tariff is estimated to generate Rs. 14 crores monthly to cover the accumulated losses to the tune of Rs. 140 crores. This one example is sufficient to state that the power charges will be on increasing trend in future.

Presently, the power sector is afflicated with problems including inefficient management, low capacity and plant load factor and high transmission losses. It is physically impossible for Electricity Boards and the State and Central Govt. to cope up with the demand in future as huge capital costs are required and high quality management is needed. Under such circumstances, there is no other alternative to Govt. except to allow the private sector in the power industry.

To attract the private sector, a clear and comprehensive power policy is the need of the hour. Permission for commercial functioning and speedy clearance for projects based on clear cut guidelines will attract adequate foreign and domestic investment for power generation and distribution.

If the power industry is not offered to the private sector, there will be 30% deficit in the VIII-plan period as only 20,000 MW is added against the target of 30,000 MW. There will be great danger in the overall development of the country if the power industry is not offered to the private sector ; therefore, a new simplified policy is offered by the Govt. of India to attract the private sector to enter in the power industry. As per the data available in June 1995, applications are received by Govt. of India from private sector for 196 power projects which may require Rs. 287250 crores and will instal 77720 MW capacity. There are 47 foreign companies who are interested to develop 33850 MW. Out of 47, 39 foreign companies are sanctioned by the Government. Out of 196 projects, 35 belong to A.P. (14400 MW capacity), 28 belong to Karnataka (5495 MW) which may require Rs. 52610 crores and Rs. 21610 crores respectively. By the end of July 1995, 243 companies have entered in the bid totalling 90370 MW capacity to be installed costing Rs. 3,35,370 crores 21402 MW against 22245 MW in VII-plan.

The privatisation of power sector for development of power in MW and required capital in different states is shown in Fig. 1.11.

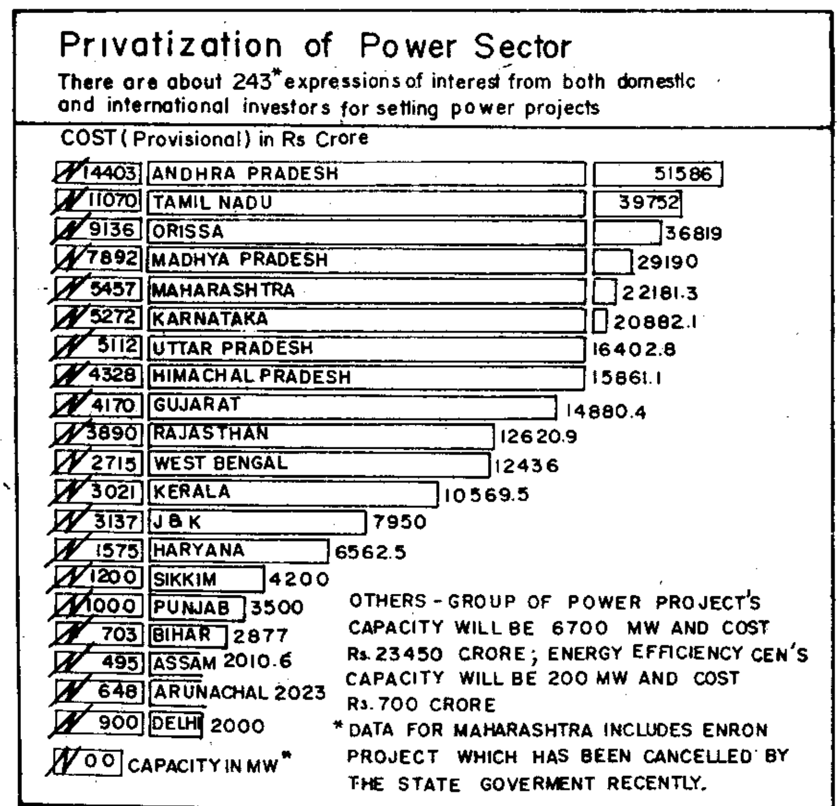



Fig. 1.11.

With the new policy of the Govt. many private companies from India and abroad have entered in power industry as there is great scope to step into power production. In Maharashtra, Enron, Nagothane, Khaparkheda, Umred and Chandrapur are going to be developed by Private Sector totalling 5000 MW capacity addition in coming future.

The GEC and Electricte de France are signing a memorandum of understanding (MOU) with Ispat group on joint development of a proposed 1000 MW thermal plant in Nagpur district of Maharashtra.

Mr. Victor, President of CMS Energy Corporation signed MoU to set up 250 MW power plant in Neyveli in Tamil Nadu which is first US power plant in India. This will be operational in 1997. The second and third unit, each of 250 MW capacity will be taken over by CMS. Tamil Nadu presently has a power shortage of 2000 MW and CMS will be able to generate around 750 MW by the end of 2000. CMS with $ 7 billion of assets and operations in electric and natural gas utilities, oil and gas exploration, natural gas pipelines and storage would also provide its expertise to manage construction and operation of the power plant in Tamil Nadu.

In qualification bids closed in Aug. 1995, 29 companies have put in 44-proposals to set up power plants in the State of Andhra Pradesh. These include Reliance Power, Mittal's of Ispal, Essar, RPG and Nagarjuna Fertilizers. Most of the bids have come for Krishnapatnum, Kakinada & Vizag. Reliance has bid in concentrated way for Krishnapatnam, including 2000 MW (LNG) unit, a 2000 MW coal unit and 410 MW naphtha unit. This is because the company is eyeing a port privatisation possibility in Krishnapatnam.

Another power plant coming up in the private sector is Kochi power project in Keràla which is most power starved state of 1200 MW gas based plant costing Rs. 3500 crores.

The plant is proposed in two phases of 600 MW each. In the first phase, naphtha will be used as a fuel and for remaining LNG.

The power plant is being set up by the Pambinan Radzy, a giant construction company with Kerala state Electricity Board equity participation. The board has also signed for purchase of power at the rate of Rs. 2.2 per unit. The site of the project is very much opposed by environmentalists as it would be disastrous to the fràgile backwater ecosystem. In addition to this, the site of the plant is surrounded by many fishery research institutes and fish seeding areas which may be affected by the blunt emissions.

The Govt. is prepared to give alternate site if the environment impact study confirms the fear. The probable site is Kayamkulam where NTPC is constructing naphtha base power plant.

The Bombay Electricity Supply & Transport Undertaking (BEST) has become the first civic organisation in the country to take up power generation of 360 MW capacity. While Bombay's demand for power has gone up to 600 MW per year, 12% increase over 1994, the BEST plant will generate only a part of this requirement. The plant is expected to be functional by 2000, will use gas as fuel and Naphtha in case of any shortage of gas. The plant will be located at Shivaji Nagar in Govandi which is near to Bombay. Since the centre is planning to buy gas from Oman & Iran, the BEST plant will be able to get its gas supply within 12 to 18 month.

In pursuance to the energy policy of the Govt. of U.P., Energy Department of U.P. Govt. invites proposals to build and operate a power plant of 300 MW capacity using Naphtha as fuel and it is to be located at Harduagani near Aligarh.

The Govt. of Maharashtra in Sept. 1995 has cleared a project of 410 MW (costing 1380 crores) to Reliance Co. going to be set up at Patalganga in Raighad District which was earlier proposed at Nagothane. The Naphtha or gas will be used as fuel. The energy will be purchased by MSEB at the rate of Rs. 2.10 per kWh. The area required is 110 acre which will be offered by MIDC and it is expected that the plant will be operational by the end of 1997.

Indian coal used in the power plants contains high percentage of ash (20 to 40%). A large quantity of fly ash, which is highly polluting, can be eliminated using integrated gasification combined cycle power generation (IGCC). India generates about 40 million tons of flyash per year and only 3% is used in brickmaking and building construction. Recent studies indicate alarming increase in pollution caused by fly ash dumped near power plants and carried to far away places by wind. Some American companies have offered to the power ministry to set up many 500 MW plants based on IGCC which can supply clean power.

### 1.7. ENRON POWER PLANT AT DABHOL IN MAHARASHTRA

There is hardly any day when there is no news about this plant in national newspapers. So much is talked and written about this plant which is first in the private sector. The disputes have come up from the public and political field, the plant is finally cancelled by the new Govt. of Maharashtra and now further negotiations are going on for again starting the project as the management has already spent Rs. 1000 crores during last one year.

The Central Govt. amended laws in Sept. 1991 to allow private sector participation in power projects. The Congress Govt. in Maharashtra and Enron signed a MoU to produce 2015 MW power in June 20, 1993. In December 1993, the MSEB signed the power purchase agreement with a price of Rs. 2.40 per unit in 1997 and will go up gradually. The Govt. of Maharashtra signed the guarantee in Feb. 1994 and counter guarantee by Govt. of India in Sept 1994. The construction work of the project started in 1995 on 300 acre plot overlooking scenic Vashisti river near Anjanveli village.

The project, the first to be developed through direct foreign private investment, involves the setting up a 2015 MW combined cycle gas plant based on the use of eco-friendly liquefied natural gas (LNG). It will come up in two phases.

In the first phase, it is expected to commence operations for generating 695 MW and development of a harbour at Dabhol and fuel oil facilities in the first quarter of 1996. In the second phase, an additional 1320 MW capacity will be added by the end of 1997. The total cost estimated is Rs. 9053 crores which includes a power plant, development of harbour and LNG terminal for re-gas facilities.

The fuel requirements for the power station will be met using LNG which will be procured by the company from West Asian Countries like Qatar and Oman. Enron has already signed a letter of intent with Qatar for a $ 4 billion, five million tonne annual capacity gas project as Qatar is the most likely source of gas for the project.

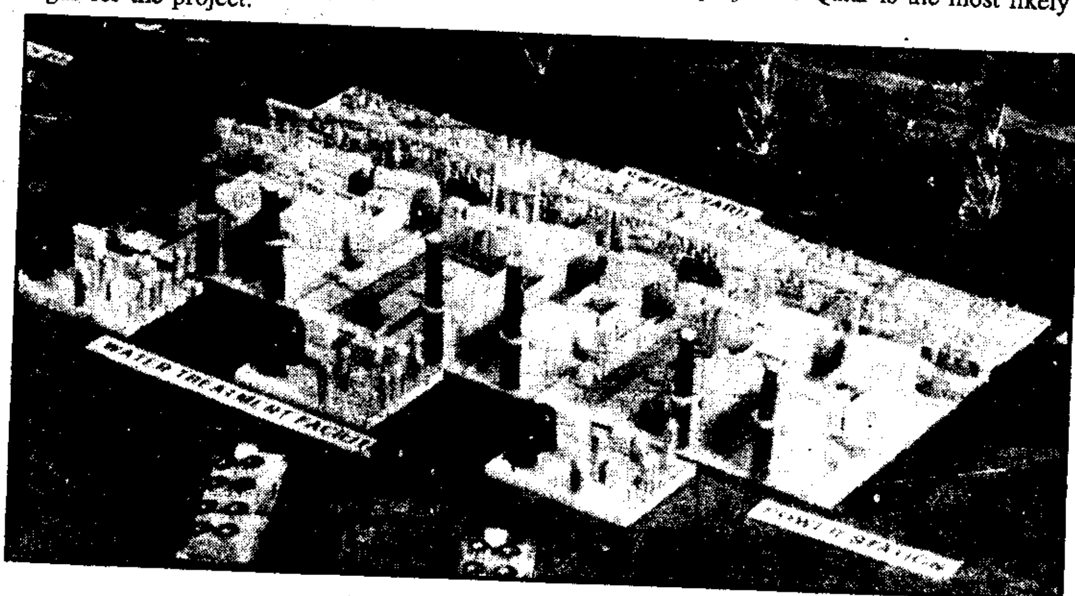


**Fig. 1.12.** (*a*) Look of Enron Power Plant.

This agreement was justified by the Congress Govt. Chief Minister Mr. Sharad Pawar. The present power capacity of Maharashtra is 9987 MW which is less by 2000 MW as per the present connected loads and 3000 MW is in demand. It is likely that the demand may go to (16600 MW) by the end of 2005 when the generating capacity including Enron project of 2015 MW would be only 13055 MW. He stressed further that considering all the existing plant capacity and new plant additions, there will still be shortfall of 4860 MW capacity and 32916 mega units as per the demand projections, particularly in view of the liberalised industrial policy.

The project was scrapped by the new Maharashtra Govt. on August 3, 1995 as per the recommendations submitted by Munde Committee on July 18, 1995. The following major drawbacks in the agreement were listed :

(*i*) The agreement was made with Enron without calling quotations.

(*ii*) The capital cost (Rs. 5 crores/MW) as well as running cost (Rs. 2.50/kWh) in the agreement were considered very high.

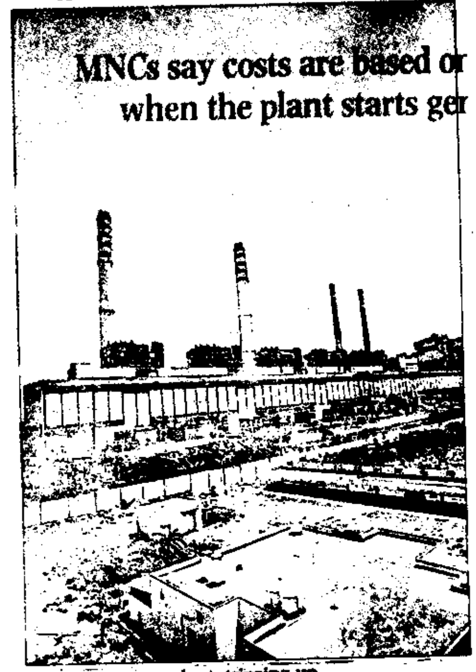
(*iii*) The project is not environmentally sound which may destroy the Konkan scenery and also may cause damage to the agriculture and fishery.

(*iv*) There may be under deal by earlier Maharashtra Govt. because, the gas based plants are always 20 to 25% cheaper than coal based ones, it seems Enron has inflated its cost by the same margin.

The objections raised by new Maharashtra Govt. for scrapping the project were objected and deal was justified by Ex Chief Minister Sharad Pawar giving comparative costs of other plants.

Enron officials state that costs do not matter for their project since it has departed from Govt's. formula and offered a financial price to MSEB (Rs. 2.47/unit) for the first year and 4% rise every year thereafter. This is still cheaper than the price of Rs. 3/unit as calculated under the Govt's. two-part formula.

The comparative capital costs for different power plants are listed below in Tables I & II.




A power plant: tripping up

**Fig. 1.12. (*b*)**

**Table I. Fast-Track-Projects Coming Up**

| | *Place* | *State* | *Company* | *Fuel used* | *Capacity in MW* | *Capital cost in crores/MW* |
|---|---|---|---|---|---|---|
| 1. | Vishakhapattam | Andhra | Hinduja National Power (USA) | Coal | 1000 | 5.81 |
| 2. | Mangalore | Karnataka | Kojantrick Development Company | Coal | 1000 | 5.08 |
| 3. | I.B. Valley | Orissa | AES-Corporation | Coal | 420 | 4.82 |
| 4. | Jagrupandu | Andhra | JVK (USA) | Gas | 235 | 3.52 |
| 5. | Zero Unit | Tamil Nadu | S.T. Power (USA) | Lignite | 250 | 4.5 |
| 6. | Dabhol | Maharashtra | Enron (USA) | Gas | 695 I-phase | 4.19 |

**Table II. Price of Power (in Rs. crores)**

| | *ENRON (695 MW gas-based)* | *GUJARAT TORRENT (650 MW gas-based)* | *GVK INDUSTRIES (235 MW gas-based)* | *AES TRANSPOWER (420 MW coal-based)* |
|---|---|---|---|---|
| Plant & Equipment | 1,452 | 1,839 | 647 | 1,100 |
| Interest During Construction | 400 | 120 | 87 | 400 |
| Infrastructure | 250 | 67 | 30 | 132 |
| Other Costs* | 598 | 272 | 75 | 368 |
| TOTAL COST | 2,700 | 2,298 | 839 | 2,000 |
| Cost per MW | 3.9 | 3.5 | 3.6 | 4.8 |

*Include insurance, guarantee and escalation expenses.

The Chief Executive Officer Rebecca Mark also denied the objections raised by the present Maharashtra Govt. stating that Enron had a contract to rebuild 400 MW Shuaiba North Power Plant in Kuwait which was damaged in the Gulf War ; even the price charged by Enron was 11 cents/kWh which was much higher than normal. Referring to other allegations over pricing of a plant set up by Enron in Philippines, Ms. Mark said that the matter was investigated by the authorities and no impropriety was found. In fact, the Govt. has given Enron, a second contract.

Irrespective of all resistance and justification given by the company and Ex-Chief Minister, the contract with the company has been cancelled by the new Govt. of Maharashtra. The company has already spent Rs. 65 crores for educating the Indians as a part of development programme in addition to the 38% of power plant which was started in March 1995. The company has gone to the London Court for compensation.

It is felt that the scrapping of Enron contract will slow down the National Development as the foreign companies would be disinterested in investing in the power sector. The country needs 142000 MW power in 2005 which will require an investment of 600000 crores and public sector cannot afford to create more than 60,000 MW and therefore the participation of private sector, including foreign companies, is a national urgency.

The scrapping of Enron Project will affect the national economy adversely as

(*i*) The foreign companies would be disinterested in investing in the power sector.

(*ii*) The cost of power production will increase.

(*iii*) The speed of coming up fast track projects would reduce.

(*iv*) The Central Govt. will have to face a financial loss.

(*v*) The foreign capital will be diverted to other undeveloped countries.

Irrespective of all adverse actions taken by the Govt. of Maharashtra, the company is still ready for renegotiation as huge capital is already poured by the company.

The Govt. of Maharashtra is ready for renegotiation provided that the Enron is ready to reduce cost of plant by 1500 crores and cost of power to Rs. 2/kWh against Rs. 2.40/kWh agreed earlier. The Govt. is insisting on significant reduction of the costs because only then, it would be possible for the Govt. to justify the continuance of the project. In addition to this, the company has to give guarantee that the plant would not damage ecology or marine life around it.

## 1.8. PRESENT POWER POSITION IN INDIA

The basic feature of the Indian Energy Scene is the low per capita consumption (315 kg coal equivalent per year). Further it is significant that a large portion of the total energy consumption is met through non-commercial sources of energy such as firewood, animal dung and agricultural wastes. Equally significant is the fact that the share of the non-commercial sources has been progressively declining. Commercial energy consists of electrical power, coal and oil roughly in ratio 25, 25 and 50% and non-commercial energy comprises fire-wood, animal waste and vegetable waste. The commercial energy has gone up from 32% in 1953-54 to 57% in 1975-76 and non-commercial energy has gone down from 68% to 43% in the same period. This is partly an account of the progressive replacement of non-commercial fuels by commercial fuels. The Fig. (1.1.3 *a*) and Fig. (1.1.3 *b*) show India's total energy consumption and share of commercial energy between 1953-2001. According to projection, the demand for coal, oil and electricity by the year 2000 is expected to increase to 531 million tons, 93 million tons and to 52 TWhs respectively. Non-commercial energy utilization is still increasing in absolute terms and it will continue to increase for some time more before it starts declining.

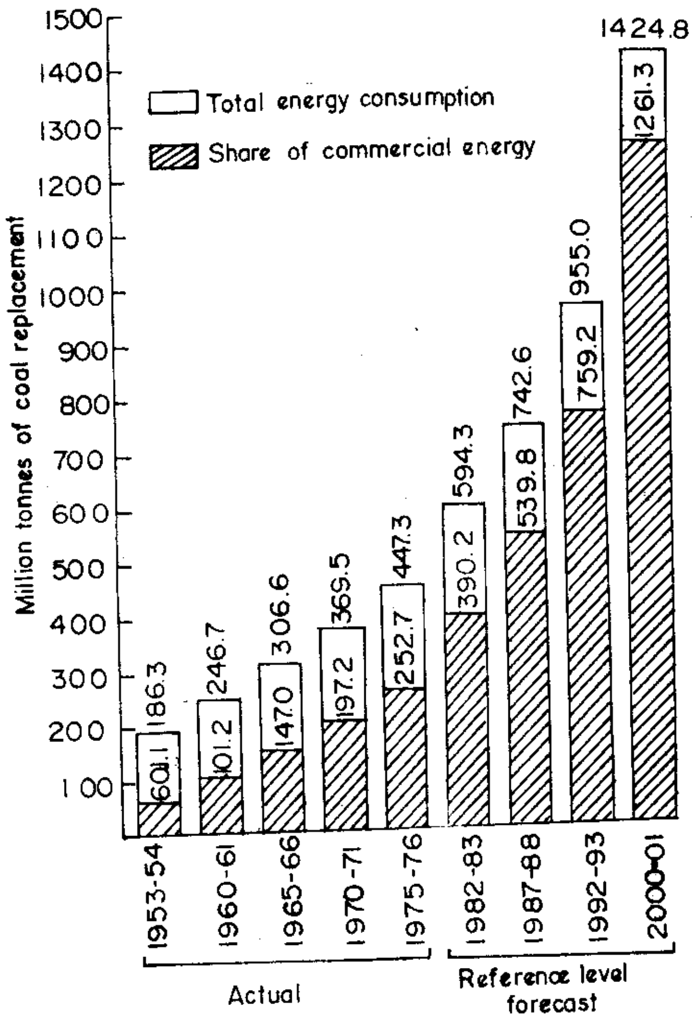



Fig. 1.13 (*a*). Total energy consumption in India and share of commercial energy for 1953-54 to 2000-01.

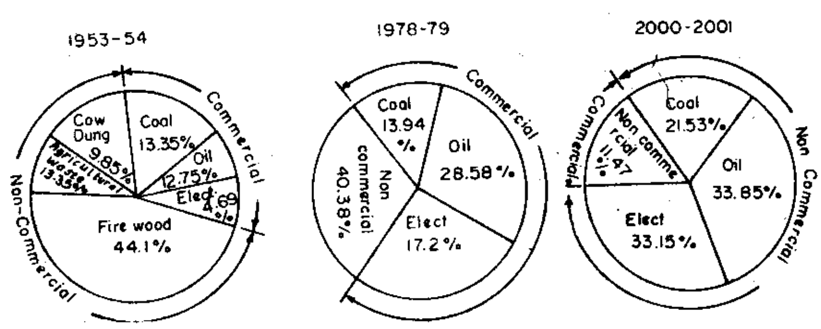



Fig. 1.13 (*b*).

The hydel and thermal resources available in India are shown in (Fig. 1.14). The total hydel resources (including mini and micro are estimated to be 75400 MW to 60% load factor (396.5 Twh/year) out of which 16000 MW are developed till today and there is enough scope for further development from this perpetual source of energy. Besides the hydro-schemes under operation and construction, hydro-electric schemes aggregating an installed capacity of 4530 MW have been formulated and are under various stages of considerations. The power capacity and energy generation developed during 1950 to 1980 are shown in Fig. 1.15 (*a*). and 1.15 (*b*).

The exploitation of coal resources in India is extremely important. Our coal reserves are plentiful (85,000 million tons) and those will be sufficient even for 100 years. But 65% of the total coal exists in the eastern sector. The area which is not yet developed in north-east India where alone we have coal with low ash but high sulfur content. We have to develop these coal resources also. While consumption of coal has risen in all sectors, production and transport of coal has not been able to meet the demand fully. In mid-seventies, coal production went up by 10 million tons in one year and 20 million tons in two years reaching a production level of 100 million tons. The coal consumers travelled from a situation of scarcity to one of full satisfaction of demand. By the end of the current plan the target is about 165 million tons per year. At the end of the century, the target is about 400 million tons which is four times the production level of 1975.

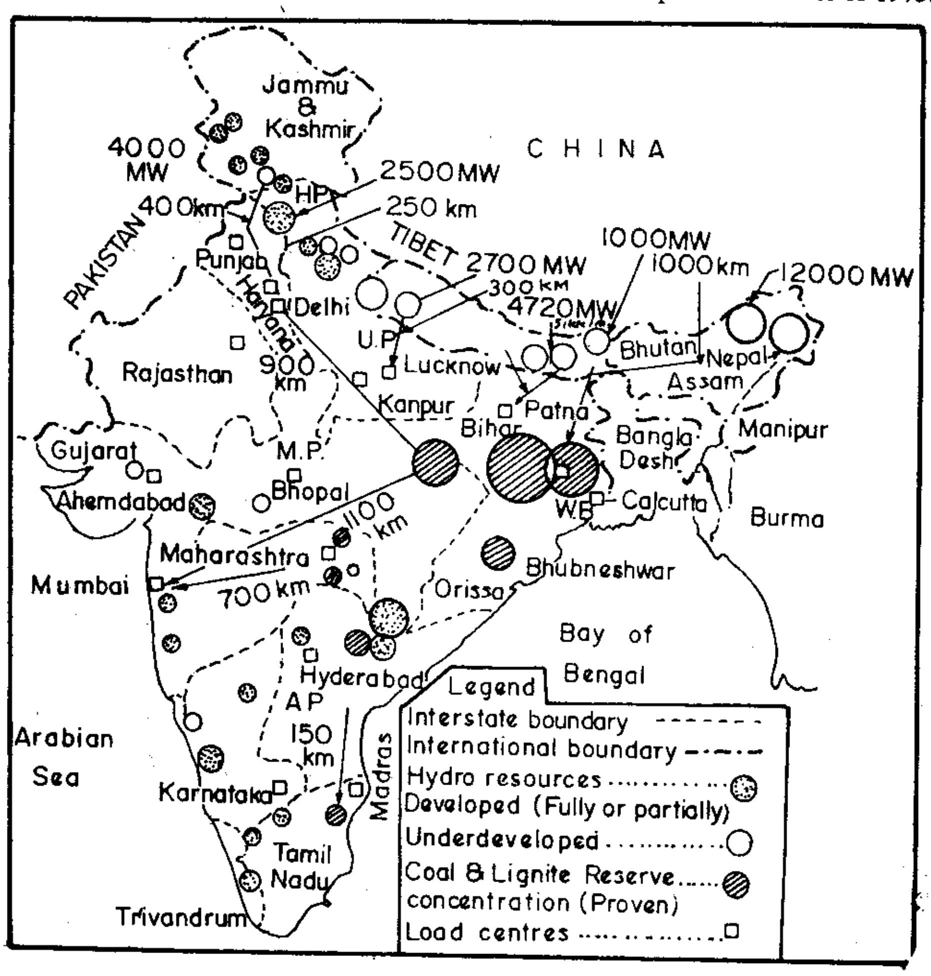



**Fig. 1.14.** Details of hydro power, coal resources load centres and power transmission lines in India.

Lignite is another form of low grade coal and it is found in the states of Tamil Nadu, Gujarat and Rajasthan. In 1976-77, a production of about 4 million tons was achieved (mostly in T.N.), this decreased to 2.9 million tons by 1979-80 on account of various reasons. As a result of various schemes being launched in the VI-plan, the production of lignite is expected to increase to 8 million tons by 1984-85.

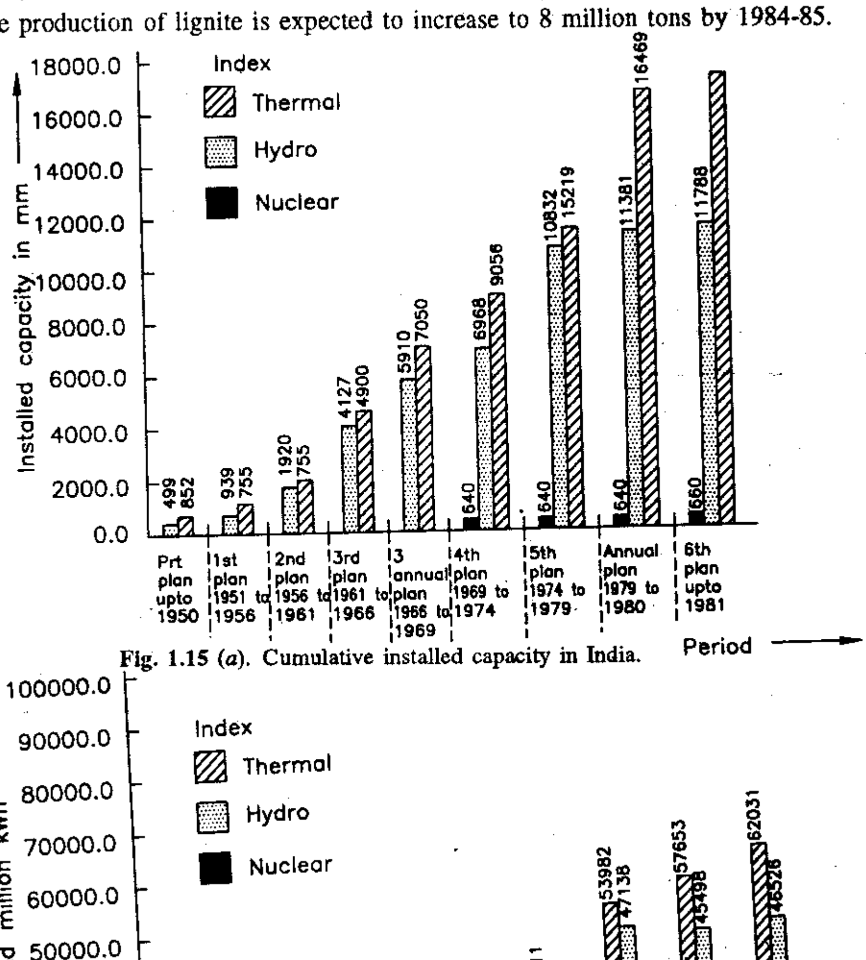



Fig. 1.15 (a). Cumulative installed capacity in India.

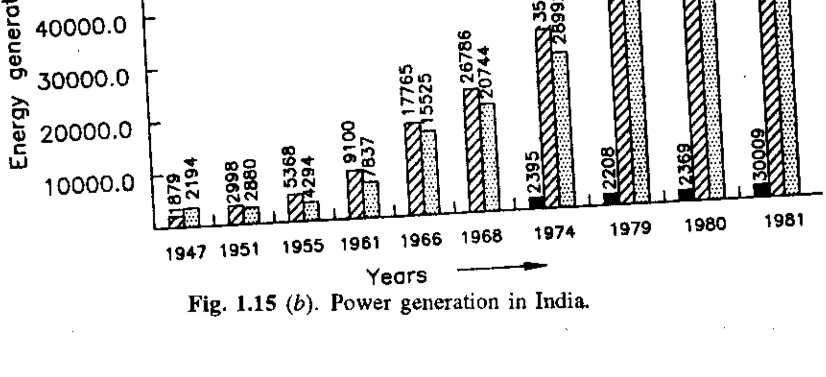



Fig. 1.15 (b). Power generation in India.

**Cumulative Installed Capacity in India (MW) (Public Utility)**

| *Plan* | *Year* | *Hydro* | *Thermal* (*coal + oil + gas*) | *Nuclear* | *Total* |
|---|---|---|---|---|---|
| Preplan | 1897 | 0.2 | — | — | 0.2 |
| | 1900 | 0.3 | — | — | 0.3 |
| | 1905 | 9.2 | 4.3 | — | 13.5 |
| | 1910 | 15.8 | 17.3 | — | 33.1 |
| | 1915 | 72.8 | 36.3 | — | 109.1 |
| | 1920 | 79.5 | 54.0 | — | 133.8 |
| | 1925 | 165.8 | 160.0 | — | 326.0 |
| | 1930 | 282.7 | 292.0 | — | 575.0 |
| | 1935 | 361.9 | 516.0 | — | 849.0 |
| | 1940 | 454.7 | 746.0 | — | 1141.0 |
| | 1945 | 470.2 | 775.0 | — | 1244.0 |
| | 1947 | 499.2 | 852.0 | — | 1351.8 |
| I-Plan | 1950 | 559.0 | 1154.0 | — | 1713.0 |
| | 1953 | 734.0 | 1571.0 | — | 2305.0 |
| II-Plan | 1955 | 939.0 | 1755.0 | — | 2694.0 |
| | 1960—61 | 1920.0 | 2733.0 | — | 4653.0 |
| III-Plan | 1961—62 | 2422.0 | 2797.0 | — | 5219.0 |
| | 1962—63 | 2939.0 | 2862.0 | — | 5801.0 |
| | 1963—64 | 3176.0 | 3400.0 | — | 6576.0 |
| | 1964—65 | 3992.0 | 3401.0 | — | 7393.0 |
| | 1965—66 | 4127.0 | 4900.0 | — | 9027.0 |
| 3-Annual Plans | 1966—67 | 4760.0 | 5333.0 | — | 10093.0 |
| | 1967—68 | 5490.0 | 6393.0 | — | 11883.0 |
| | 1968—69 | 5910.0 | 7050.0 | — | 12957.0 |
| IV-Plan | 1969—70 | 6138.0 | 7544.0 | 420 | 14102.0 |
| | 1970—71 | 6386.0 | 7903.0 | 420 | 14709.0 |
| | 1971—72 | 6615.0 | 8219.0 | 420 | 15254.0 |
| | 1972—73 | 6788.0 | 8874.0 | 620 | 16282.0 |
| | 1973—74 | 6968.0 | 9056.0 | 640 | 16664.0 |
| V-Plan | 1974—75 | 7532.0 | 10145.0 | 640 | 18317.0 |
| | 1975—76 | 8467.0 | 11010.0 | 640 | 20117.0 |
| | 1976—77 | 9029.0 | 11870.0 | 640 | 21539.0 |
| | 1977—78 | 10020.0 | 13009.0 | 640 | 23669.0 |
| | 1978—79 | 10832.0 | 15219.0 | 640 | 26691.0 |
| Annual Plan | 1979—80 | 11381.0 | 16469.0 | 640 | 28490.0 |
| VI-Plan | 1980—81 | 11788.0 | 17698.0 | 840 | 30346.0 |
| | 1981—82 | | | | |
| | 1982—83 | | | | |
| | 1983—84 | | | | |
| | 1984—85 | | | | |

Due to uneven distribution of energy resources, it was not possible to plan equal power development in all states of the country. To face this problem, Government of India has divided the country into five regions as shown in Fig. 1.16.

The power development programmes are planned by the Government of India and the plan-wise increase in power capacity in the country is listed in the table on page 1.43.

To overcome this difficulty, Government of India has planned to set up 5 super thermal pit head stations each of nearly 2000 MW capacity. These stations are Singrauli (U.P.), Korba (M.P.), Ramagundam (A.P.), Farakka (W.B.) and Naveyli (T.N.).

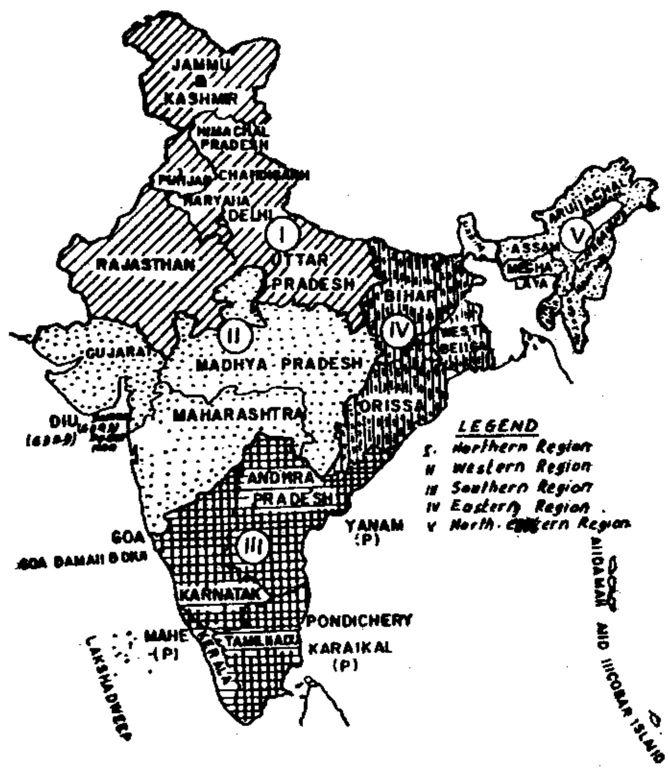



**Fig. 1.16.** Map of India showing Power Regions, States and Union Territories.

All India consumption of electricity in 1984-85 is estimated at 140 TWh and in order to meet this demand, it is estimated that the generation should be of the order of 191 TWh. At the end of 1983, schemes with total generating capacity of 29665 MW had been sanctioned. Of these, 19665 MW are identified as capable of being commissioned during the VI Plan period. The regionwise break-down is listed below.

**Generation Capacity to be Added in VI Plan**

| *Region* | *Hydel MW* | *Thermal MW* | *Nuclear* | *Total* |
|---|---|---|---|---|
| Northern | 1292 | 3660 | 220 | 5172 |
| Western | 457 | 5480 | — | 5937 |
| Southern | 2205 | 1890 | 470 | 4565 |
| Eastern | 503 | 2820 | — | 3323 |
| North-Eastern | 311 | 358 | — | 669 |
| Total | | | | 19666 |

It would be observed that the capacity benefits envisaged during VI Plan in the Eastern region are lower than the other regions (except North-Eastern).

The first 3-years of VI Plan witnessed an addition of 7058 MW and total installed capacity at the end of July 1983 stood 36420 MW (13165 MW hydro + 21410 MW thermal + 750 MW diesel and gas turbine + 1095 MW in nuclear). One of the most significant events during sixth plan is the commissioning of two nuclear units, one of 210 MW at Rajasthan Atomic Power Plant in November 1980 and the second of 235 MW at Kalpakkam in July 1983. The growth of electric energy also maintained the pace with requirement (5.1 TWh in 1950-51) and it was 131.5 TWh in 1982-83. During the first two years of the VI Plan, an expenditure of Rs. 88928.7 million was increased for energy sector. During 1982-83, the expenditure was Rs. 67370 million and provision of Rs. 83233.5 million had been made for the year 1983—84.

The power generation during December 1982 was 11619 million units. Over the years, there has been considerable improvement in availability of power in the country. The gap of requirement and availability had come down from 16.1% in 1979-80 to 12.6% in 1980-81, 10.8% in 1981-82 and 8.6% during 1982-83. The load factor of the thermal power plants has increased considerably. The power generation and % increase for the period 1978-79 to 1982-83 are listed below.

**Power Generation of Thermal Plants**

| *Year* | *Generation GWh* | *% Increase from previous year* |
|---|---|---|
| 1978—79 | 53420 | — |
| 1979—80 | 57115 | 10.70 |
| 1980—81 | 62031 | 18.85 |
| 1981—82 | 70346 | 11.34 |
| 1982—83 | 66265 | 11.47 |

Oil is a versatile fuel used for a variety of purposes in all sectors of economy. Over 80% of the total oil used in India as energy source is consumed in two sectors—transport and household sector. The total recoverable reserves of oil in India onshore are about 40% while offshore are at 60%, For gas, the recoverable reserves lie mainly offshore constituting about 93% of the total recoverable reserves of gas. As per ONGC recent estimates, the reserve of sedimentary basin in India is 15000 M.T. of oil and oil equivalent of gas but the proved recoverable reserves of oil are 471 M.T. located mainly on west coast in Cambay and Bombay High basins.

The total production of crude oil in the country during 1983-84 was targetted to be 26.23 million tons. In the year 1984-85, this was expected to be stepped upto 29.63 million tons against the requirement of 45 million tons. The uptrend in crude output has been sustained in 1983-84 with the contribution from off-shore and onshore wells being encouraging at 25.77 million tons against 21.06 million tons in 1982-83 and 16.19 million tons in 1981-82. The increase has been mainly on account of offshore wells with their output touching a new peak of 17 million tons against 12.88 and 7.98 million tons respectively in the two previous years.

The quantity of crude imported in 1983, was 11.61 million tons as compared to 16.95 million tons in 1982 and that of petroleum products was 2.69 million tons against 5.03 million tons. It was estimated that the gap for 1983-84 would be about Rs. 4800 crores (import) against Rs. 5526 crores in 1982-83. As it is expected that there will be fresh rise in crude output to 30 million tons, the cost of import of crude and petroleum to decline further in 1984-85. Therefore, it was thought to be possible to effect a significant reduction in imports of crude and petroleum products.

The net recoverable reserves of gas were about 420 million $m^3$ as per 1980 estimate. There has been a complementary increase in the production of gas. Gas production which was 1.4 million $m^3$ in 1970-71 rose to about 5 billion $m^3$ in 1982-83. As far as gas is concerned, ONGC planed to envisage the gas availability as 2 MM CMD by 1981, 2.88 by 1982, 3.6 by 1983, 8.6 by 1984 and 13.6 by 1985.

The quantity of gas available in Bombay high alone is considered to be very high and can be used for power generation. In the year 1983 we have been flaring away 4-million $m^3$ of gas per day from Bombay High as means are not available for its transport and storage. This is estimated as a loss of Rs. 400 crores during the year 1983. Assam is also not behind—about half as much as Bombay High was flared there during the same period costing Rs. 200 crores more.

According to the official sources, substantial increase in the gas availability had been made in the VII Plan. The free gas production will gradually go up from 5 million $m^3$ to 20 million $m^3$ per day.

Initially four gas turbine plants of 250 MW capacity are proposed to be established for the utilization of the free gas available. These plants will be put up at a considerably lower cost compared with thermal plants. A thermal plant of 250 MW capacity costs Rs. 250 crores presently whereas a gas turbine plant using gas costs only Rs. 70 crores for the same capacity. The Government of Maharashtra is setting up a gas turbine plant of 100 MW capacity in Uran at a cost of Rs. 33 crores. The gas available will last for 30 years which is twice the life period of the plant.

Another gas source in this country is biogas which can be economically and efficiently used for cooking and lighting in this country. This will reduce the considerable burden on the import of petroleum products. Our cattle dung production is equivalent to 20 million tons of kerosene in heat value per year. If all of it were to be fed into biogas plants, we could have 300 billion $m^3$ of gas and some 200 million tons of manure. The high quality manure has about as much nitrogen as all our fertilizer plants production put together.

It has been estimated that 20% of the dung can be easily collected to feed to biogas plants and accordingly 8 million plants are needed. The target in V Plan was 100,000 units and number was raised to 1 million in VI Plan. Presently the number of working units are only 0.3 million—about 4% of the 8 million that we should have.

There is steady development in Nuclear Power. The present installed capacity is 840 MW and three more plants, each of 400 MW capacity are planned in the next plan period. India's presently indicated reserves of Uranium ($U_3O_8$) are of the order of 67000 tons. In addition, about 13000 tons are estimated to be contained in the monazite sands. India is reputed for her thorium reserve. The known reserves contained in the monazite sands are estimated at 363000 tons of thorium oxide.

**Expense for Power Sector**

(Rs. in crores)

| *Plan period* | *Total plan expenditure* | *Power sector expenditure* | *% share for power* |
|---|---|---|---|
| I (1951—56) | 1960 | 260 | 13.3 |
| II (1956—61) | 4672 | 460 | 9.8 |
| III (1961—66) | 8573 | 1252 | 14.6 |
| 3 Annual (1966—69) | 6756 | 1223 | 18.1 |
| IV (1969—74) | 15779 | 2932 | 18.6 |
| V (1974—79) (revised) | 39288 | 7293 | 18.6 |
| Annual (1979—80) | 12550 | 2473 | 19.7 |
| VI (1980—85) | 97500 | 19265 | 27.1 |

**Planwise Installed Capacity**

(In million KW)

| *Plan period* | *Capacity added* | *Cumulative capacity* |
|---|---|---|
| As in 1950 | — | 2.30 |
| I (1951—56) | 1.10 | 3.40 |
| II (1956—61) | 2.25 | 5.65 |
| III (1961—66) | 4.52 | 10.17 |
| 3 Annual (1966—69) | 4.12 | 14.29 |
| IV (1969—74) | 4.17 | 18.46 |
| V (1974—79) | 10.54 | 29.00 |
| Annual(1979—80) | 1.81 | 30.81 |

**Position of Power Utilization in India in 1995**

In stead of all strides made by the Govt. the power consumption is increased from 120 kWh in 1975 to 300 kWh per capita in 1995. But this power consumption is far low compared with the developed countries as shown in Fig. 1.17. There is lot of disparity in the power consumption in the different parts of the country as shown in Fig. 1.18. It is as high as 780 kWh in Delhi whereas it is as low as 125 kWh per capita in Bihar.

The thermal resources being higher compared with hydel, the contribution of thermal power plant in the total generation is also higher. The statewise power generation capacity as total in March 1992 is shown in Fig. 1.19 and thermal and hydel generating capacity statewise as per data available in 1995 is shown in Fig. 1.20.

One of the major drawbacks in India is lack of peak capacity. The scene on the national level shows heavy shortages of power in almost all states, and that particularly in April-June. The shortages as per the data available in 1995 is shown Fig. 1.21.

Our achievement in the VIII-plan in terms of additional generating capacity is likely to be 18000 MW against the target of 30800 MW (40% short). In terms of transmission lines, we are adding only half of our early achievement of 6000 km in a year. Our planning is going to a critical shortage, both for power and its distribution. There are serious shortages in many parts of India, and they are more serious in respect of peaking power. As per 1994-95, the shortages of peaking power are 11.5% in Maharashtra, 12.5% in Gujarat, 22% in M.P., 18% in A.P. and 11% in Tamil Nadu. There was 50% power cut in Karnataka in Aug. 1995 because of failure of monsoon as the State hydel power generation is 70% of the total. It is very high time for Karnataka to stress for development of power projects like 1000 MW Cogentrix and 960 MW Kaiga nuclear plant.

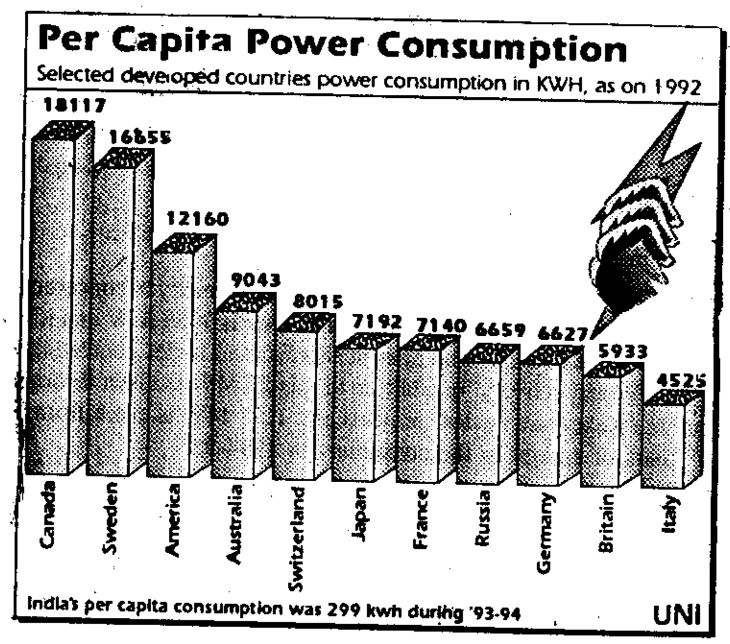



Fig. 1.17.

The first priority for power planners is to help even our surpluses and shortages between regions. A crash plan is essential to strengthen interregional links, as example, between Maharashtra and Gujarat in West, A.P., Tamil Nadu and Kerala in South, and the Damodar Valley and Orissa in the North-East. At least, this will remove the cause of costly failures, such as A.P. or Maharashtra *separating out* as quaint

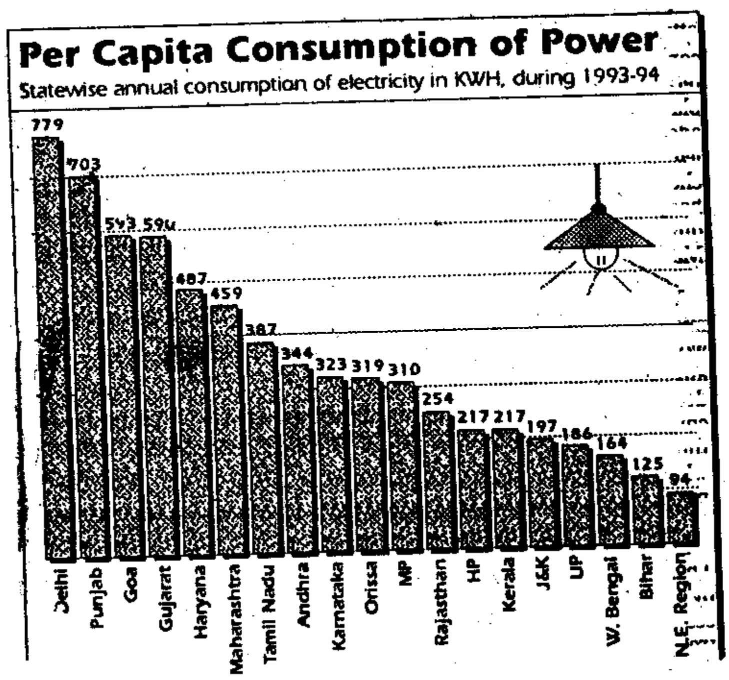



Fig. 1.18.

phrase goes when they leave the rest of the grid hanging. The task of strengthening transmission and distribution has to be tackled on a crisis footing. Over the years loss and less is being spent on transmission and distribution, with the result, the losses stay at high level of 22%. Even these losses are reduced by 5%, which will be equivalent of adding 5000 MW capacity.

**Present Power Position in Maharashtra**

The State Maharashtra is first in the country as generating capacity is concerned as well as generating units are concerned. The present generating capacity of the state is 9089 MW and it is estimated that it will be 18135 MW by the end of the century. The present thermal and hydel generating capacities in the state are 7544 MW and 1537 MW respectively. In addition to this 53 MW is taken through Pench hydel project, 327 MW from Tarapur and Kakrapara nuclear projects and 1221 MW is taken from NTPC. The Board has supplied $40536 \times 10^6$ units of energy to the consumers in 1994-95.

The present transmission includes 23654 km high tension line and 18918 km 33 kV line and there are 313 substations of high tension and 961 sub-stations of 33 kV capacity in the state.

The board has provided power to 17 lakh pumps and electrified 100% villages in the state. The present power consumption of the state is 440 units per capita against 268 units per capita of the nation. The most of the power plants in Maharashtra have been awarded by Govt. of India (Koradi, Chandrapur, Nasik, Bhusawal and Khaparkheda) for their high power factor and best performance.

During 1960-93, there is 61 times increase in the power supply to the industry, 604 times to the *agricultural*, 199 times in domestic supply and 83 times in commercial sectors.

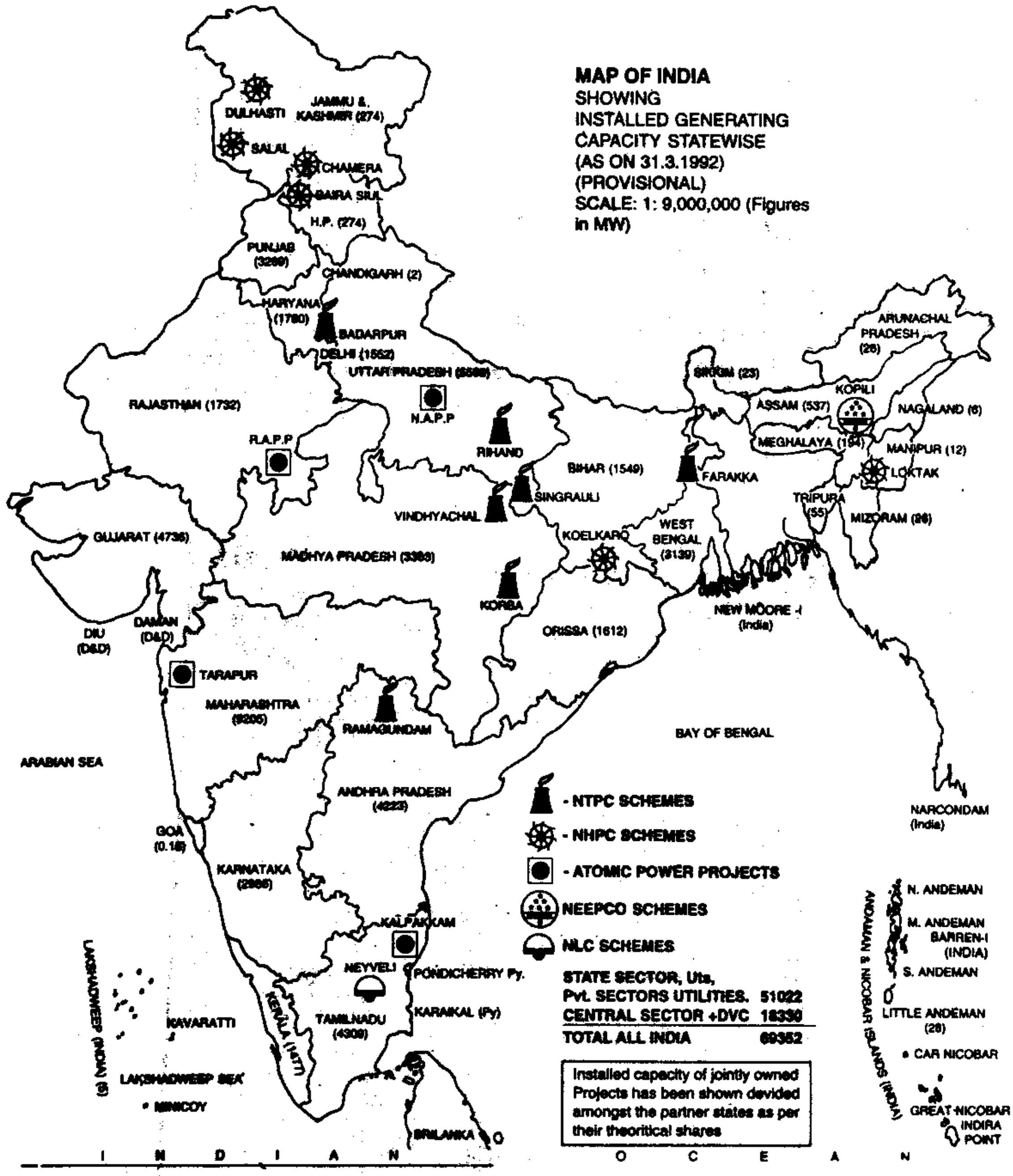

MAP OF INDIA
SHOWING
INSTALLED GENERATING
CAPACITY STATEWISE
(AS ON 31.3.1992)
(PROVISIONAL)
SCALE: 1: 9,000,000 (Figures in MW)
JAMMU & KASHMIR (274)
DULHASTI
SALAL
CHAMERA
BAIRA SIUL
H.P. (274)
PUNJAB (3269)
CHANDIGARH (2)
HARYANA (1780)
BADARPUR
DELHI (1552)
UTTAR PRADESH
RAJASTHAN (1732)
N.A.P.P
R.A.P.P
RIHAND
SINGRAULI
VINDHYACHAL
BIHAR (1549)
FARAKKA
SIKKIM (23)
ARUNACHAL PRADESH (26)
ASSAM (537)
KOPILI
NAGALAND (6)
MEGHALAYA
MANIPUR (12)
LOKTAK
TRIPURA (55)
MIZORAM (26)
GUJARAT (4736)
MADHYA PRADESH
KOELKARO
WEST BENGAL (3139)
KORBA
NEW MOORE (India)
ORISSA (1612)
DIU (D&D)
DAMAN (D&D)
TARAPUR
MAHARASHTRA
RAMAGUNDAM
BAY OF BENGAL
ARABIAN SEA
ANDHRA PRADESH (4223)
GOA (0.18)
KARNATAKA
KALPAKKAM
NEYVELI
PONDICHERRY Py.
KARAIKAL (Py)
TAMILNADU (4309)
KERALA (1477)
KAVARATTI
LAKSHADWEEP SEA
MINICOY
LAKSHADWEEP (INDIA) (6)
SRILANKA
NARCONDAM (India)
N. ANDEMAN
M. ANDEMAN
BARREN-I (INDIA)
S. ANDEMAN
LITTLE ANDEMAN (26)
CAR NICOBAR
GREAT NICOBAR
INDIRA POINT
ANDAMAN & NICOBAR ISLANDS (INDIA)
- NTPC SCHEMES
- NHPC SCHEMES
- ATOMIC POWER PROJECTS
NEEPCO SCHEMES
NLC SCHEMES
STATE SECTOR, Uts,
Pvt. SECTORS UTILITIES. 51022
CENTRAL SECTOR +DVC 18330
TOTAL ALL INDIA 69352
Installed capacity of jointly owned Projects has been shown devided amongst the partner states as per their theoritical shares
I N D I A N O C E A N

Fig. 1.19.

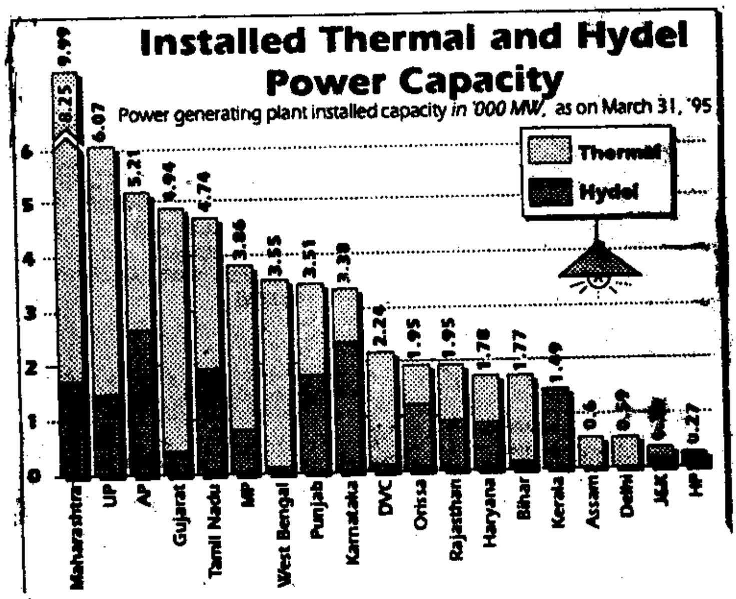



Fig. 1.20.

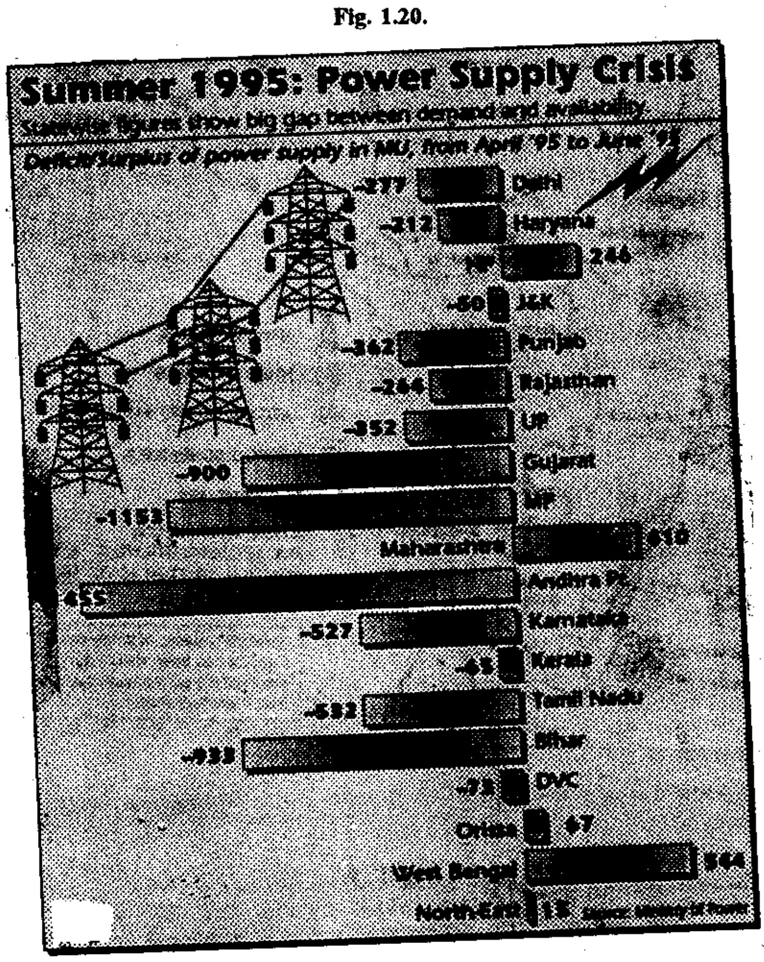



Fig. 1.21.

The performance of the Board during the last five years is listed in the following table.

| *Year* | *Generated units in millions* | *% Increase compared with previous year* |
|---|---|---|
| 1988 – 89 | 34196 | 8.58 |
| 1989 – 90 | 38178 | 11.64 |
| 1990 – 91 | | 6.26 |
| 1991 – 92 | | 7.14 |
| 1992 – 93 | | 2.64 |

The expected power generation in the coming 7 years is listed below.

| *Year* | *1993 – 94* | *1994 – 95* | *1995 – 96* | *1996 – 97* | *1997 – 98* | *1998 – 99* | *1999 – 2000* |
|---|---|---|---|---|---|---|---|
| Expected capacity (MW) | 11107 | 11323 | 12379 | 13827 | 16317 | 17135 | 18135 |

This includes MSEB, Tata, BST, Nuclear, NTPC and some will be from the private sector. The private sector contribution includes 410 MW from Nagothane combined plant and 2015 MW from Enron combined cycle plant.

The different power plants in Maharashtra are shown in Fig. 1.22.

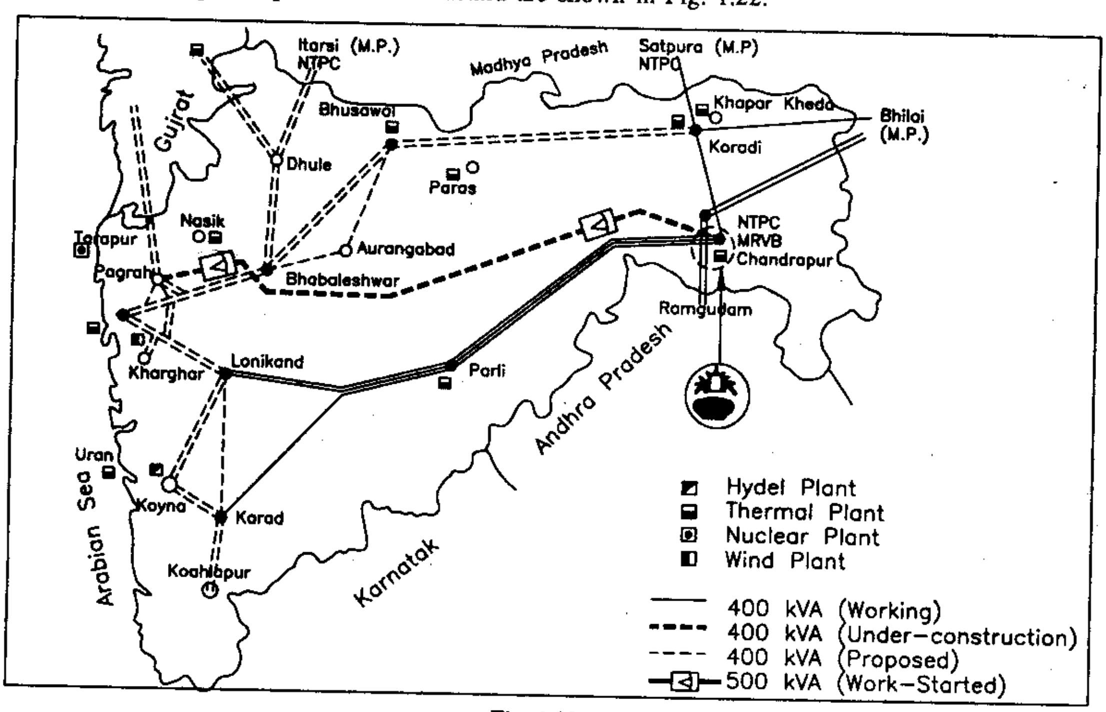



**Fig. 1.22.**

The 500 MW thermal power plant of Bombay Suburban Electric Supply (BSES) at Dahanu in Thane district will be fully operational by the end of the year 1995. Both units (each 250 MW) have become operational even though the plant is facing a shortage of coal. The BSES sells the power to MSEB at a rate of Re. 0.91 per unit which is far below the rate of Rs. 2.40 per unit which Enron was to charge MSEB. On 15th Sept. 1995, BSES has commissioned a 220 KV Ghodbunder and a 220 kV transmission line connecting the city Bombay to its 500 kW power station at Dahanu.

The second phase of Rs. 1000 crores Dahanu plant is currently having trial runs. The supply of coal from the Korba collieries is inadequate and plant has to depend on collieries further away in Orissa to meet its requirements. This has led to an increase in cost of rail transportation and delay in coal supply also.

**Power Generating Capacities of Different Power Plants**

| *Chandrapur* | *Koradi* | *Khaparkheda* | *Durgapur* | *Parali* | *Bhusawal* | *Nasik* | *Koyna* | *Uran* | *Trombay* |
|---|---|---|---|---|---|---|---|---|---|
| 900 (MW) | 1000 (MW) | 400 (MW) | 1800 (MW) | 660 (MW) | 450 (MW) | 800 (MW) | 760 (MW) | 900 (MW) | 1400 (MW) |

## 1.9. FUTURE PLANNING IN INDIA

With the programme of large scale industrialisation and increased agricultural activity, the demand for power in the country is increasing at a rapid rate. The latest power survey estimates indicate that the demand for power is expected to increase from 14 Million kW in 1975-76 to about 26.5 million kW in 1978-79, the end of the Fifth Plan. If the present trend in the increase of demand for power continues, it can be reasonably expected that the demand for power by the end of this century would be about 125 to 150 million kW. Allowing for adequate reserve margins required for scheduled maintenance, forced outages, etc, a total generating capacity of about 175 to 200 million kW could be needed by 2000 AD to meet the anticipated demand. This would mean an eight to ten fold increase of the existing capacity with a corresponding increase in transmission and distribution facilities. With the growth in power system, higher and higher voltage levels have become necessary for transmission. After 15 to 20 years it might become necessary to use 750 kV or even 1000 kV lines. These goals call for massive investments and appropriate strenghening and improving of the organisational machinery for planning, construction, operation and maintenance of power supply facilities.

Fortunately, India being rich in potentials, the required growth can be gained by proper development of hydel, thermal and nuclear resources of the country. As per the survey of CWPC report, the total hydroelectric potential of the country is about 41000 MW. But the energy available from these sites will only amount to 220 million kWh/year which is equivalent to an installed capacity of 25,000 MW. Out of the total available hydel potential nearly 16% of it has been already exploited. The capital cost of the plant ranges from Rs. 2000/kW to Rs. 5000/kW as the location of the plant (Rs. 1900/kW for Koyna extension, Rs. 2500/kW for Chibro and Rs. 4900/kW for Dehar power station). Apart from high capital investment required, some of the projects have taken long time for their completion—9 years for Idikki and 11 years for Dehar. Even if all the hydroelectric potential in India is developed, it will not be sufficient to meet the growing energy demands under the most optimistic assumptions. Even then, the problem of energy requirement of the country in the coming two decades can be partly solved at the cheapest rate by building a chain of hydel generating sets of the size of Bhakra on the mighty rivers of Arunachal Pradesh. At least 100 Bhakra projets can take shape at 10% each of the cost of Bhakra project. This is possible because go round reservoir in the region is necessary as annual rainfall varies from 500 cm to 750 cm and each major river snakes her way through 200 to 300 kilometres through the Himalayan slopes (fall of about 7000 metres) to descend to the Brahmaputra Valley. A chain of medium size dams of 30 m to 50 m high on some of the rivers will generate 12.46 million kW at 60% load factor according to the preliminary estimates made by CWPC some 20 years back, but the actual potential would be much larger than what is being produced in the whole of India today.

A national concentration on hydel generation, as evidenced in China, is essential. China is going ahead with a mega project in the three Gorges which will generate 10,000 MW. We also need a similar national focus. Himachal Pradesh has a hydel potential of 5000 to 6000 MW, Nepal and Bhutan have resources of 20,000 to 30,000 MW of environmentally safe projects. We can weave a gasland of power, removing petty political differences, which can help both our neighbours and depressed areas of Bihar & U.P. An Indo-Himalayan power generation programme can convert rivers of distress into rivers of hope and prosperity. The Asian Development Bank has shown commendable initiative by encouraging the Mekong basin countries to come together for such exploration of common hydel resources.

Coal deposits of considerable magnitude exist in different parts of India. It is known that the total reserves of coal is well above 80 billion tonnes, but out of this only 21 billion tons is in the form of proved reserves. Of the 21 billion proved reserves, about 80% is with an ash content of more than 20%. The current annual production of coal in India is 90 million tonnes per year. About one-third of this is used to produce electricity. More than 50% of the coal deposits are located in the states of Bihar and Bengal. This uneven distribution of coal deposits necessitates the transportation of coal over long distances from the mines to the various points of consumption, implying heavy investment in transportation facilities. Assuming that we plan for a per capita energy consumption by the end of this century to about half of the present per capita energy consumption in Europe, we will have to increase the coal output by nearly a factor of 10 besides planning for its transportation. If one considers this carefully, it looks like an almost impossible task.

We, therefore, cannot entirely depend on coal also for the production of all the electricity we need. We have to consider other possibilities to meet the energy demand like nuclear fuel which is a concentrated form of energy. The transportation required for nuclear fuel is almost non-existent, because compared to 30,000 rail wagons of coal required per year for a 500 MW coal fired plant, a nuclear power station of the same size would require only five truck loads of nuclear fuel per year. The latest estimate of the total uranium resources in India is about 52000 tonnes of uranium and about 520,000 tonnes of thorium. Though the amount of uranium available in India is relatively small, the potential energy available from the nuclear fuel is much more than from the coal deposits. The energy potential which can be made available from coal and nuclear resources in India is listed in Table 4.

**Table 4**

| *Type of fuel* | *Energy kWh* |
|---|---|
| Coal | $100 \times 10^{12}$ |
| Uranium in thermal Reactors | $7.2 \times 10^{12}$ |
| Uranium in Fast Reactors | $208 \times 10^{12}$ |
| Thorium in Fast Reactors | $1280 \times 10^{12}$ |
| Energy from all hydro potential per year | $225 \times 10^{6}$ |

The future planning for power development should aim at optimum exploitation of the abundant resources potential available so that a proper mix of hydro, thermal and nuclear capacity is achieved.

Another important aspect of the power planning in India is setting up of super thermal projects in the central sector. These stations would be located at or near the pitheads and would have capacity ranging between 500 to 2000 MW. It is intended to take up the work on these in a phased manner and the benefit from these stations would start to flow during the course of the Sixth Plan.

India's first 500 MW super thermal plant is to be located in Bombay. The union cabinet cleared the proposal and communicated the decision to energy ministry. This unit will be commissioned by 1982 and this would be the first multiple fire designed unit with facilities for firing with either coal or oil or gas.

The danger of exhausing the fossile fuels by the end of 20th century is the major problem before energy hungry civilisation. The population of the world will continue to rise at the rate of 2% per year till the year A.D. 2000 and will increase from the present figure of $3.5 \times 10^9$ (as per data in 1972) to $6.6 \times 10^9$. And if the man's use of power will increase even with the present rate, the fossil fuels resources of the world will be exhausted within few decades. The U.S.A. has less than 4% of the world population and uses 34% of the total annual energy consumption of the world. Thus U.S.A. uses $8.2 \times 10^4$ kW-hr per head per year is more than four times the world average of $1.9 \times 10^4$ kW-hr per year. The demand of energy is increasing at accelerated rate in U.S.A. and simultaneously there is greater stress on cleaner energy, so that pollution is abated. Cleaner energy means more costly energy and shortage of fuel of one kind or the other would also raise the price of energy. With the increasing demand for power and cleaner power will create more complicated problems and the cost of energy will go on rising. At present, world consumption of

$7 \times 10^{13}$ kW-hr per year, we spend about the same on energy as on food. The predicted world consumption in 21st century will be as high as $28 \times 10^{13}$ kW-hr, so that even if the average man has a better diet, fuel costs will still be twice those of food.

The standard of living of a country increases almost in direct proportion to the fuel consumption per head. If every one in the world is to have the present U.S.A. standard of living, there are two objections to this simple principle. The first is that, if by the year A.D. 2000, we have twice the world population and we expect to use 4.5 times as much energy per head, the nine-fold increase will use up all the readily accessible possible fuels in less than two decades and all the expected coal, oil, shales and tar in less than one century. The second objection is that, it is becoming increasingly doubtful to many thoughtful people whether a standard of living as high as that in U.S.A. at present is not already above the optimum from the point of view of the quality of life of the individual especially when one takes into account the probable overcrowding owing to the doubling of world population. It is interesting to study the situation in U.S.A. that is fast coverging towards the problem of choice between more energy use and consequent increased pollution, on the one hand, reduction in energy use to reduce the environmental pollution, on the other hand. The development cannot be an end itself. It has inherent limitations based on the ecology of nature. Such posing problems open a new dimension of thinking to our planners and present experience in the States should help us to rethink our cherished values.

During present times of threatening energy crisis, when attention is properly being focused on the full utilisation of fossil and nuclear fuels for the production of electricity, we must not overlook the contribution to power generation that can come from an efficient development of our natural water resources. Water is essentially an inexhaustible source and a perpetual source of energy. Unfortunately when initial plant costs rule out hydroelectricity in favour of other competing modes of generation, allowances are not made for the value of the wasted power. Thus, when potential hydro development is deferred, an enormous amount of power is wasted during deferred period. For example, when fossil fired unit is selected over a hydro-plant with the potential of 1 million H.P., 6.5 billion kW-hr/year of water power is wasted and world's fossil resources depleted by more than 2.5 million tons of coal per year or 9.3 million bbl oil/year. The longer we delay the full exploitation of our potential for hydro-electricity, the more we unnecessarily delete these vital resources. Therefore where they are environmentally feasible, hydro-electric plants are superior to other power generation units because of their long plant life, low operating costs, immediate power availability, lower station power consumption, low machine outage rates, recreational value of reservoirs and the potential use of regulated water discharges for irrigation and other commercial applications.

The total hydro-electric power potential in the world is about 4200 million kW of which 4.5% are developed so far. It is interesting to note that maximum development of hydro-power has taken place in advanced countries like U.S.A., U.S.S.R., Canada and Japan which they have done in spite of the fact they have large deposits of coal in those countries (except Japan). For example, coal reserves in U.S.A. is 1800 billion tonnes and U.S.S.R. 4100 billion tonnes while in India it is only 80 billion tonnes. Still in both these countries, hydro-project has been taken up even in difficult situations and power is also developed to make the best use of the perpetual sources like wind, solar and micro-hydro power generations. It is also anticipated that by the middle of the 21st century, 50% of the energy need of the world community will be taken from the solar energy which is considered non-exhausting source of energy.

The people in the developing countries have certain basic needs, as light, cooking, and drinking water. Considering each household needs two 60 watts bulb to lit up for 3 hours, two hours for cooking and 10 gallons of pumped water, a 200 house village could satisfy all needs from a 20 kW energy supply. These basic requirements of the people can be achieved by generating the power from the sources which are locally available. The renewable sources in village energy centres must be function-oriented as wind energy is good for pumping, solar energy is ideal for heating and mini-hydro resources best suited for electric generation. Instead of a single village energy source, Usmani's Plan (energy adviser to the UN Environment programme) is for centres containing a variety of equipment, a wind mill, a small hydel plant, a solar converter, a biogas unit or organic waste and a charcoal/oil/gas plant.

The energy demand as per the forecast by 2000 A.D. will be about 300 million tonnes of coal, 75 million tons of oil and 470,000 MkWh of electricity in India. By a proper balancing and exploitation of commercial and non-commercial sources of energy we could do a lot to conserve the non-renewable sources of energy and reduce the use of high quality energy sources to a level that we take care of the future needs of the people of this country.

The scientists in various institutes of this country are engaged in research and development in the area of new and renewable sources of energy. A major program in VI plan is to undertake extensive demonstration of energy systems based on solar and wind energy. These sources are bound to play a major role in future (by the end of this century), but the problem of shortage of energy during this transition period still remains unanswered.

The Planning Commission is expected to consider an outlay of Rs. 3,000 crore for the development of non-conventional energy sources in the seventh five-year plan. The outlay in the Sixth Plan was Rs. 100 crore.

The department has decided to give a big thrust to renewable programmes this year and has chosen, in particular, the solar energy area. It includes solar thermal systems and solar photovoltaic systems. In addition, it was proposed to enlarge the biogas and improved chulha (wood stove) programmes.

About 100 villages will be covered by the integrated energy systems programme this year.

The department recently announced a range of subsidies to popularise solar thermal systems. Not only institutions, but individuals who want domestic water heating facility would get subsidies. Solar desalination plants set up in villages and backward areas and solar drying systems used by agricultural farms, mills and individual farmers will also be entitled to the concession.

The national project on biogas development saw 92.500 plants set up in 1983-84 against the target of 75,000 plants. About 2.76 lakh family type biogas plants have been installed so far. A target of 1.5 lakh has been fixed for 1984-85.

The energy hungry world (western countries) is presently seriously thinking for developing the renewable sources instead of developing the conventional energy sources for the future survival. The highest hydro-power capacity in U.S.A. is 55 million kW. The figures for the other countries are U.S.S.R. (31), Japan (20), Canada (20), Norway, France, Switzerland, Italy and Spain each about (15), and India so far 7 million kW only. Hydel power projects in India contribute 40% in installed capacity as also in the total energy production of the country.

The total world energy resources available in different forms are listed in Table 5.

**Table 5. World Primary Energy Resources**

| *Types of Primary Resources* | *Reserves* | *Energy content* $\times 10^{18}$ *Joules* |
|---|---|---|
| (1) Fossil Fuels. | | |
| Coal ( $\times 10^6$ tonnes) | 591,199 | 13,858 |
| Oil ($10^6$ tonnes) | 91,525 | 3,958 |
| Natural Gas ( $\times 10^9$ $m^3$) | 52,532 | 1,933 |
| (2) Hydro Resources (capacity in MW) | 555,060 | 16 |
| Nuclear Fuels Uranium (tonnes) | 984,474 | 824 |
| Total World Energy Content | — | 20,589 |

Coal and nuclear energy are still the leading official candidates to replace dwindling supplies of oil in this century. Both have serious, unresolved hazards in production and use.

## 1.10. PRESENT WORLD POWER POSITION AND FUTURE

The era of abundant energy at prices especially favourable to global expansion of industry and transportation has come to an end. Acute scarcity of energy sources has become a global phenomenon. The days of cheap energy are gone for ever and this commodity is becoming dearer and rarer day by day. There appears to be no panacea for the problem. It has to be tackled on many fronts, some comprising immediate measures to stem the deterioration. Yet others involving long term measures.

The key to the short-term measures is conservation and management. The last kJ of useful work has to be extracted from the energy before it is vented to the abysmal sink of entropy. The long term measures should include extension of fossil fuel usages and exploration of new reserves. The extension should comprise through revamping and modernisation of mining techniques and streamlining transport bottleneck. On the other hand, renewable resources have to be developed sufficiently so that they can take up a significant supplementary role in the energy scene, eventually replacing non-renewable resources as the major partner.

In the past 50 years, there has been a dramatic shift in the pattern of energy consumption. In 1925, 83% of the world energy supply depended on coal. In 1950, it reduced to 61%. After the war, liquid fuel, mostly oil, accounted for 28% of the supply. But by 1975, oil alone provided about 50%, coal was reduced to 33% and nuclear energy contributed but only 3% of the world energy supply. The shift was decisively in favour of oil. Industrial countries with only 22% of world's population produce 54% of the total amount of energy and consume 84%. On the other hand, developing countries with 78% of world's population, produce 46% of energy and consume barely 16%.

The world power production between 1972 to 2020 is listed in the following table. Even if the present world average power consumption is to be maintained, the all available resources will be exhausted by the middle of the next century.

**Table 6. Potential World Primary Energy Production—exajoules****

| Resource | 1972 | 1985 | 2000 | 2020 |
|---|---|---|---|---|
| Coal | 66 | 115 | 170 | 259 |
| Oil | 115 | 216 | 195 | 106 |
| Gas | 46 | 77 | 143 | 125 |
| Nuclear | 2 | 23 | 88 | 314 |
| Hydel | 14 | 24 | 34 | 56 |
| Unconventional oil | 0 | 0 | 4 | 40 |
| Renewable (Solar, biomass) | 26 | 33 | 56 | 100 |
| Total | 269 | 488 | 690 | 1000 |

**1EJ = $10^{18}$J.

The energy demand for different countries is also presented in Fig. 1.23 for the period 1965 to 1990. It shows that U.S. will continue to be a prolific user of energy even though its share would fall from 47% in 1965 to 33% in 1990. The major increases will come in the developing world whose demand for energy is expected to rise from about 5 million *BOE/day to 35 million BOE/day— a sevenfold increase in 25 years.

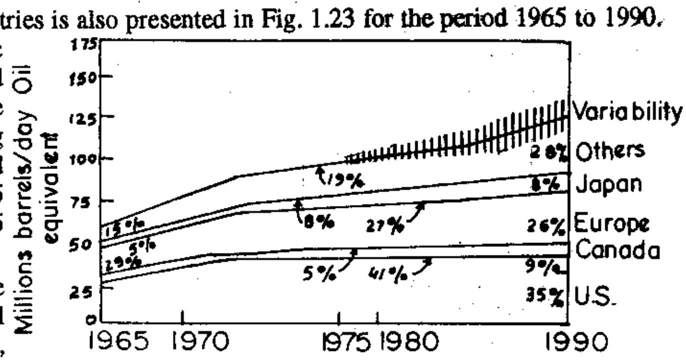


Fig. 1.23.

As regards world energy supplies of the 130 million BOE/day expected in 1990, oil would provide 45%, gas 18%, coal 20%, nuclear 7% and hydel and others about 8%. It can be noted that oil and gas will continue as most important sources of energy throughout the remainder of this century.

In 1973-74, oil prices quadrupled (from 83 to 813 per barrel) and there was an immediate realisation that such a price hike would have a global political, economic and social impact. The middle east has 2/3 of the world oil and controls 80% of the world oil market. The price hike gave a jolt to the economics of

*1 BOE (barrel of oil equivalent)
= 5.8 million Btus = 158.7 $m^3$ of natural gas = 0.27 tons of coal equivalent = 1700 kWh.

the world. In a few years, with commendable resilience, the world economy absorbed the shock but the point has been painfully driven home that oil is depleting resource.

Indeed, if one were in look for a silver lining in the oil crisis, it is the global acceptance of the fact that the oil era is expected to end in a few decades and in the mean time, world must prepare itself for a change-over to other energy sources.

By the time of the second oil shock in 1979 (from $13 to $32 per barrel), counter measures begun in the developed world to meet the first shock (1973) were under way. President Carter had unleashed his energy plans in 1977 in order to safeguard U.S. interest in a world where prices of petroleum and natural gas were soaring uncontrollably. Included in his package were plans for stepping up exploration for crude, enhanced coal production, encouragement for solar energy projects and $88 billion synfuels developments. Similar programs for energy developments of alternate forms were also followed in other developed countries like West Germany, New Zealand and others. Between 1979 and 1981, there was a decline of 5 BOE/day in oil consumption by the OECD countries which is an indication of growing recession and also by high consumption in the earlier year due to high economic growth.

The present oil price is very high while it may go up even further. We are entering in a new era of more costly energy as compared to the past. Eventually we can hope for an era renewable energy replacing the present one of depleting fossil fuels.

(*a*) **Oil and Gas.** The major factor in effecting a smooth and gradual transition to other forms of energy will be to maintain adequate supplies of oil and gas. To do this, offshore oil and gas industry must greatly expand its offshore operations. Worldwide production by 1990 is not expected to reach its maximum demand of 80 million BOPD. The rapid growth in this decade will be in the less developed nations.

The second major source of energy is expected to be natural gas. The estimated gas reserves lie between $6 \times 10^3$ to $10 \times 10^3$ trillion cubic ft. The present gas reserves are accepted to run out in 50 years and oil in less 30 years.

Synthetic fuels present another alternative source of hydrocarbons. Deposits of heavy oil exist principally in Venezuela (375 × 22 miles area contains 2 trillion bbl of oil), Canada and U.S., World reserves of oil extracted from sand is forecast to be $10^{12}$ BOE.

**Table 7. Country-wise Imports of Crude Oil (Quantity in 1000 tons, Value in Rs. Crores)**

| Country | 1981 | | 1982 | | 1983 | |
|---|---|---|---|---|---|---|
| | Quantity | Value | Quantity | Value | Quantity | Value |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Iran | 6030 | 1488.74 | 3667 | 837.27 | 3521 | 739.57 |
| Iraq | 806 | 202.87 | 3437 | 882.55 | 2954 | 654.19 |
| Saudi Arabia | 2870 | 622.38 | 6809 | 1575.51 | 4447 | 969.15 |
| UAE | 1803 | 452.81 | 1285 | 329.68 | 930 | 210.14 |
| USSR | 2273 | 563.72 | 1935 | 442.26 | 3539 | 793.81 |
| Algeria | 987 | 278.82 | — | — | — | — |
| Venezuela | 445 | 113.88 | 194 | 49.62 | — | — |
| Kuwait | 167 | 38.19 | — | — | — | — |
| Mexico | 129 | 28.38 | — | — | — | — |
| Malaysia | 18 | 4.02 | — | — | — | — |
| Total | 15528 | 3793.83 | 17327 | 4116.89 | 15391 | 3421.16 |

The oil in Canadian tar sands is 894 billion bbl. Present production in Canada is $170 \times 10^3$ BO/day and two additional projects are planned to raise the production to $500 \times 10^3$ BO/day by 2000. Another source is shale oil. It is forecast that shale oil production in 2010 can reach 8 million bpd in the U.S.

(*b*) **Coal.** King coal, with its pollution problems and hazardous mining was gradually being displaced from the world's energy markets and replaced by oil, and gas after World War II. With the hike in prices of oil 1973 and 79, coal though dusty, dirty and expensive to handle, re-emerged as the world's cheapest and most abundant fuel. Furthermore because it is plentiful in Europe, USA and Australia, coal offered something oil did not : security of supply. Coal is considered the other major alternative to oil besides nuclear power.

Worldwide, there is plenty of coal and fortunately it is not distributed in the same way as oil. In terms of reserves, there is an order of magnitude. Recoverable reserves of coal in the U.S. are estimated at $660 \times 10^3$ million tons or about 250 times the total production in 1977. The other countries which follow to the U.S. are former USSR and China. These three nations together produced 60% of the 1977 output of 2500 million tons. In 1980, the Coal Advisory Board to the International Energy Agency estimated that OECD area coal output would surge from 900 million tons in 1978 to 1.7 billion tons in 1990 and 2.4 billion tons by 2000.

World coal production and coal imports from different countries of the world are listed in the Tables 8 and 9.

Coal, now, accounts for more than 25% of the world energy demands and will increase to supply 35% of total demand by 2000. World coal trade is expected to increase from three to five times or maximum of 13 BOE/day by the close of the century.

The total international trade is expected to quadruple with the coal trade multiplying by 15 times. The implications for a huge increase in world coal supplies are many. This will require building a very considerable number of coal carriers, as many as 1000, over the next 20 years, each costing $40 millions. It also means new ports, terminals and rail facilities in the US, South Africa and Canada. The expansion of the American coal industry alone will require 10,000 miles slurry pipeline, 8000 railway engines, 16,000 lorries and 300 barges. Also the opening of 700 new pits at a total cost of over $100 billion.

**Table 8. World Coal Production (in million tons)**

| 1980 | | 1990 | | 2000 | |
|---|---|---|---|---|---|
| Country | Coal | Country | Coal | Country | Coal |
| USA | 673 (25.3)* | USA | 927 (24.0) | USA | 1430 (27.8) |
| USSR | 486 (18.2) | USSR | 679 (17.6) | China | 856 (16.6) |
| China | 434 (16.3) | China | 643 (16.6) | USSR former | 745 (14.5) |
| Poland | 164 (6.2) | Australia | 205 (5.3) | Australia | 300 (5.8) |
| W. Germany | 128 (4.8) | Poland | 192 (5.0) | India | 285 (5.5) |
| U.K. | 107 (4.0) | India | 168 (4.4) | S. Africa | 264 (5.1) |
| S. Africa | 92 (3.5) | S. Africa | 162 (4.2) | Poland | 200 (3.9) |
| India | 79 (3.0) | W. Germany | 127 (3.3) | W. Germany | 131 (3.5) |
| E. Germany | 78 (2.9) | U.K. | 110 (2.8) | U.K. | 121 (2.3) |
| Australia | 71 (2.7) | E. Germany | 93 (2.4) | E. Germany | 97 (1.9) |
| Total | 2312 (86.9) | | 3306 (85.6) | | 4429 (85.9) |

*Percentage of global production.

**Table 9. World Coal Imports (in million tons)**

| 1980 | | 1990 | | 2000 | |
|---|---|---|---|---|---|
| Country | Coal | Country | Coal | Country | Coal |
| Japan | 63.4 (24.3)* | Japan | 125.4 (28.0) | Japan | 169.1 (27.2) |
| France | 32.2 (12.3) | Italy | 45.7 (10.2) | France | 56.0 (9.0) |
| Italy | 16.7 (6.4) | France | 33.0 (7.4) | Italy | 51.4 (8.3) |
| Canada | 14.8 (5.7) | W. Germany | 22.0 (4.9) | Other Asia | 45.0 (7.2) |
| W. Germany | 12.0 (4.6) | S. Korea | 21.0 (4.7) | S. Korea | 37.2 (6.0) |
| Belgium | 10.1 (3.9) | Other Asia | 20.2 (4.5) | W. Germany | 36.5 (5.9) |
| USSR former | 10.0 (3.8) | Netherland | 18.7 (4.2) | Netherlands | 28.1 (4.5) |
| Denmark | 8.7 (3.3) | Canada | 14.7 (3.3) | Spain | 21.4 (3.4) |
| E. Germany | 8.6 (3.3) | Turkey | 13.7 (3.1) | Turkey | 21.4 (3.4) |
| S. Korea | 7.2 (2.7) | Spain | 13.6 (3.1) | Belgium | 14.3 (2.3) |
| Total | 186.6 (70.3) | | 328.0 (73.5) | | 180.4 (77.2) |

*Percentage of global imports.

(*c*) **Nuclear.** Nuclear power was seen as a long term clean, attractive, high technology solution to the world's energy supply problem. But by the end of the decade (1980), the nuclear power industry was beginning to shatter. However, the investment of the developed world in nuclear power and a continuing program reduces demand of world oil supplies by between 4 and 8 million barrels of oils per day.

Total world nuclear energy capacity was expected to triple between now and 1990, growing at a rate of about 10% per year. A further increase of some 250 giga watts is expected during the 1990's. As indicated in the following table, almost 75% of the installed capacity during 1990s will occur outside the US, in countries with few energy options, such as France and Japan showing the target increases.

**Table 10. Installed Capacity in Gigawatts (Total)**

| *Country* | *1978* | *1990* | *2000* |
|---|---|---|---|
| U.S. | 53 | 147 | 207 |
| Europe | 30 | 117 | 230 |
| Japan | 12 | 39 | 77 |
| Others | 07 | 46 | 88 |
| Total | 102 | 349 | 602 |

The present world nuclear program is based on thermal reactors which use uranium extremely wastefully. The program can be seen only an interim arrangement although uranium supplies are not likely to constrain even the projected nuclear program until past 2010 at the earliest. Maximum production capacity at the present is 44000 tons/year and could increase to 119000 tons/year by 1990 if necessary. World enrichment capacity is also adequate to cope until 2000 A.D. Currently almost all nuclear fuel is enriched in U.S. However, by 1990, 35% will be handled elsewhere.

A trebling of the coal supply and a fifteen-fold increase in nuclear power to overcome the oil dependency is the forecast over the next fifty years. The various constraints as questions of safety, transport and storage of spent fuel, reliability in operation and costs have powerful effects on nuclear program.

An anti-nuclear power lobby, assisted by accidents at Three Mile Island, and Charnabole had reduced the nuclear program to such an extent that worldwide the number of new orders for nuclear reactors is at its lowest point since the early 1960s and in U.S. in 1979, there were no new orders and 13 cancellations.

The world nuclear program is in the doldrums after a period of stable growth through the 1960s. The nuclear generating capacity of the world in September 1980 was 186 installations in 18 countries, over 80% of which are light water reactors. These stations provide largely base load electricity in seven western countries and account for 10% of the electricity generated. The cost of nuclear generated electricity is half the price of electricity generated by burning oil. Despite this price advantage, orders for new nuclear power stations are at their lowest point for 10 years. Over the last three years (1979-82), within OECD, 36 new stations were ordered but 48 were cancelled, 32 of them in the U.S. The nuclear industry in UK, US and West Germany faces setback. Only in France, power station building program is on target, with at least one new station is coming up each year. The EEC plan to introduce 1,50,000 MW nuclear power by 1985 was reduced to 78,000 MW. In the Eastern block, nuclear power is seen as an essential ingredient in the energy supply and progress is steady.

(*d*) **Renewable Resources.** The advantages of solar power and associated technologies of hydro-power, wave-power, wind-power and biomass are enormously attractive. Of these, hydroelectric power is the best developed, providing 5% of the world's energy supply in the form of very cheap electricity (1/2 and 1/10 of the cost of nuclear and fossil fuel generated electricity). The expansion of hydro power would provide 8 million BOE/day to the world's hydro-power use and being total hydropower to an oil equivalence of 20 million BOE per day by 2000, even though the percentage contribution of hydel power in total remains same.

With a possible threefold expansion, hydropower will still only provide 5% of world energy demand by 2030. Of the other technologies, the best developed is the growing and harvesting of fuel wood which provides 10% of world's energy. Any extension of total supply would be extremely difficult to achieve and there is added hazard of the *green house* effect whereby the concentration of $CO_2$ in the upper atmosphere steadily increases as a result of burning fossile fuels.

Any additional burning of fossil fuel intensifies the problem, which can only be reduced by increased dependence on solar heat and nuclear power. Unfortunately the technologies of solar electric conversion, wave power and wind power are not in engineering terms developed on large scale and are expected to be expensive compared with other energy supplies, though the picture will change over within the next 50 years. Biomass (crops of fuel) suffers from nature's inefficiency in converting solar energy by photosynthesis with only 0.5% efficiency.

The other major problem associated with renewable resources is our inability to store large quantities of energy, either in the form of heat or as electricity. Conversion to $H_2$ is a possiblity as it is with nuclear generated electricity, and proponents of the hydrogen economy are enthusiastic about this route, with $H_2$ being used in fuel cells for transport.

The diffuse or dilute nature of renewable resources means that large tracts of land or ocean will be necessary to accommodate solar collectors, 25 miles square for a solar power station or 1000 wind mills with 90 m blades set 300 m apart to replace a nuclear power station on a 1 mile$^2$ site.

The use of renewable resources can only come slowly but the development of the technologies has a very long time scale. For comparison, one should look at nuclear power which was technically feasible in 1945 has taken 30 years of enormous expenditure on development to produce today's 3% of the world energy demand. A figure 10% for renewable by 2030 can only be seen as fairly optimistic.

To give the thrust to non-conventional energy development, the Indian Govt. has formed a separate ministry for non-conventional energy sources. The present planning of generating power through these non-conventional sources is of 2000 MW. An incentive is also given to the private sector who will generate power using such non-conventional sources. The electricity, even today, is not provided in remote areas of the country. The only economical source to provide electricity to such areas for lighting and pumping is through solar energy only. It is planned that by the end of VIII-plan, 10 lakh lights and 50,000 pumps will be provided electricity through solar energy. 3 lakh m$^2$ area is already reserved in different parts of the country to provide electricity through solar energy. Presently, 209 villages are electrified by photovoltaic source and 203 are planned to be completed by the end of VIII-plan. The present photovoltaic capacity is 9 MW and will be 25 MW by the end of the plan.

Another potential source is wind power. The present wind power capacity in the country is 350 MW. The total estimated wind capacity in India is 20,000 MW and 500 MW will be available by the end of VIII plan and it will be third largest country in the world to generate power through this source. Nearly 80 sites are located in 8 states and estimated power through these plants is 4000 MW. A 500 crore rupee wind plant is planned in Osmanabad district of Maharashtra.

The third important source of energy considered is mini and micro hydel plants. The present capacity of these sites is 10,000 MW, out of which 236 MW plants are in developing stages and 120 MW plants are under consideration. 2000 sites in the country are already located whose capacities lie between 1 to 15 MW and it is expected that all these plants will be able to generate 5000 MW power. The first unit of 5 MW capacity of Gandak Canal Project at Valmiki Nagar in Bihar is commissioned in 1994. The second unit (5 MW) is awaiting a trial run and third unit (5 MW) has been completed. The cost of the project which was estimated Rs. 17.4 crores in 1983 has risen to Rs. 66 crores and out of that 22 crores has been loaned by Japanese firm. The project will sell power to Bihar Electricity Board at the rate of Re. 1 per unit which owns the supply and transmission network. The tidal energy, one of the major sources in India is considered most promising and it is estimated that the potential of this source is 80,000 MW. A 900 MW capacity plant is already planned in area of Gujarat.

The present microhydel capacity is 100 MW. The pumps which are running on wind power are 3000. There are 20 lakh biogas plants working in the country and 10 lakh more will be added by the end of VIII-plan period.

The power scenario in India will continue to be a difficult one, at least for the next 50 years. We have to draw up and implement plans for more generation and better distribution. Vision in power sector can be translated into reality only if we bring together the plans, projects, the money and implementation. While we need resources from abroad, they can never come in the amounts we need. We have to bend our energies to suit our own sources. Foreign power producers can be the icing on the cake, not the cake itself.

The world energy review emphasizes the fact that for the next two decades, oil and gas will continue to play a significant role in the world energy economy.

Coal and nuclear power are expected to be the major supplies of energy (55% of total) after 2000. The contribution by gas and oil will be reduced to 30% of the total. Overall non-renewable resources will provide 8% of the world energy supply by 2020. Research and development for non-conventional energy sources are likely to bear fruits if properly funded and adequately managed. The power contribution from these sources is expected to 7-8% by 2020.

The world energy demand will continue to grow, perhaps by as much as three times through the next 50 years. This is compounded by population increase and economic growth. Particularly in developing countries where growth of 1% in the economy requires energy supply growth of 1.5% but in the mature industrial economics, the figure is 0.5% energy growth for 1% economic growth.

**Power Position of Developing countries.** For the present, the problem for the developing countries is : how to minimise the dislocation caused by rapidly rising oil prices. The problem is more serious for developing countries compared with developed countries. Because, the oil importing developed countries can atleast soften the impact of costlier oil by raising the prices of capital and consumer goods they export to oil exporting countries. But the countries of the Third World are hit both ways. Therefore economic condition of these countries is paralysing their economics very rapidly. They hardly benefit from the recycling of petro-dollars. Their import bills shoot up not only because of higher prices of oil but higher cost of capital goods from the developed countries. The sharp deterioration in their condition is exemplified by Costa Rica. Its biggest export is bananas. In 1973, it had to export 28 kg of bananas to buy one barrel of oil. In 1979, to buy one barrel of oil, it had to export 420 kg of bananas. Even the countries like Zambia, Korea, India and Pakistan which are less dependent, compared with other developing countries, oil imports are painfully caught in this pincer. When we look at the global picture, we also have to see how certain areas of the globe are going to be badly affected. Large as the commercial energy resources of India appear, the reserves are small in per capita compared to other countries. While India has reserves of 176 tons of coal/person, USA has 13488 tons, former USSR has 22066 tons and China has 1168 tons. The proven reserves of oil are only 0.55 tons/person against 34.83 tons in USSR, 16.32 tons in China. Low per capita resources of fossil fuels is a common feature of developing countries in South and South East Asia, Latin America and Africa.

Even today, energy consumption in the developing countries is very low. Industrial countries with 22% of the world population consume 84% of energy and on the other hand, developing countries with 78% of world's population consume barely 16%.

The modern technological society is consuming energy at the rate of 8 TW ($8 \times 10^{12}$W). However this has benefited only 1200 million inhabitants of the rich nations, leaving the remaining 3 billions in the developing countries to eke out their subsistence economies using less than 1 TW, mostly from non-commercial energy resources.

The level of economic development of a country and its energy consumption are inter-related. Therefore, there is no escape from the need to ensure progressive stepping up of the energy supplies so that energy consumptoin can go up in the developing countries in the years to come.

It is against this background that the developing countries are asking for same kind of a guarantee that their minimum requirement of oil will be met. Various international efforts are being made to this end. But there is no response to help the developing countries in this problem area. Therefore, in India, we should accordingly draw up a blue-print for the development of our indigenous energy resources as thorium, solar and biogas. In other words, we have to exploit all resources of energy available to us at an acceptable price.

It is anticipated that even if the present rate of power production is continued, the world fossil and nuclear fuel resources will be exhausted earliest by the end of this century and *latest* by the middle of the next century. Therefore, it has become essential for the *survival* of the human *community* to find out the new resources. Humanity is in a transition period from one energy system based on depletable fossil fuels to other based on non-depletable sustainable resources. Let us strive to design strategies to meet the future needs of our country.

Fortunately, India having large resources in the vast areas, the problems of power development without pollution are not much challenging within coming few decades. But every care must be taken in advance to maintain clean environment for our future generation.

Further it is also a fact that use of renewable sources such as solar, wind, biomass and tidal energy are likely to prove far less hazardous as compared to the depleting fossil and fissible fuels. Thus, perhaps, the crisis is a blessing in disguise and it is merely a question of time before commercially viable technologies bring out an era of energy abundance with a far more favourable ecological balance.

## Development of Power Industry in India & Abroad during 1996-97

### A. Development in States

**1. KARNATAKA**

State owned Karnataka Power Corporation Ltd. (KPCL) Rs. 1545 crores Raicher Thermal Power Station (RTPS) expansion project is going to be the largest power project in Public sector in India. The capital required for V & VI units is Rs. 1236 crores and it is the major landmark in the history of power projects in the country. When these two units are commissioned, nearly 8 million more units would be added to the state grid, marking a 20% increase in the supply.

The V-unit is scheduled to be completed in 1999 and next one in 2000 A.D. The project cost of Rs. 3.68 crores per MW is among the least in the country. A power purchase agreement had been signed with Karnataka Electricity Board which now owned Rs. 900 crores as arrears to KPCI. The coal for the plant will be supplied from the Singreni and Mahanadi Coal Fields and total requirement for all six units of RTPS would be 5.16 million tons a month. The first four units had been established between 1980 and 1995.

The expansion would improve the hydro-thermal mix for the power grid of Karnataka, which was predominantly hydro (75%) and would mean that the state would be less dependent on monsoon swings.

**2. ANDHRA PRADESH**

A 235 MW Jegurupadu combined cycle plant sponsored by GVK-Industries faces a problem of fuel supply. The Spectrum Power Generation Ltd. sponsored 208 MW plant based on natural gas, facing a problem of fuel supply. The Hinduja National Power Corporation Ltd. sponsored Vizag Thermal Plant of 1040 MW was asked to modify the fuel risk clause in the original as the Coal India Ltd. refused to take the fuel risk.

CMS Generation sponsored 250 MW (Neyveli) thermal plant, the main problem was the guarantee of supplying the required fuel. The fuel suggested was lignite for which there is no substitute and NLC has accepted the responsibility to supply the required fuel.

The power projects in India are scattered throughout India. In a number of cases, they are not in close vicinity of either oil, gas or coal. Oil and gas stations are situated far away and not connected to prospective power plants.

Independent power producers pursuing for small projects for an aggregate capacity of more than 1500 MW in Tamil Nadu will be asked to make their own arrangements for liquid fuel. Chairman of TNEB told that the Govt. would be able to allocate naphtha only to the projects of about 480 MW among 20 proposed projects of 2000 MW capacity. The rest of the plants planned in T.N. would be asked to make their own arrangements for fuel.

**3. WEST BENGAL**

With the trouble regarding water package of Rs. 136 crore almost over, all deals for the construction of first two units (2 × 210 MW) of the long awaited Bakreswar Thermal Power Project in W.B. have been finalised. The third unit is awaiting the clearance of the Union Ministry of Power.

**4. MAHARASHTRA**

Present MSEB installed capacity is 11582 MW and an addition of 18320 MW is expected by 2002. The energy consumption has increased 76 times compared to 1960-61 and domestic consumption is at 248 times and agricultural consumption is 1110 times.

The total pump sets so far energised are 2025973 which is highest in India. The availability factor has increased to 83.7% compared to 1994-95 (81.9%). The generation registered 38212 M units in 1994-95 and 39390 M units in 1995-96. In 1960, MSEB supplied 191 M units which has gone to 14404 M units in 1995-96. The peak demand has increased from 4900 MW (1988) to 8578 MW (1996). A short term measures are taken by MSEB in order to meet the immediate requirements of power. Fifteen Units in MSEB (each of 210 MW) will be refurbishment of 15 MW which will add 250 MW to the grid.

Considering power shortages, immediate steps have been taken to implement 7-medium size power stations in MIDC areas Waluji (Aurangabad), Sinner (Nasik), Kagal (Kolhapur), Ranjangaon (Pune), Chincholi (Sholapur) and Wai (Satara). The capacity of each is expected to be around 100 to 180 MW. Addition of Koyna unit stage IV (4 × 250 MW) and addition of Hydro capacity by small hydro-stations and pumped storage will be used for peaking purposes. Efforts are also being mode to implement co-generation in sugar factories and wind power is expected to add around 300 MW in coming 3 to 4 years.

The proposed capacity addition is listed below :

| *Year* | *Type of Projects & Capacity* |
|---|---|
| 1996-97 | Six small hydro projects—68 MW.<br>Tata Bhira pump storage—150 MW |
| 1997-98 | Chandrapur Unit VII—500 MW.<br>Dudhganga Project—24 MW. |
| 1998-99 | Dabhol Project—Phase I—740 MW.<br>Koyna stage IV (Unit 1 & 2)—500 MW.<br>Tata Bhivpuri pump storage—90 MW.<br>Karanjwan—3 MW. |
| 1999-2000 | Khaparkheda Unit III & IV—420 MW.<br>Koyna stage IV (Unit 3 & 4)—500 MW.<br>Reliance Patalganga—410 MW. |
| 2000-2001 | Ghatghar pump-storage—250 MW.<br>Nippon Denro Bhadravati—1082 MW.<br>Dabhol phase-II—1444 MW. |

The State Govt. of Maharashtra has decided to develop 15 hydro-plants through private sectors as listed below :

| *Sl. No.* | *Name of the Project* | *Capacity in KW* |
|---|---|---|
| 1. | Khaner Project—Distt. Satara | 1200 KW |
| 2. | Kasari Project—Distt. Kolhapur | 2500 KW |
| 3. | Shenur Project—Distt. Amrawati | 750 KW |
| 4. | Chasakman Project—Distt. Pune | 3000 KW |
| 5. | Karwa Project—Distt. Nasik | 500 KW |
| 6. | Dham Project—Distt. Wardha | 750 KW |
| 7. | Dehali Project—Distt. Dhule | 150 KW |
| 8. | Hetwane Project—Distt. Raighad | 1500 KW |
| 9. | Ganagamsheth Project—Distt. Kolhapur | 500 KW |
| 10. | Kadwi Project—Distt. Kolhapur | 1500 KW |
| 11. | Kumbhoi Project—Distt. Kolhapur | 2500 KW |
| 12. | Patgaon Project—Distt. Kolhapur | 2500 KW |
| 13. | Mukne Project—Distt. Nasik | 1000 KW |
| 14. | Upper Wardha—Distt. Amrawati | 750 KW |
| 15. | Wan Project—Distt. Akola | 1500 KW |

**5. TAMIL NADU**

Twenty new 100 MW power projects will be developed in T.N. at the total cost of 8000 crores. With the development of these projects, the state would be free from power shortage.

TIDCO would provide 15 acres of land for each power project, which would be completed within 18 to 20 months.

The projects would come up at Manali, Gummidipoondi, Arakkonam, Ranipet, Sriperumbudur, Maraimalainagar, Cuddalore (two projects), Tiruchi, Salem, Coimbatore, Dindigul, Thirumangalam, Vadipatti-Nilakottai, Hosur, Pudukottai, Tuticorin, Tirunelveli, Perundurai. The power stations would use either Naphtha, or light sulphur heavy stock (LSHS) or furnace oil.

**6. HIMACHAL PRADESH**

Topographical constraints, coupled with natural disasters and power shortage, has hit the progress of the gigantic Nathpa-Jhakri hydro power project in Shimla, Kinnaur districts of Himachal Pradesh, resulting in cost escalation of Rs. 3,000 crores.

The 1,500 MW prestigious power project, scheduled for completion in late 1998, is running more than two years behind schedule and the project costs have gone up from Rs. 4,338 crores to Rs. 7,200 crores, according to revised estimates. The power generation cost is also likely to go up from 68 paise to Rs. 2 per unit.

The Nathpa-Jhakri Power Corporation (NJPC), a joint venture of the Centre and the Himachal Pradesh government, has reset the target for commissioning the project in 2001 AD. The project is funded by the World Bank to the tune of $43 million (approximately Rs. 1,500 crores).

According to NJPC chairman-cum-managing director, the Planning Commission has agreed to provide funds for the project and Centre's decision on it is expected soon. The Centre and the Himachal government had equity in the ratio of 3 : 1 in the project which is being funded through loan and equity in equal proportion.

The project, conceived in the early '70s, actually reached the take-off stage with the award of contracts worth Rs. 2,040 crores to three international joint venture consortium. Additional commercial foreign currency loans equivalent to Rs. 644 crores for electro-mechanical package were also tied up in the initial stages.

The major excavation works of the project are nearing completion and the work on the biggest underground power project with cavern size of 222 m × 20 m × 49 m and the deepest 301 m surge shaft is going on in full swing.

The Bharat Heavy Electricals Limited (BHEL), in collaboration with the European consortium Eucona, has designed a 250 MW turbine for the first time for six units of the project.

The project faced the first challenge when a 10 million cubic metre block of mountain rock fell on Sutlej at the dam site at Nathpa, blocking the river for nearly one year.

Further, the height of the concrete dam had to be raised from 60.5 m to 65.5 m and slope stabilising measures had to be undertaken on both banks of Sutlej.

While the excavation of 20 km out of a total 27 km length of the tunnel has been completed, only 35 m of it could be dug up in the past six months.

In the Vadal Adit area, a hot water spring flooded the tunnel, raising the temperature to 68 degrees Celsius. The work was seriously hampered due to this and the hot water had to be diverted but the temperature inside the tunnel remained between 50 and 60 degrees.

The biggest handicap faced by the project is power shortage. Against the requirement of 20 MW power, the project is getting six to seven MW of power per day during the winter, and low voltage, frequent interruptions and tripping are further compounding the problems.

The project stretches over a length of 50 km from Nathpa in Kinnaur, where the dam and the biggest underground desilting chambers to prevent flow of particles of 2 mm are being constructed at Jhakri in Shimla district where the huge power house complex, studded in mountain rocks is coming up.

**B. NTPC : IMPRESSIVE GENERATION**

During the year 1995-96, power stations of National Thermal Power Corporation (NTPC) all over the country generated 93,468 million units (MUs) of electricity, registering an increase of 18.2 per cent over the previous year's generation of 79,090 MUs. This is approximately 31 per cent of the total generation in the entire country during the year.

**Increased Availability and PLF**

NTPC coal-based units recorded an impressive Plant Load Factor (PLF) of 78.80 per cent and a high availability of 85.23 per cent.

Six, out of nine stations on commercial operation, achieved more than 75 per cent PLF. These are :

| | |
|---|---|
| Rihand | 86.76 per cent |
| Singrauli | 85.29 per cent |
| Unchahar | 84.21 per cent |
| Vindhyachal | 83.77 per cent |
| Korba | 83.47 per cent |
| Ramagundam | 79.92 per cent |

The Ramagundam Super Thermal Power Station has achieved a distinction by running its 500 MW unit No. six continuously for 406 days, surpassing all previous records of continuous run by any generating unit in the country.

The Badarpur Thermal Power Station and Balco Captive Power Plant which are managed by NTPC generated 4037 MUs at a PLF of 65.19 per cent and 2232 MUs at a PLF of 94.09 per cent respectively.

The generation could have been still higher but for constraints like grid restrictions and inadequate fuel supplies mainly for the gas units. As much as 12321 MUs of generation loss was recorded because of the following reasons :

| | |
|---|---|
| Non-availability of coal | = 3320 MUs |
| Non-availability of gas | = 4366 MUs |
| Grid restrictions | = 4635 MUs |

**High Turnover**

The turnover of the Corporation has risen to Rs. 8482.67 crore, recording an increase of 30.8 per cent over last year's turnover of Rs. 6485.52 crore. The Corporation earned an estimated profit of Rs. 1235.47 crore during the year against Rs. 1124.55 crore during 1994-95.

**Eighth Plan Targets Achieved**

By adding a capacity of 710 MW during the year, the Corporation has achieved the 8th Plan target of creating an additional capacity of 5002 MW. The additional capacity during the year was achieved by the synchronisation of the second 500 MW unit at Talcher and fourth 210 MW unit at Kahalgaon. With this, the total installed capacity of the company as on March 31, 1996 has risen to 16795 MW.

**Projects at Hand**

The construction activities for the expansion phases of Vindhyachal (2 × 500 MW). Unchahar (2 × 210 MW) and Kayamkulam (400 MW nominal) are progressing satisfactorily. The main plant equipments package for the Kayamkulam project is to be awarded shortly.

**Projects in the Pipeline**

The Government of Madhya Pradesh has asked NTPC to take up Seepat Super Thermal Power Project of 2000 MW capacity at Seepat in Bilaspur District (now in Chhattisgarh). Also the Tamil Nadu government has shown keen interest in NTPC developing a 2000 MW project near Chhennai. The Corporation has adopted a multi-pronged approach for adding a capacity of 10,000 MW in the next seven years, through the following schemes :

***Expansion of Existing Projects**

| | |
|---|---|
| Vinchayachal (work in progress) | 1000 MW |
| Unchahar (work in progress) | 420 MW |
| Talcher | 2000 MW |
| Rihand | 1000 MW |
| Ramagundam Stage-III | 500 MW |
| Anta | 400 MW |
| Auraiya | 650 MW |
| Kawas | 650 MW |

***Green Field Projects**

| | |
|---|---|
| Kayamkulam Gas (work in progress) | 400 MW |
| Faridabad (Gas) | 400 MW |
| Simhadri (Coal) | 1000 MW |
| Hyderabad (Gas) | 650 MW |
| Seepat (Coal) | 2000 MW |

***Takeover of Stations/Semi-completed Projects**

After taking over the Unchahar project in 1992, NTPC has now taken over the 460 MW Talcher Thermal power station from Orissa ECB on June 5, 1992. This power station was running at 0.2 PLF at the time of take-over, has achieved 0.44 PLF in March 1993, within 10 months of its take-over by NTPC.

**NTPC likely to Set-Up 3000 MW Thermal Plant near Bilaspur**

One of the biggest power plants in the country may come up near Bilaspur in the Chhattisgarh region if the plans of the public sector National Thermal Power Corporation (NTPC) fructify.

The Government has agreed, in principle, to provide 4,000 acres of land around Seepat, just 20 kms from Bilaspur, and water linkage from Bango dam on Hasdeo river for a 3,000 MW power station which the NTPC proposes to set up there.

The cost of the project depends on proper availability of water, which would be pumped there, through a 70 km pipeline, from the left bank canal of the dam which passes by Seepat. However, a small patch of forest land would be affected due to the proposed power station. Seepat, near Korba, where the NTPC already has a 2100 MW super thermal station, besides a 270 MW power station it is running as a captive plant for BALCO, the public sector aluminium plant.

After completion of the Seepat Power Project, the western region would be able to generate 7,653 MW. The new project would certainly give a boost to the industrial development of Chhattisgarh, Vidarbha and neighbouring areas.

Coal for the proposed plant would be supplied by nearby South Eastern Coalfields Limited.

S.R. Khaneja, General Manager (NTPC-Wester Region) presented that the shortage of power in western and southern regions of the states could be successfully overcome if coastal power stations would ultimately reduce the dependency on railways for coal transportation. The State Government have identified 13 locations along the coastal sides for setting up coastal thermal stations. He further stated that the recent power load survey has projected demand of 148000 MW by the end of 2000 against the present installed capacity of 84000 MW. 65000 MW capacity is to be added in ninth plan period to bridge the gap.

NTPC has proved outstanding achievements in power generation as shown in Fig. 1.24. Major difficulty faced by NTPC is the large amounts of dues to be collected from State Electricity Boards as shown in Fig. 1.25.

ABB has announced the commencement of commercial operation of the first gas turbine of 235 MW combined cycle plant being built at Jegurupadu in A.P. The turnkey order on ABB of $\$195 \times 10^6$ was placed by GVK Industries Ltd., Hyderabad, an independent power producer which will implement the project. Complete operation of the plant in combined cycle mode is scheduled for summer 1997.

**Eight Thermal Plants by Larson & Toubro**

Larson & Toubro has entered in contract with other foreign companies to start 8 thermal plants in the country. Contract is made with Maruben Co., Japan for two plants. Insearch Co. USA for 3 plants, Torrent in Gujarat for two plants and one plant each with HIE and KBDL. These plants are going to be established in Maharashtra, M.P., Karnataka, Orissa and Tamil Nadu. The basic fuels which are going to be used are coal, lignite and naphtha.

In addition to above, 500 MW plant at Bhilai based on coal and 200 MW plant at Hasan based on Naphtha are already in the hands of the company.

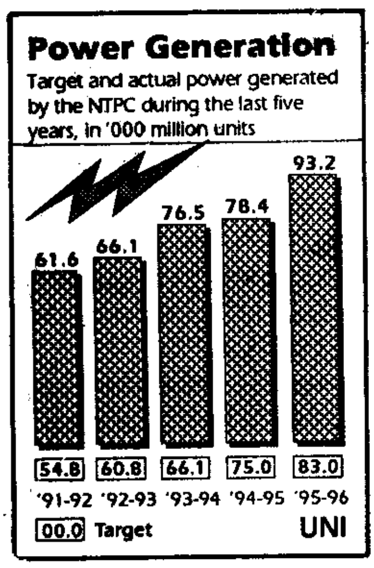



Fig. 1.24. Power Generation.

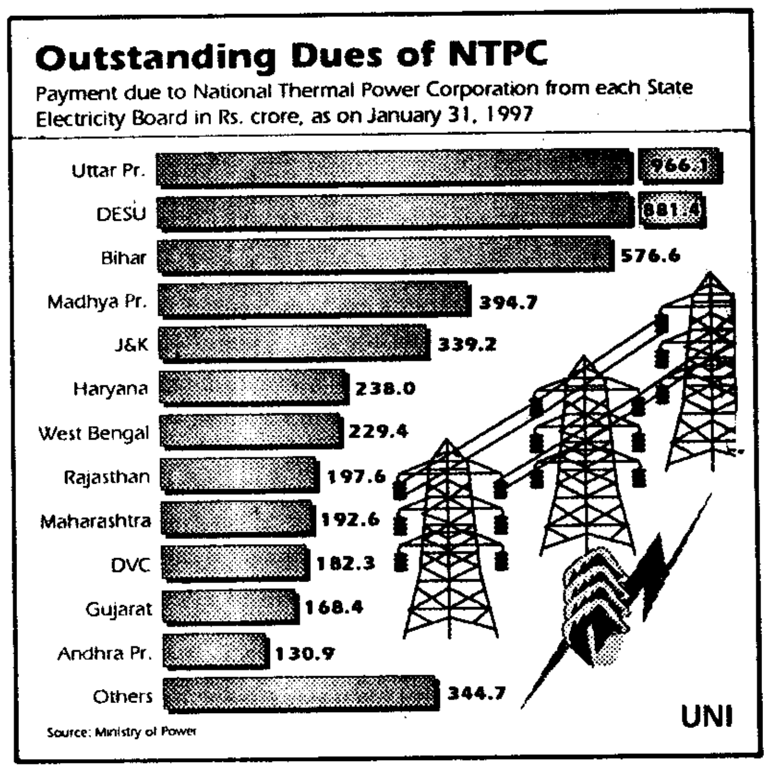



Fig. 1.25. Outstanding Dues of NTPC.

## C. POWER GENERATION IN PRIVATE SECTOR

In the VIII plan, the capacity addition originally planned was 30538 MW but the actual addition is merely 18000 MW. Presently, capacity addition between 1996 and 2001 is estimated to be 44000 MW. This will cost Rs. 262, 400 crores including investment in transmission and distribution.

Weak support infrastructure and sagging bottom lines have ensured that even the allocated external aid remains unutilised, at the end of March 1995, the total undisbursed external assistance was to the tune of $ 4.9 billion.

As the NTPC and State Electricity Boards are unable to keep the pace with increased demand of power in future and as such a huge capital is not available with the Govt., the Govt. of India has decided to allow the private sector to enter in power generation industry. In response to an attractive package offered to the private sector, the Govt. has received about 200 proposals from domestic and foreign private companies for power projects with a generation capacity of 90,000 MW with an estimated cost of Rs. 360,000 crores.

The Dabhol-Enron high capacity power project is the first of its kind which is going to be developed by private sector. With the modified agreement, the first phase capacity will be 826 MW instead of 695 MW. The total capacity of the project is going to be 2450 MW instead of 2015 MW. The second stage will be able to generate 1624 MW. The total cost of the project will be $ 495 × $10^6$. The first phase of the project would be completed by Dec. 1998, a few months ahead of schedule. The power would be generated using natural gas. Gas is environment friendly and would help to protect the natural surrounding area. The work for laying a 75-km transmission line from Dabhol to Koyna to link the project with the national grid had begun and would be completed by June 1998.

Reliance Industries Ltd. has signed its power purchase agreement (PPA) with MSEB for its 410 MW project at Patalganga. The Patalganga project will cost Rs. 1411 crores. The plant is scheduled to commence operation by the end of 1997. This project, originally proposed to be set up at Nagothane was shifted to Patalganga. This will result in saving of Rs. 450 crores in project cost because of land acquistion need not be undertaken afresh. Moreover, a pipeline already exists from Mahul to the project site at Patalganga where Reliance is already running a 40 MW plant. This plant will be able to run on either naphtha or gas. In addition to this PPA for 1080 MW project of Nippon Denro Ispat Ltd. at Bhadravati has been initialled with the signing of this PPA, Maharashtra would be able to add about 3700 MW by the year 1998.

The Delhi Vidyut Board's (DVB) proposal for signing a power purchase agreement (PPA) with Reliance which will be setting up 421 MW gas based plant in Bawana, costing 3.304 crores per MW. The first privately owned power unit in Delhi, has been cleared.

Krishak Bharati Co-operative Ltd. (Kribhco), the co-operative fertiliser giant, has decided to make foray into the power sector. The company with cash reserve of 800 crores is contemplating at setting up power plants in Gujarat, Rajasthan and Karnataka, capacities ranging from 100 to 400 MW.

Goa is a state which does not generate any power and it gets 394 MW from national grid but the state uses only 160 MW. The major difficulty for getting this power from Maharashtra and Karnataka is a loss of 26% during its transmission as the transmission is very old and it costs Rs. 32 crores to the Goa Govt. Therefore, Goa cabinet has approved the power purchase agreement of the private sector Salgaocar-Reliance Power Project at Sancoate. The plant capacity is of 40 MW and costs Rs. 90 crores. This project will start generating power by Oct. 1998. The plant will be using naphtha as fuel. Goa Govt. is also considering granting permission to the Zuari Agro Chemicals which is operating a 12 MW plant for expanding their capacity.

## (D) OIL & GAS RESOURCES

The indigenous resources for oil and gas are not sufficient to meet the increasing demand of the country with rapid industrial growth. The gap between the demand and supply is continuously increasing. The demand and supply for petro-products is shown in Fig. 1.26 (*a*) and Fig. 1.26 (*b*).

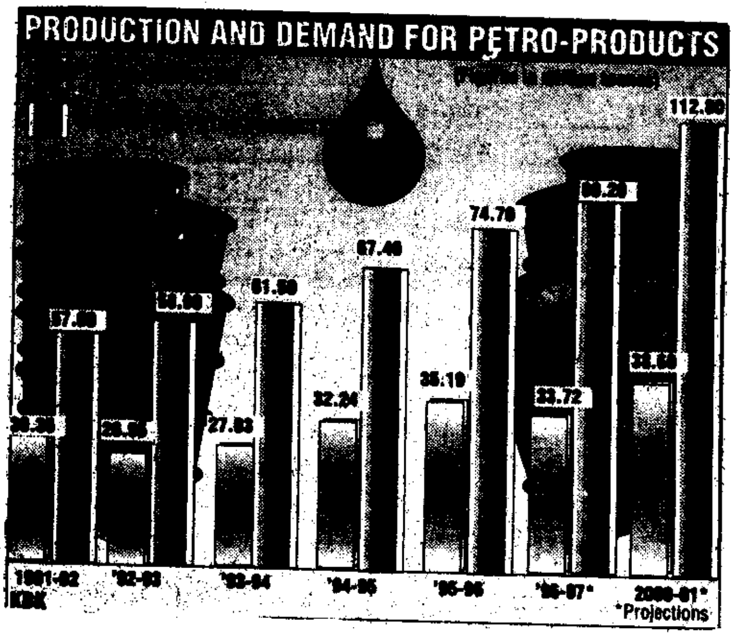



Fig. 1.26. (*a*) Production and demand for petro-products.

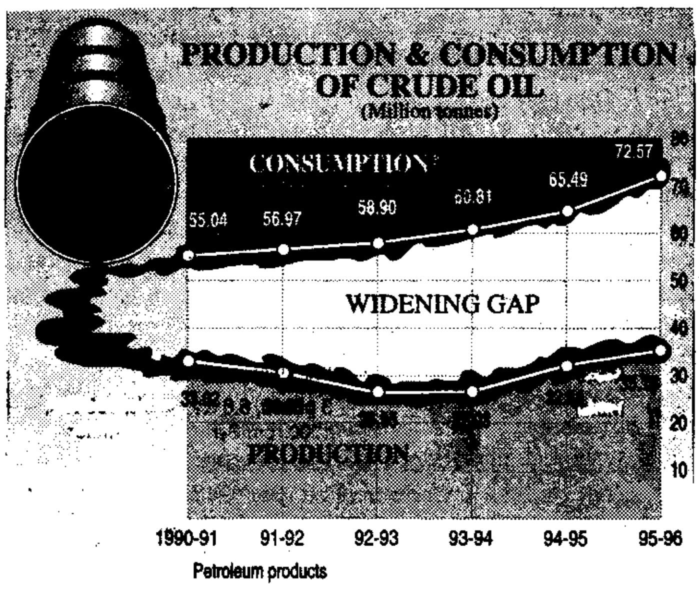



Fig. 1.26. (*b*) Production and Consumption of crude oil.

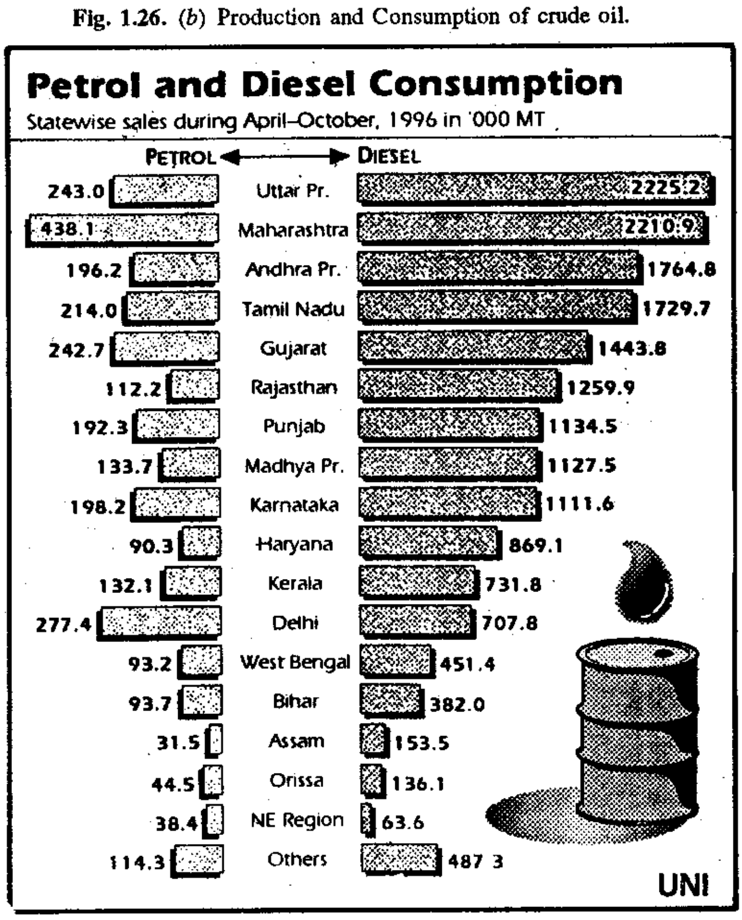



Fig. 1.27. (*a*) Petrol and Diesel Consumption.

The consumption of petro-chemicals in different states is shown in Fig. 1.27 (*a*) during April-Oct. 1996. Another worry to the Govt. of India is large variations in the prices of petro-chemicals every month as shown in Fig. 1.27 (*b*) which is affecting the finances of the Govt.

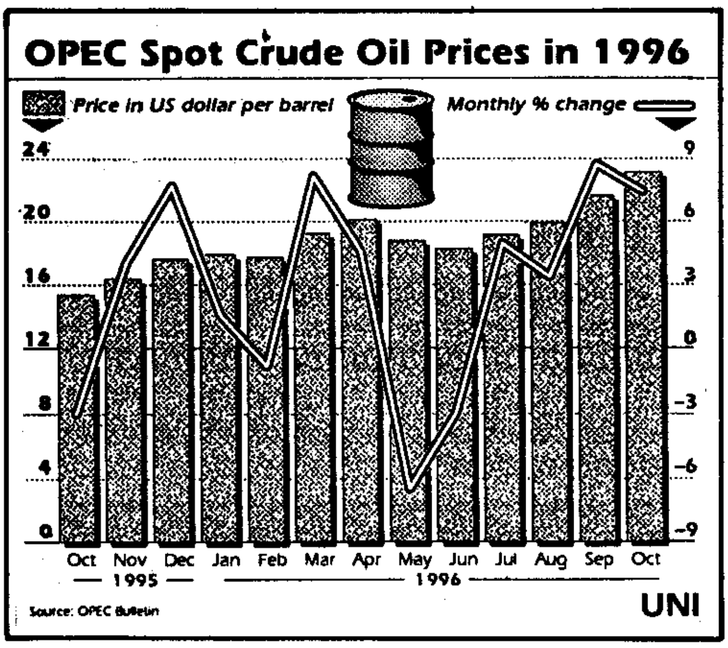



**Fig. 1.27.** (*b*) OPEC Spot Crude Oil Prices in 1996.

The Oman and India Govts. had signed a MoU in 1993 to put double 1300 km pipeline under sea to supply $10^9$ cuft of natural gas per day from 1999 onwards to India.

The Govt. of Oman has announced the cancellation of multi-billion dollar Indo-Oman under sea gas pipeline to transport natural gas to India. The Oman Govt. had spent $7 crores to find out the possible potential to supply the gas but decided to cancel for many technical problems.

Apart from the high cost of laying sea-bed pipeline, the technology required for conduits which can withstand high pressure does not exist presently. Therefore, the Govts. have decided to keep the project in abeyance till the technology becomes available.

India and Iran have identified the hydro carbon sector as immidiate area for co-operation. It would be possible to expedite the implementation of the proposed 2000 km gas pipeline project which may cost $5 billion as Iran accounts for 15% of the world proven gas reserves.

The exploration of gas by private companies has already started in India. Enron Oil & Gas Ltd., Reliance Industries Ltd. & ONGC have started extracting gas from Tapti area which is situated 100 km from Hajira. The Govt. of India has permitted the private sectors for digging in Tapti area in 1994 spending Rs. 900 crores. It is also estimated that $42 \times 10^5$ $m^3$ of gas will be taken out per day by the end of 1997 and this will continue for coming 25 years. This gas will be supplied to Gas Authority of India Ltd.

## A. TERMINALS PLANNED FOR IMPORT OF LNG

An elaborate plan was being introduced to import liquefied natural gas (LNG) into the country. Two terminals had already been cleared, on the East and West coast respectively, to facilitate the import of LNG.

Approximately $3 billion would be required for setting up a domestic network and another $10 billion for downstream units. The country has registered a demand for natural gas of the order of 260 million cubic metres of gas per day (MCMD) against an availability for sale of about 60 MCMD.

The present refining capacity in the country is of the order of 60.4 metric tonnes per annum (MTPA) and is likely to increase to a level of about 130 MTPA within the next six years.

This alone would require an investment of the order of $22 billion. Setting up new refineries would permit further integration of petrochemical units, thereby ensuring higher value addition.

Investment possibilities also existed in the marketing sector as private marketing of LPG and kerosene has been allowed from 1993. Many other products like naphtha, benzene, toulene and lubricants have been decanalised.

The damand for petroleum products in India is expected to grow by 260 per cent in the next 15 years as compared to the world average of about 60 per cent and average growth in demand of 87 per cent in developing countries.

So far 35 exploration blocks have already been awarded or cleared for award and 30 discovered fields are on production by joint venture of private oil companies. It is estimated that investment in these fields would soon cross $1.5 billion.

The government was keen on investments in exploration and has already introduced a programme for accelerated exploration at a cost of about $2 billion, he said.

**(B) RS. 30,000 cr. GAS GRIP COMING UP**

A Tamil Nadu gas grid with two liquefied natural gas terminals will be set up at a total cost of Rs. 30,000 crore. Two American companies, one Malaysian company and one French company have evinced interest in implementing the LNG terminal project.

Natural gas could be imported from Indonesia and Dubai and stored in gas terminals before being distributed to industrial complexes through pipelines. Gas carrier ships could unload the gas at the Ennore port, where a gas terminal with all the necessary facilities would be constructed at a cost of Rs. 1,500 crore.

In a year, ten million tonnes of gas could be unloaded at the terminal. For a 2,000 MW power station, about 2.5 million tonnes of gas would be enough.

A fertiliser plant at a cost of Rs. 2,500 crore, a gas cracker unit at a cost of Rs. 4,000 crore, and a petrochemical complex at a cost of Rs. 2,000 crore could be constructed. About 7,000 acres of land acquired by TIDCO in the Ennore area would suffice for this. For the gas terminal, power station, fertiliser plant and petrochemical complex, a total of Rs. 8,000 crore would be needed.

The gas could be taken through pipelines from Ennore to Arakkonam, Ranipet, Jolarpet and Salem and used for industrial development.

**ONGC INTENSIFIES GAS SEARCH ALONG BORDER WITH BANGLA**

The Oil and Natural Gas Corporation (ONGC) has intensified its exploration activities in the gas-bearing structures along the Indo-Bangla international border with Tripura where natural gas is abundantly found.

There are a large number of gas-bearing structures on both sides of the international border. Bangladesh has already identified seven odd-gas-bearing structures in their territory along the border.

The ONGC has allocated current year's annual budget of Rs. 57 crore, a hike of 15 per cent over the last year's budget, in the Tripura project.

The ONGC was supplying 2.8 lakh cubic metre per day (LCMD) of gas to Tripura state electricity department for generation of electricity in the state. At present Rokhia and Baramura thermal power units in West Tripura are generating 36 MW of power against the installed capacity of 50 MW.

ONGC is now able to increase the gas supply to Rokhia from 2.8 LCMD of gas to 3.5 LCMD of gas since May 1, 1997 to the state electricity department. It was also ready to supply 4 LCMD of gas to the North-Eastern Electric Power Corporation (NEEPC) for the 84 MW Ramchandra Nagar power station, now being commissioned in West Tripura.

During ninth five-year plan, the ONGC envisaged to carry out exploratory drilling for reserve accretion at Rajnagar, Sonamura, Tulamura, Khowai, Tichna, Batchla, Langal and Machilthun.

## ONGC SHOWS SMALL RISE IN PROFIT of Rs. 1,975 Crores

The public sector Oil and Natural Gas Corporation (ONGC) Ltd. has registered an increased net profit of Rs. 1,975 crores for the year ended March 31, 1997, against Rs. 1,945 crores recorded in the previous year, according to the company's provisional results announced.

The ONGC registered a record liquefied petroleum gas (LPG) production of 11,27,510 tonnes, exceeding the target of 9,93,000 tonnes, a release issued by the company. During 1996-97, the ONGC supplied 17,310.34 million cubic metres of natural gas to consumers in various parts of the country, thus realising 104 per cent of its target.

The increase in LPG production and gas sales contributed significantly to the profit of the company. The ONGC initiated various short-term and long-term measures during 1996-97 to overcome the decline in production in the Western offshore and North-East areas of its operations.

The crude oil production at 28.7 million tonnes was marginally short of the target of 29.5 million tonnes.

The ONGC, which is ranked among the top 20 oil companies in the world with reserves of over one billion tonnes of oil and gas, is now focussing on international opportunities by developing foreign acreage. It is also embarking on deep water exploration within the country's extended economic zone.

The ONGC is currently implementing seven major projects costing Rs. 2,190 crores in Bombay High. These projects include the commissioning of hx-hy platforms for the development of Heera phase-III.

## OIL IMPORT BILL MAY CROSS $ 10 bn

The oil import bill for the fiscal 1997-98 would balloon to $ 10.03 billion (Rs. 36,104 crore)—a whopping 32 per cent increase over $ 7.6 billion (Rs. 26,600 crore) projected for 1996-97.

The largest chunk in the phenomenal increase is accounted for by a 30 per cent jump in crude oil imports at 33.66 million tonnes from 25.837 million tonnes last year. However, due to the declining prices in the global market, its impact on the import bill has been pegged at $4,695.6 million with per barrel price estimated at $19.

Coupled with international prices for crude oil produced from Ravva, Mukta and Panna etc.—paid for in foreign exchange—the outflow would be $4,822 million. The joint venture consortiums expect to produce 0.9 million tonnes of crude oil for which they would be paid $216 million.

Import of petroleum products has been estimated at 24.98 million tonnes with imported diesel accounting for 17.38 million tonnes. The forex drain for product imports alone would be $5,207.2 million, states the 1997-98 Oil Economy Budget. The 1996-97 OEB had projected product imports at 20.48 million tonnes amounting to $4,285.16 million.

## OMAN GAS PROJECT GETS KOREA DEAL FOR 25 YEARS

Oman secured its first deal to export gas after signing a 25-year supply deal with South Korea's state power utility Korea Gas Corporation.

The signing ceremoney in Muscat gives the green light to a $6 billion liquefied natural gas (LNG) project in the Gulf Arab sultanate that will begin exporting LNG from early 2000.

Oman has promoted the gas project as the centrepiece of its plan to diversify its oil-dominated economy while Korea Gas Corp needs imports to keep pace with soaring local power demand.

"This agreement marks the opening of a new era of commercial activity between the Sultanate of Oman and South Korea", a joint statement released.

"It clears the way for construction to begin soon on a 6.6 million tonnes per year LNG complex at Al Ghalilah near the town of Sur on the northeast coast of Oman."

Under the sale and purchase agreement, Oman LNG Company will ship 4.1 million tonnes a year to Korea Gas Gorp, the largest single LNG contract between two firms.

Oman LNG Co. is aiming to tie up firm LNG supply deals with utilities in Thailand and Japan.

A $1.4 billion contract to develop Oman's gas fields for the project was also signed.

## PLAN TO EXPLORE GAS HYDRATES

A national programme for exploration and exploitation of gas hydrates estimated at 700 billion barrels of oil equivalent would be launched to narrow the demand-supply gap for natural gas.

The programme would be financed by the Oil Industry Development Board (OIDB) and would have the participation of the US and Japan, said Petroleum Secretary Vijay L Kelkar while addressing the second Indian Oil and Gas Conference.

As a first step, the OIDB would sanction a grant of Rs. 48 crore to the Gas Authority of India Ltd. for the programme.

Gas hydrates (of methane) are an alternative source of natural gas and preliminary studies by the Oil & Natural Gas Corporation, directorate-general of Hydrocarbons and GAIL have revealed the seismic evidence of its presence both on eastern and western offshores of India.

Kelkar said coal-bed methane would also be explored and exploited to augment the sources of energy. Detailed terms for fiscal and contractual conditions for CBM exploitation have been prepared and would be announced soon.

In order to augment the declining oil output from the offshore Neelam Oilfield, he said, a joint venture company would be formed between the ONGC and a multinational. The ONGC board has approved the proposal and a tender would be floated soon for selecting the foreign partner.

## (E) NUCLEAR POWER GENERATION

## 3 MORE N-POWER PLANTS LIKELY IN INDIA

At least three nuclear power reactors of 500 MW each, are likely to come up at Ujani and Jaitapur in Maharashtra and Nagarjunasagar in Andhra Pradesh. These sites are considered "acceptable" and rated high in the list presently under serious consideration of the nuclear power authorities.

Nagarjunasagar is situated on the Krishna River, in Kurnool district of Andhra Pradesh. Ujani, in Solapur district, is on the banks of the Bhima River, while Jaitapur is in a coastal area of Ratnagiri district.

The possible choice of these three sites is part of a nation-wide search for suitable locations to set up six nuclear reactors of 500 MW each, in order to achieve the targeted 10,000 MW generated from nuclear power reactors by the end of this century.

Meanwhile, reactors that are in existence or have been committed, have already raised the planned capacity to 7,000 MW. The reactors already in operation are two units at Tarapur, with an installed capacity of 160 MW each ; two units at Kalpakkam of 235 MW each and two units at Rawatbhata of 220 MW each, according to figures of the Nuclear Power Corporation.

In addition, a total of eight reactors cleared for construction, are located at Kaiga, Rawatbhata, Kakrapara and Narora, with each site allotted two units of 235 MW each. The further sanction of ten reactors last year relates to four more units of 235 MW each at Kaiga, two units of 500 MW each at Tarapur and four units of 500 MW each at Rawatbhata. This clustering of units is with a view to gaining maximum mileage on existing infrastructure, according to Mr. S.L. Kati, Managing Director, Nuclear Power Corporation.

Stating that the decision on sites for the remaining six reactors of 500 MW each will be announced by next year, Mr. Kati, however, refused to divulge details of the sites under consideration. Asked about the criterion for choice of a site, he revealed that availability of cooling water, geological setting, foundation conditions, population distribution and meteorological conditions were amongst the prime factors.

Sites fulfilling all these conditions are not too many, and the best use has to be made of those that come closest to the required standards, Mr. Kati said.

Referring to Maharashtra, Mr. Kati said the State receives 160 MW of power from the two units at Tarapur, while an equivalent amount is shared with Gujarat. With the commissioning of the two additional units of 500 MW each, power from Tarapur will be distributed between MP, Gujarat and Maharashtra, which fall under the NPC's western zone.

According to Mr. Kati, the country's hydro electricity potential is narrowing with the vociferous opposition to large dams, leading to a shift in focus to thermal and nuclear energy sources.

Thermal sources, however, impose limitations with the decreasing supply of coal, and distance of coal fields from thermal power stations, thereby increasing costs. While Tarapur supplies power at 43 paise per unit, the cost of thermal power in the State is much higher, with the pattern repeated elsewhere in the country. "As we go further away from the coal fields, nuclear power becomes competitive", Mr. Kati said.

## KAMINI REACTOR MAY BRING SELF-SUFFICIENCY IN NUCLEAR POWER GENERATION TO INDIA

*Kamini*, a mini nuclear reactor of 30 KW capacity which went critical on 30th Oct. 1996 at Indira Gandhi Centre at Kalpakkam is the only operating reactor now in the world to use U-233, derived from thorium. It is inherently a safe reactor because of its reactivity coefficients.

Prominent among its unique features are low inventory of fuel (600 gms.), compact core volume of 10 liters and high neutrons flux ($100 \times 10^6$ neutrons per cu. cm per second). The reactor consists of U-233 aluminium alloy plates fuelled core with beryllium oxide encased in zircaloy acting as reflector. Demineralised light water acts a moderator, coolant and shield. Operation and control of the reactor are done by safety control plates which also provide emergency shut-down. The entire reactor is housed in stainless steel tank which is surrounded in high density concrete biological shield. The reactor would be used for neutron radiography of irradiated fuel of fast breeder test reactor.

## INDIAN SCIENTISTS CLAIM SUCCESS IN REPAIRING N-POWER PLANTS

Indian scientists claim to have developed the technology required to repair nuclear power plants and increase their life span by 15 years.

Scientists at the Rajasthan Atomic Power Project at Rawatbhata were successful in repairing one of the power-generating units which was shut down three years ago. The unit will start generating power by April, 1997.

The first unit of the atomic power station was closed down in 1994 because of a leakage in coolant tubes of its reactor, resulting in the leakage of heavy water and helium gas.

Nuclear scientists all over the world had suggested that the Rawatbhata plant be closed down and "buried" as it was impossible to repair it. They had claimed that any attempt to repair it would cost millions of dollars with no guarantee of success.

Despite this, the scientists here undertook the challenge of changing six of the eight damaged coolant tubes. The exercise cost was about Rs. 20 crore.

The scientists assessed the damage caused to the tubes by inserting an instrument equipped with a remote control device and studied the possible remedial measures. A gasket, designed by Hyderabad's Nuclear Fuel Corporation, was inserted into the coolant chambers using robots. This enabled the scientists to plug the leakage in the tubes.

"The repairing of coolant tubes by fitting the gasket is being hailed as a major landmark in the world of nuclear power generation", claimed V.K. Chaturvedi, project director.

The department of atomic energy might even sell the technology, according to sources. A number of third world countries face problems in their atomic power stations, forcing them to "bury" the unit.

The repair work will now be formally examined by the Mumbai-based Atomic Energy Authority, and after its clearance, the commercial production of power would begin. The power thus generated will help the state to overcome its power shortage considerably. Initially, 100 MW of power will be generated.

Mr. Chaturvedi added that later efforts would be made to revive the second unit using similar technology. The atomic power station has already received 29 coolant channels for replacement. He said gradually the capacity would be raised to 220 MW.

**A New Reactor at Kalpakkam by 2007**

The conceptual design of 500 MWė proto-type fast-breeder reactor (PEBR) is complete and likely to be commissioned in 2007. The total cost of the plant is estimated at Rs. 2800 crores and the Department of Atomic Energy (DAE) has asked for an allotment of about Rs. 800 crores from the Centre during IX plant. Construction is expected to be started by 1999 when the design layout would be ready.

This pool type reactor, employing uranium-plutonium oxide as fuel and sodium as coolant would have a plant life of 30 years. The PFBR would be the first of its kind in the country and would be a major milestone in the atomic power programme.

Two units at Kalpakkam had achieved a generation of 454 MW and 935 MW as against the targets of 230 MW and 540 MW despite the fact that unit-1 was shut down for inspection from April to August 1996.

**428 N-power Plants Operating in World (June 1996)**

At least 12 nuclear power reactors in seven countries were connected to electricity grids last year, raising the number of operating nuclear power plants in the world to 428.

According to preliminary data made available to the International Atomic Energy Agency (IAEA), this was the first time so many nuclear power reactors were commissioned in one year.

The reactors commissioned last year are : France (two), West Germany (two), South Korea (one), Spain (one), England (three), the USA (two) and the USSR (one).

The IAEA data, published in the 'Nuclear News' magazine, also shows that nuclear power accounted for more than 16 per cent of global electricity production.

The total worldwide electrical generating capacity of nuclear plants grew by about 11,500 megawatts-electric (MWe) in 1988, to a total of more than 3,09,000 MWe.

In all, 26 countries generate electricity from nuclear power plants, and in some countries the nuclear share is in the range of 50 to 70 per cent.

One nuclear reactor, Berkeley-2, in England was closed down permanently last year, according to the IAEA data. The Berkeley-2, a 138-MWe gas-closed reactor, had been connected to the grid in 1962.

According to IAEA, at least 109 nuclear reactors were under construction worldwide last year.

When completed, these reactors are expected to add at least 87,768 MWe to the global electrical generating capacity.

The reactors under construction are : Argentina (one), Brazil (one), Bulgaria (two), Canada (four), China (three), Cuba (two), Czechoslovakia (eight), France (nine), East Germany (six), West Germany (two), Hungary (two), India (eight).

The other countries where nuclear reactors are under construction are : Iran (two), Italy (three), Japan (14), South Korea (one), Mexico (two), Poland (two), Romania (five), England (two), the USA (seven), the USSR (25).

**Mini-revolution in Chernobyl Town**

A mini revolution swept through the Chernobyl nuclear plant and its satellite town of Slavutich in Jan. 1997 after the nuclear accident of 1986 with the decision to scrap vouchers which have helped to artificially sustain a high living standard for its workers. The vouchers had provided a degree of comfort and facilities unknown elsewhere in Ukraine, for the people of this town. Its well heated houses, swimming pools, sport grounds, efficient social services and high salaries made these workers the envy of their countrymen.

Chernobyl management has done utmost to encourage the workers to stay in Slavutich despite the high level of radioactivity in the area. Presently 26000 residents are staying and 80% of them rely for their livelihood on the nuclear plant. Two months after the shut-down of the plant reactor number-1, only one reactor is still operating at Chernobyl, the number-3.

## F. NON-CONVENTIONAL POWER GENERATION

Increasing power consumption per capta (280 KW-per person-per year) in India, the pressure on fossil fuels would be accentuated. The country possessed only 6% of the world's known coal and 0.59% of oil and gas. Worldwide, oil reserves are predicted to last 46 years, gas for 64 years, uranium for 74 years and coal for 219 years. To reduce the burden on conventional fuel used for power generation, it is planned that 15% of the total power should be generated from non-conventional sources of energy by 2000.

**1. Solar Energy.** Sun energy is considered as non-exhaustible source of energy as $383 \times 10^{21}$ KW energy is emitted by the sun from its surface and merely $2 \times 10^{-9}$ of total energy comes towards the earth. The amount of energy falling on earth surface is 1373 W/m$^2$, which is sufficient to boil the whole water on the earth. There is not much progress in this direction as capital cost required for solar plant is as high as Rs. 65 crores per MW against thermal plant costing Rs. 4 crores per MW.

The most successful solar plant of 50 MW capacity is working at Gwalphadi in Gurgaon District of Haryana. With this experience, Govt. of India has decided to establish 30 MW solar power plant in Rajasthan, Punjab and Gujarat also.

**2. Wind Power.** It is principally accepted to tap non-conventional sources of power to bridge the growing gap between supply and demand for power. One way to reduce the shortfalls is to cut transmission losses (30%). Generation of power by using wind is one major source in India. But the area of non-conventional energy remains substantially unexplored in the country.

This vast country with a coastline of 7516 km, has 60 wind sites in 8 states where winds exceeding 18 km/hr which is essential for generating wind power economically. All these sites fall in Southern and Western States and the total potential energy from these sites is estimated as 30,000 MW.

Wind farms have the potential of being the most feasible and cost effective (Rs. 4 crores per MW) option among all renewable sources for supplementing the conventional means of power generation on large scale.

Presently the installed wind capacity in India is 800 MW and globally this puts India third after U.S. and Germany. The total installed capacity in the world is 5000 MW.

The share of Maharashtra is 500 MW out of total 30,000 MW available in the country. Maharashtra has been able to generate 46 MW through wind energy and another 50 MW is expected to be added in the next two years.

To enable this sector to grow, MSEB needs to provide all infrastructure with regard to substations, transmission lines as well as adequate grid availability. The grid becomes necessary since wind turbines cannot function without grid as they are fitted with induction type generators which require that they be connected to a grid.

The National Wind Resource Assessment Programme has evaluated the potential for this source to be over 4000 MW of grid quality power. This option, therefore, needs greater stress, through simple and fast track clearances and policy offering incentives like availability of stable grid, attractive floor level, banking of generated electricity which will motivate investors to come up with more wind power projects.

**Certified Sites by MNES in Maharashtra**

| *Station* | *District* | *Mean Annual Wind Speed* | *Wind Monitoring From* | *Period To* |
|---|---|---|---|---|
| Chalkewadi | Satara | 20.17 | Dec. 88 | Aug. 93 |
| Vijaydurg | Sindhudurg | 19.61 | Dec. 86 | Dec. 93 |
| Gudepanchgani | Sangli | 19.83 | Jan. 93 | Continues |
| Thosghar | Satara | 21.62 | May 95 | Continues |
| Kolgaon | Ahmednagar | 20.92 | May 95 | Continues |
| Kotoli | Kolhapur | 19.69 | May 94 | Continues |
| Khokade | Satara | 18.07 | May 95 | Continues |
| Panchgani | Satara | 18.39 | Dec. 88 | Aug. 93 |

MNES = Ministry of Non-conventional Energy Sources.
Out of these sites MEDA has already commissioned a demonstration project of 1.5 MW and 2 MW capacity at Vijaydurg and Chalkewadi respectively.

During 1995-96, NEPC-MICON Ltd. installed 440 machines of different capacities like 225 KW (336 Nos), 250 KW (49 Nos), 400 KW (53 Nos) and 600 KW of 2 Nos. Such rapid growth of wind energy development did not happen anywhere in the world. NEPC-MICON Ltd. have installed 1147 wind electric generators at different parts of the country totalling to 280 MW by March 1996. The same company planned to install 170 machines more during April to Sept. 1996, of which 100 would be 225 KW, 30 of 250 KW and 40 of 400 KW capacity.

**Private Co. to Build Wind Power Unit in Rajasthan**

The Rajasthan government has accorded permission to a private company to set up a 50 MW wind energy-based power plant in Chittorgarh district.

The government had recently given the clearance for setting up the first wind energy-based power plant in the state to the company, NEPC-Mecon, and subsequently a power purchase agreement was signed between the company and the Rajasthan State Electricity Board (RSEB).

The state government had been making efforts to encourage wind energy projects for the past three years for maximum power generation capacity.

The Rajasthan Energy Development Agency (REDA) had set up eight wind monitoring stations in the state at Nahargarh (Jaipur), Dabsi (Nagaur), Dhamotar and Sawa (Chittorgarh), Jaswantgarh (Udaipur), Bhagwanpura (Ajmer), Sheopura and Gadoli (Bhilwara) in December 1994 towards achieving this goal.

Looking into the importance of non-conventional energy sources and its availability, the Govt. of India provided sufficient funds to the State Govts. to develop this source of energy as shown in Fig. (1.28).

**3. Energy from Municipal Waste**

Western Paques at Pune is first company in India, which is running a five-tonne per day plant very successfully for power generation. Mumbai Municipal Corporation entered with an agreement with Western Paques Co. to set up a Rs. 200 crores waste-to-power plant when the company has failed to setup a similar project in Calcutta for 1000 tons of waste per day.

Western Paques plans to generate 8.6 MW power and 400 tons of manure by treating 1200 tons of organic waste at the Deonar dumping grounds every day. The technology to be used is ***anaerobic bio-digestion in a closed reactor*** which will generate methane gas. This gas will be collected in very big cylinders and the same will be supplied through a pipeline at a considerable high pressure using compressors.

The same company had sold the same hi-tech dream to the Calcutta Corporation a couple of years ago but the corporation dream turned into a prolonged nightmare. The project failed to takeoff and the Calcutta Corporation now wants its 8-hectares land back. This is because the technology developed by Western Paques has not yet been proved suitable to Indian conditions.

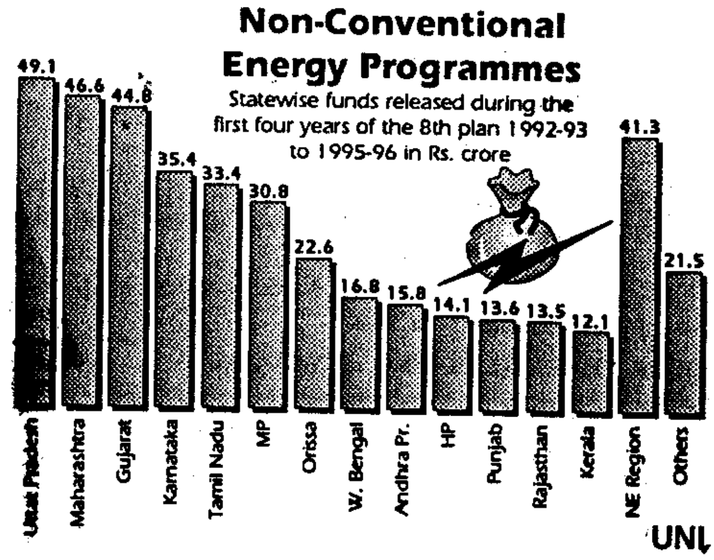



**Fig. 1.28.** Non-conventional energy programmes.

Hosahalli village in Karnataka is fully lighted by using biomass gasifier system and diesel-generator set. This power set fulfills all the requirements of the villagers as drinking water, house lighting, floor mill etc. Hosahalli is perhaps the only fully electrified village in India getting reliable and quality power supply. The wood required is 1.2 to 1.6 kg per KWhr. Less than a year after the plant started, the required wood was procured from energy plantation in two hectares of village land. The capital cost of 20 KW capacity plant to meet all electrical requirements for lighting, drinking water, milling and irrigation would cost Rs. 9 lacs. The irrigation system, drinking water supply system and floor mill would cost an additional Rs. 8 lacs.

Hanumanthanagara, another village, will also become totally self-reliant for electricity very soon.

## F. POWER DEVELOPMENT IN SURROUNDING COUNTRIES

### 1. Pakistan

Like in India, power is a crisis sector for the Pakistani administrations, though its requirement is not as massive as in India. Pakistan has a much smaller geographical size and level of industrialisation compared to India. However, the malaise in the Pakistani power sector is no less crippling than that in India.

The absence of cohesive power planning and decades of mismanagement of the electricity boards have brought Pakistan to the point of a virtual 'blackout'. An alarmed government is now handling the crisis on war footing.

The target of generation in Pakistan is 4692 MW by the year 1998. The financial closing of the first independent power producer (IPP), the $1.6-billion Hub power project, was completed in January 1995 (1292 MW). Financial closing of seven more IPs followed.

Pakistan is short of its 1998 target by 2065 MW. However, power officials in Islamabad are confident of surpassing the generation target. Their confidence stems from the fact that there are at least 10 more IPPs in different stages of financial closing, making up for a total generation capacity of about 3000 MW.

As the first and one of the largest projects of the IPPs, the Hub power project is a milestone in Pakistan's experiments with power sector privatisation. Negotiation for the project had started in 1985. It went through different governments and more than 200 legal documents since. This experience was valuable to the power officials who has become conversant as to what are the requirements of a financial institution for vetting IPPs.

Soon enough, Pakistan Private Power and Infrastructure Board (PPIB) was formed. This is literally single window clearance agency for all IPP proposals. PPIB has also brought about uniformity in power purchase and fuel supply agreements.

India being a vast country with a rapid pace of industrialisation requires huge power capacities (additional generation of 66,000 MW by 2002) and massive investment (Rs. 230,000 crore by 2002).

Considering the magnitude of the Indian power scene, a comparison with Pakistan may look to be irrational. However, it will be useful to know how a crisis is being handled in a neighbouring country.

However, it may be argued that when the house is on fire, it is to be put out under any cost. In that case, time is the costliest of all elements. By that argument, Pakistan is justified in being extra liberal to the power developers.

Pakistan is a bold country that declared it needed electricity, and went about creating a process that allowed power plants to get the financing on time.

## 2. LANKA OPTS FOR THERMAL POWER GENERATION

Sri Lanka's state-run electricity utility said that it was urgently increasing thermal power generation to ride out a drought caused by the failure of monsoon rains for the second straight year.

"We are confident that with new thermal power plants coming on stream we can ride out a possible drought and avoid power cuts which dislocated commerce and industry last year" 1995, said Ceylon Electricity Board (CEB) chairman Arjuna Deraniyagala.

"The north-east monsoon, which should have broken by the end of 1996, has failed", he told a news conference. "We have taken action to supply uninterrupted power throughout the year". The Indian Ocean island endured daily power cuts of upto eight hours at the height of the drought last year.

Water levels in hydroelectric power reservoirs, which supply 85 per cent of the country's electricity, have fallen to dangerously low levels with the failure of the north-east monsoon and the delayed onset of the south-west monsoon.

The CEB would cut dependence on hydropower to 57 per cent of the total requirement by building more thermal power plants by June 1997, Mr. Deraniyagala said. The island now has an installed capacity of 1,135 MW of hydropower and 250 MW of thermal power.

Under emergency power generation measures, the CEB will buy 83 MW from small private sector diesel plants, he said. A 20-MW plant has been connected to the national grid and a 40-MW plant will be connected by end of 1997.

The CEB plans to install a 115 MW gas turbine and a 40-MW diesel plant by June 1997 to ensure enough power through the dry spell in the first half of 1998, Mr. Deraniyagala said.

In 1998, the CEB will add up to 108 MW by connecting three more diesel plants to the grid, enough to meet demand without any power cuts during that year, he said.

Future plans call for the CEB to commission a 100-MW combined cycle plant by 1999.

## 3. BANGLADESH

Many natural gas reserves located recently at different parts of Bangladesh. Many international agencies have shown interest to provide funding for developing the gas reserves.

Paul Fieldsend (consultant in Edinburgh) says, there is massive amount of interest for developing these fields by the foreign agencies as the geology is good, gas is of good quality and area is underexploited. International focus on Bangladesh's natural gas reserves sharpened last year after *Cairn Energy* announced its discovery of between 1 to 2 billion cu. ft. The U.K. company now estimates that the reserves amount to 6 billion cu. ft., almost half the country's total reserve of 12 tcf.

With the vast availability of gas, many foreign investors are interested in funding and building much-needed infrastructure in the country. Cairn already has plans to build 45 km pipeline to the port of Chittagong to pipe gas from Sangu field when production commences in April 1998.

Increasing power generating capacity is the key to the country's economic development and people's domestic life. A company Midland Power of U.K. agreed to build 300 MW power plant in the south-east.

Occidental Petroleum Corporation (U.S.A.) has also expressed interest in building 300 MW power project in the North-East that includes the promising Jalalabad field. Unocal Corp. which recently signed a letter of intent with Petrobangla to explose at Shahabazpur field, is also planning to build a 150 MW plant near the field with a possibility of adding another 300 MW in later stages.

The obvious market for export is India because of its geographical proximity. There is a huge demand in India, as India is looking at building pipelines from the Middle East. So, Bangladesh is well placed to sell to India.

## (G) DEVELOPMENT ON NATIONAL BASIS

The nation's installed capacityaa as in March 1996 was 83288 MW which included hydel 20976 MW, thermal 60087 MW and nuclear 2225 MW. There was a big gap between demand and supply of power to the tune of 35676 million units in the country during 1995-96 whereas total availability in the country was 335045 million units.

The capacity addition during VI and VII plans was 14226 and 21401 MW respectively. During VIII plan period 38000 MW was expected to be added.

There was always a gap between supply and demand during 1991-96 as increase in capacity never coped up with demand of power. The Fig. (1.29 *a*) shows the gap between demand and supply during 1991-95 and Fig. (1.29 *b*) shows the gap during 1996 in different states of India. Projected requirement of additional installed capacity during IX plan period is 57000 MW and 67,000 MW in the X plan (2002-2007). Because of the fund constraints with the Govt., Govt. will be able only to add 20,000 MW in each plan and 40,000 MW by the end of X plan period.

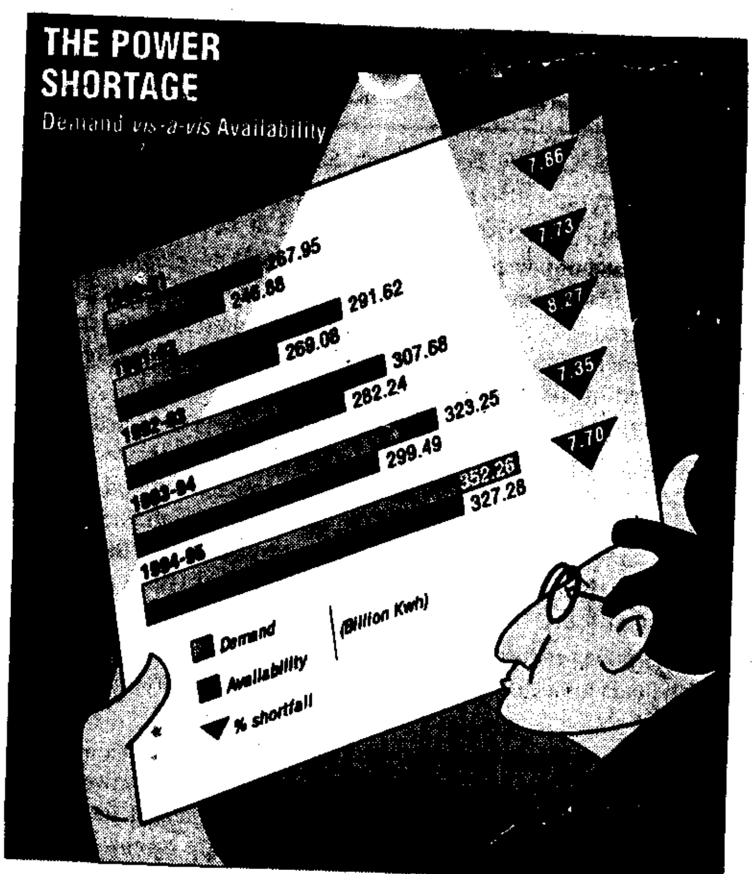



Fig. 1.29. (*a*) The Power Shortage.

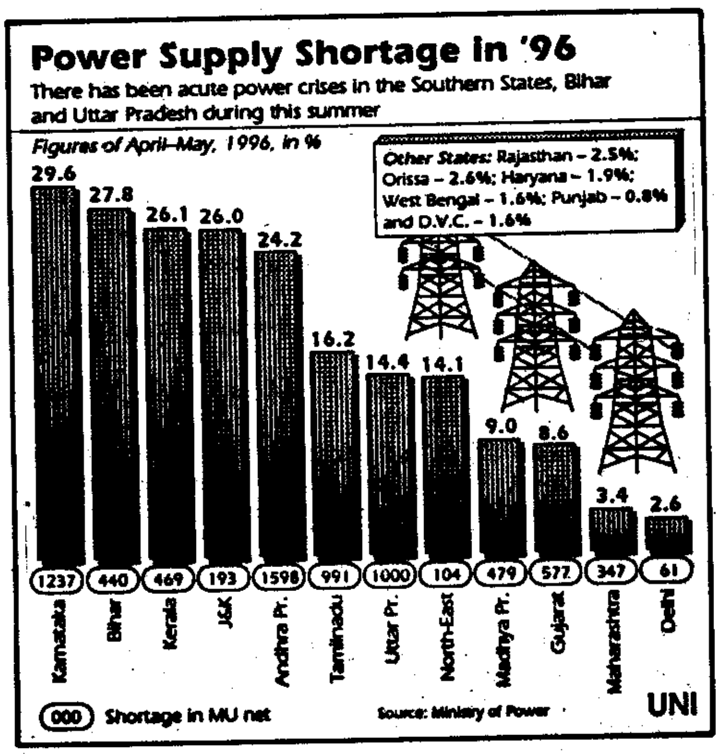



**Fig. 1.29.** (*b*) Power Supply Shortage in '96.

Fig. 1.30 (*a*) shows the present installed capacity in different states by March 1996 and Fig. 1.30 (*b*) shows budgetary support provided by the Govt. during 1993-96 to increase the power generation.

Considering the future demand of power with expected industrial development, the Fig. 1.31 (*a*) shows the statewise power requirements in different states of India by 2000. To meet the requirements as mentioned in Fig. 1.31 (*a*), the required generating capacity upto 2007 (end of X-plan) is shown in Fig. 1.31 (*b*). Keeping the expected gap in the mind, Govt. of India has kept a few projects as fast track projects as shown in Fig. 1.31 (*c*) to meet immediate need of the country.

A large capacity of 84000 MW costing about Rs. 4 lacs crores is expected to be financed through private sector, both Indian and foreign. Investment of about Rs. 150,000 crores ($47 billion) is required during IX plan period. As there are no matching investment proposals for coal, oil and transportation sector to meet the rise in demand for fuel and oil, almost all the foreign proposals being pursued are based on imported fuel. It is difficult to comprehend the level of foreign investment that the country can absorb. The country's present foreign debt totals to about 80 billion dollars (25% of GDP) and trade balance is about 1% of GDP and not in favour of India.

One of the main goals of power industry is to provide rural electrification for better life to the people. The Fig. 1.31 (*d*) shows the funds allocated by Rural Electrification Corporation (REC) to different State Electricity Boards during 1996-97.

The final power to clear the construction of power plant was in the hands of Central Govt. with an intention that it might cause mismanagement in the ecology scenario if the power lies with State Govts. This procedure took lot of time ; therefore, the ministry of environment and forests notified that all co-generation plants, upto 250 MW capacity, can now be cleared directly by the State Governments. This liberalisation, would boost the eforts of State Govts. for setting up additional capacity through private sector.

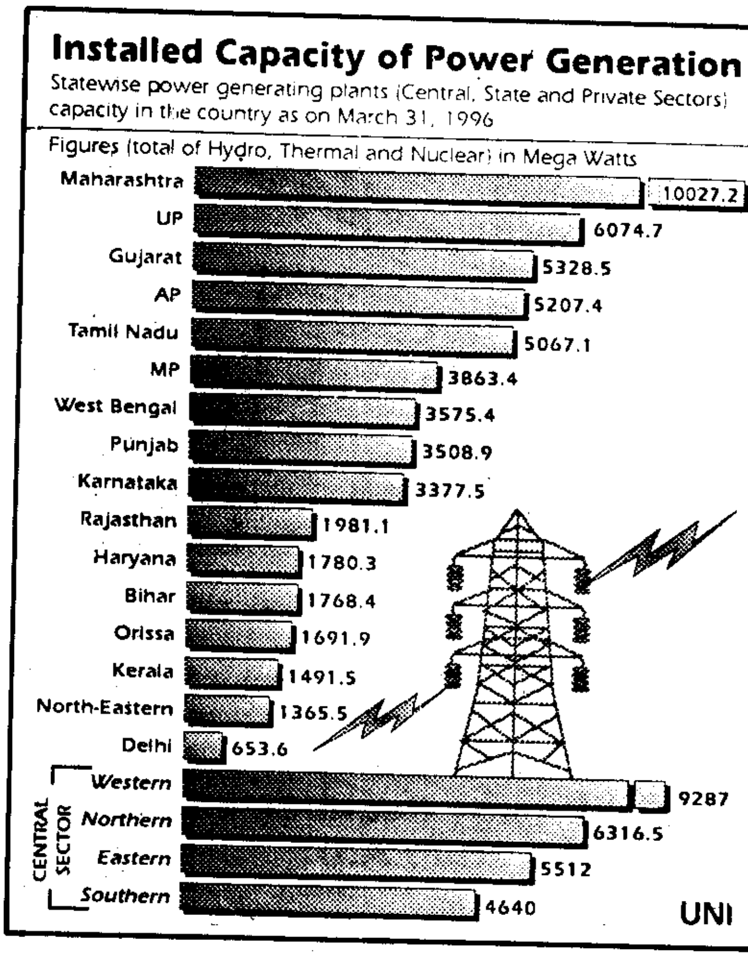



**Fig. 1.30.** (*a*) Installed Capacity of Power Generation.

In developing the power industry in India, main thrust will be on coal based plants. India's annual demand for coal is likely to be 550 million tons per year which will be double of present 250 million tons. Our strategy is to increase the use of locally available coal through improvements in the washeries to treat various types of coal and promote better use of existing facilities. Because of high ash content (25-30%) in Indian coals against the world average of 9-12%, major users, steel industry and thermal plants import huge quantities of low ash coal, about 40% of the required coal is imported. The imported coal is blended with locally available coal and then used. Australia is the main country to supply high grade coal to India. CFRI is now promoting the use of low volatile coal which has an estimated availability of 12 billion tons.

Surging demand for electricity in the rapidly growing economies of Southeast Asia, backed by vast world reserves, will spearhead the ballooning global appetite for coal. Australian and US exports are set to roughly double by 2010. While imports into China, South Asia and East Asia will grow almost by a factor of four. Coal is the most carbon-intensive fossil fuel and increased use of it means more greenhouse emissions and warmer planet.

Among developing countries, China will remain the single largest source of emissions and its emission will be doubled by 2010, as coal accounts for 75% of all electricity generated in China. The increase in China's emissions oiver the next 15 years will roughly equal that of the combined total of Europe, North America and wealthy countries of the Pacific region. Therefore, one implication is that national initiative by rich countries to reduce $CO_2$ emission will have only limited effect on global emission and even less on atmospheric concentrations of all greenhouse gases by 2010.

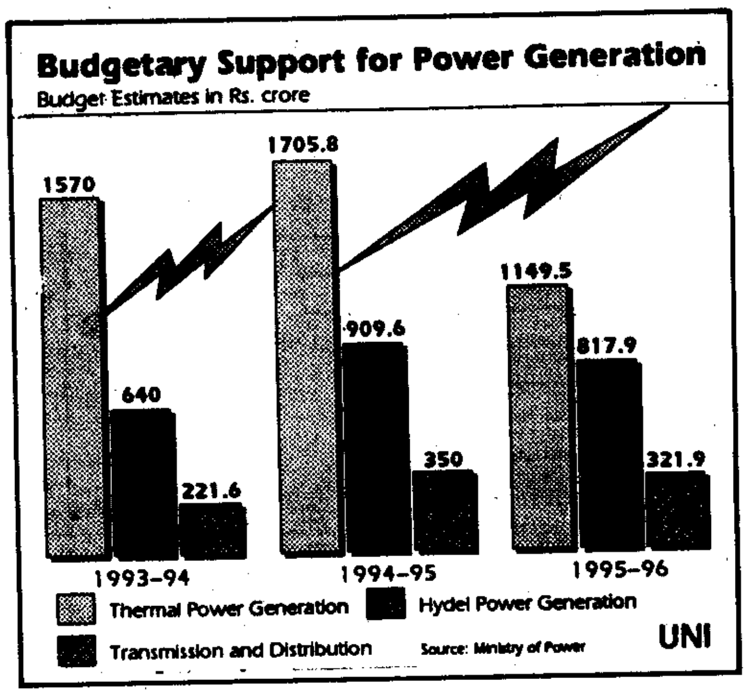



Fig. 1.30. (*b*) Budgetary Support for Power Generation.

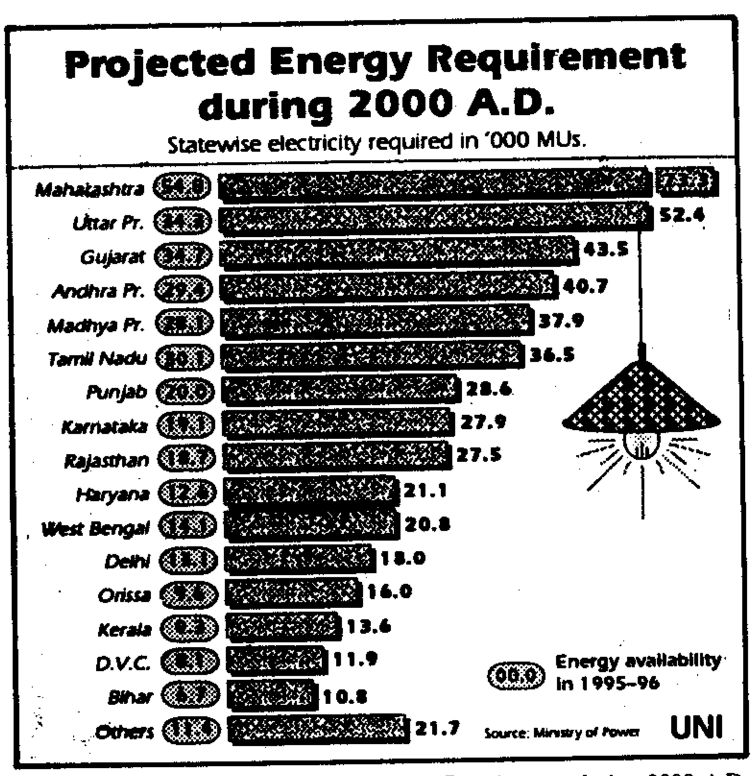



Fig. 1.31. (*a*) Projected Energy Requirement during 2000 A.D.

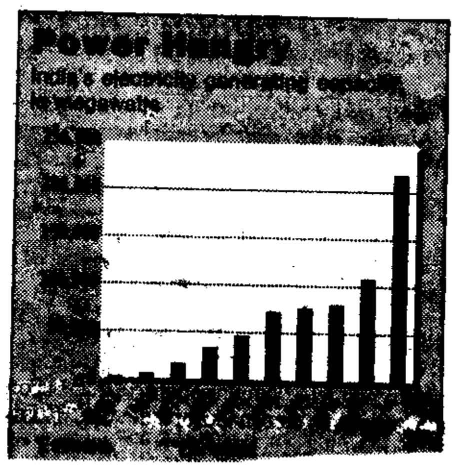


Fig. 1.31. (*b*) Power Hungry.

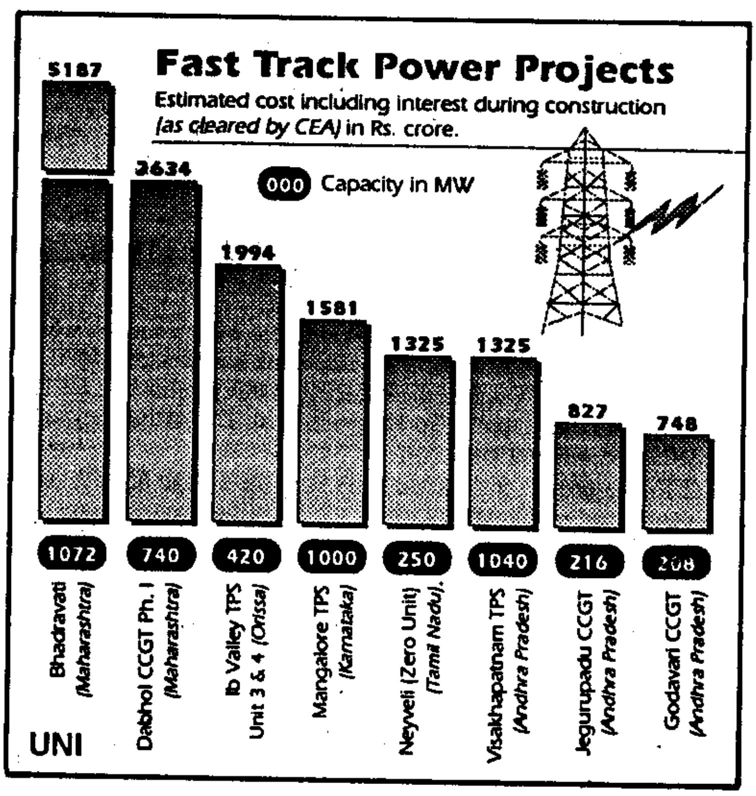



Fig. 1.31. (*c*) Fast Track Power Projects.

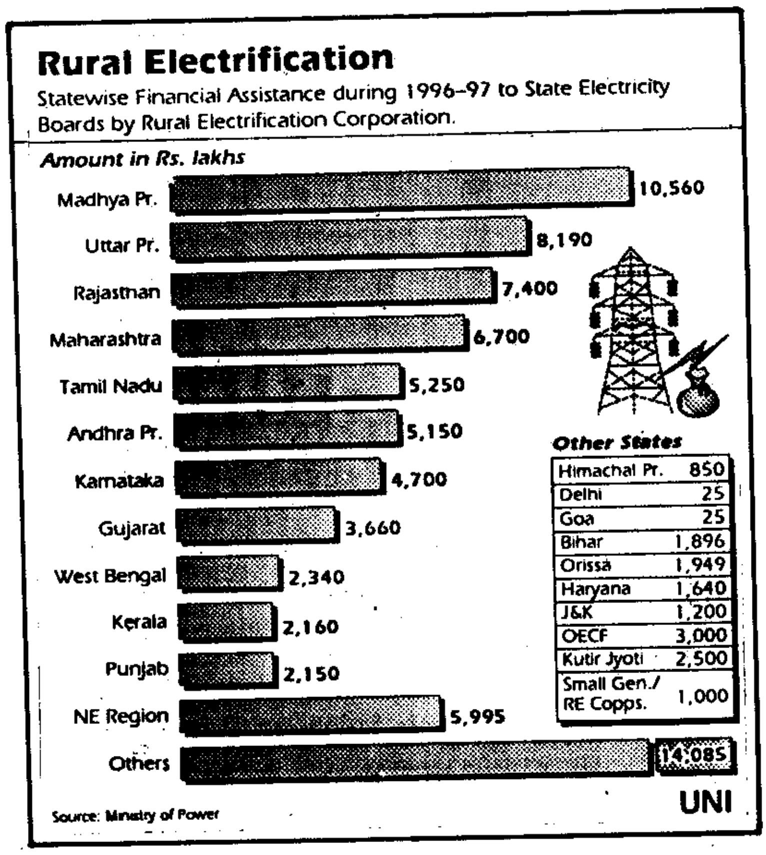



Fig. 1.31 (*d*). Rural Electrification.

# RECENT POWER DEVELOPENTS (1999-2001)

**(1) Hydel Power**

The fourth stage of Koyna-hydel project which is one of the wonders in the world was started on 3rd Oct. 1999 by the Chief Minister of Maharashtra. The world bank has financed $400 million (1680 crores) for this project. After completing this IV-stage, the capacity of this project will be 1920 MW. This is the first hydel project in Asia where Lake-Tapping Technique is used. This technique was used on 13th March 1999 and a turbine of 250 MW was started.

The I & II-stage of Koyna project was started in 1954 in the I-stage 65 MW and in II-stage 75 MW power was developed under a head of 628 meters where the Shivsagar dam capacity is $98.8 \times 10^9$ m$^3$. The project was developing 560 MW in 1962. Excess amount of water was dropped into Kolkewadi dam through an underground tunnel. The III-stage was completed during 1966-1975 with an addition of 320 MW power in underground power house. Till 1999, this project capacity was 920 MW and 1000 MW will be added in IV-stage making total capacity of this project 1920 MW. In the IV-stage, the water is carried through an underground tunnel of 4.22 km and supplied to underground power house to generate 1000 MW through 4 units of turbine. The water coming out of underground power house is carried to Kolkewadi dam through 2200 m long underground tunnel and 165 m long open channel. Till this time, Rs. 1137 crores are spent and Rs. 115 crores are reserved for the year 1999-2000.

The centre has sanctioned two mega-hydro power projects in Dihang and Subansiri in Arunachal Pradesh which will have an installed capacity of 2100 MW. The work of this project had been entrusted to NMPC. The project will cost Rs. 120,000 crores. The project would have six stages and the first stage of 600 MW capacity will be completed by 2008 and remaining five stages to be completed by 2012.

Another hydel project Tipaimukh of 1500 MW in Manipur has been also cleared. A 100 MW Karbi-Langpi hydel power project in Assam will also be completed providing funds through the power finance commission.

S. Kumar has promoted Rs. 1881 crore Muheshwar hydel power project of 400 MW capacity in M.P. It is a "run of river" scheme which will utilise the natural flow of the river. A leading German bank has provided a 17-years loan towards the equipment being supplied from Europe. ABBSA, Portugal, is the hydro-mechanical equipment supplier while Siemens of Germany will be supplying electrical mechanical equipments. Contract of civil work has been given to SEW Construction & Prasad Co. Hyderabad.

Bhutan's main power source, hydel power, is being developed with Indian assistance and power starved India is to buy the surplus power generated from these projects. Three mega projects are, Rs. 3500 crores, 1000 MW Tala power project, Rs. 500 crores, 60 MW Kurichu power project and Rs. 400 crore Dungsam project. The last is not yet taken off because it is in an area adjacent to Assam's-Bodo infested area.

Currently (1998), there is about 700 GW* installed hydro-capacity worldwide generating about 2600 TWh ($2.6 \times 10^{12}$ kWh) of electricity per year and producing 19% of the world electricity. Hydro-power supplies 50% of electricity production in 66 countries and 90% in 24 countries. It is estimated that only 32% of the economically feasible hydro-power potential worldwide have been developed.

In 1997, Asia had an installed hydro-electric capacity of about 100 GW. Asia is the continent with the fastest growing hydro-electric industry.

China currently has the highest level of hydro power development activity in the world. The 18.2 GW. Three Gorges dam, the 3.3 GW Ertan and 1.8 GW Xiaolangdi hydro-electric projects are all under construction. Hydro-electric schemes with a total capacity of 50 GW are currently under construction which will double the existing capacity in the country. The construction of four large scale projects Xiluodo (14.4 GW), Xiangsiaba (6 GW), Longtan (4.2 GW) and Xiaowan (4.2 GW) will commence shortly. A further 80 GW of hydro-power is planned, including 13 stations along the upper reaches of the Yellow River and 10 stations along the Mongshui River.

The installed hydro-power capacity in Australia is 7.6 GW. In the Philippines, construction has started on 70 MW Bakun AC scheme which will be first private hydro project in the country. Vietnam has a large number of medium to large-scale hydro schemes planned for completion and by the year 2010, including the 3.6 GW Son La scheme. Indonesia has six large scale hydro schemes planned with a total capacity of 2 GW. India has 10 GW of hydro power under construction, with a further 28 GW planned.

Another solution thought to meet the further power demand is micro hydro power plants (100 kW) which can be locally installed to meet the local needs in rural and isolated areas. It is estimated that in 1990 there was an installed capacity worldwide of small hydro power of 19.5 GW. Micro-hydro installations are widespread in Asia, where there is a significant resource potential for further development. China has well developed hydro power with an estimated 60,000 small hydro power installations ( < 1 MW). The installed capacity of micro-hydro power in Nepal is estimated to be 8.7 MW. The topography of Nepal is ideal for micro-hydro power, with high hills, scattered settlements and more than 6000 rivers crossing the country. It is estimated that the economical viable micro-hydro potential in Nepal is about 42 MW. In Vietnam, 3000 sites have been identified for micro-hydro installations in the range of 1 kW – 10 kW. These sites will serve irrigation needs in addition to generating electricity for 2 million households. It is estimated that over 3000 family units of 1 kW or less are installed in Vietnam.

Places to set up 6000 mini-hydel plants with installed capacity of 10,000 MW have been identified in India. Most of these projects will be located in Himachal Pradesh, Haryana, Karnataka, Tamil Nadu and Maharashtra.

**(2) Thermal Power**

The present power position in India is approximately 100,000 MW whereas it is estimated the demand of power will go to 240,000 MW by the year 2012. Such massive increase requires 11 lac crores capital against the available 2.5 lac crores. The power vision of the Govt. plans to add 80,000 MW before 2008.

*1 GW = 10,000 MW.

It is an attractive alternative for developing countries.

The Union Cabinet has decided that all the inter-state thermal power plants over 1000 MW and hydel plants over 500 MW would be recognised as mega projects and would qualify for various concessions and incentives to accelerate the power generating capacity of the country.

The projects which would qualify for duty include Maithon, Anta, Kawas, Auriya, Gandhar, Cuddallore and Narmada. Maithon (1000 MW) is setup jointly by NTPC and Damodar Valley Corporation (DVC). NTPC would be expanding 4-gasbased plants. Anta Auriya, Kawas and Gandhar to an additional capacity of 1300 MW each. The other inter-state projects which have been approved are Cuddalore (1000 MW) and Narmad (1000 MW to be expanded to 2000 MW). The other projects which had already been notified for duty concessions include Kahalgoan stage-II (1500 MW). North Karanpara (2000 MW), Barh (2000 MW), Hirma (3960 MW), Krishnapattanam (1500 MW) and Pipava (2000 MW).

The inter-state high capacity hydel projects identified for concessions were Koel-Karo (710 MW), Teena stage-V (510 MW), Koldam (800 MW) and Parvati (800 MW).

Gujarat Mineral Development Corporation (GMDC) is implementing 2 × 125 MW lignite based Akrimota Thermal Power Station near village Chhernani, dist Kutch, Gujarat.

Govt. of Maharashtra also approved seven new medium size power projects to be setup in various MIDC areas of the state for generating capacity of 1000 MW. The projects would use liquid fuel and these projects will be completed by June 2001. Each plant has a capacity in between 150 to 180 MW.

A Govt. of Karnataka has also sanctioned power plant of 1500 MW capacity in private sector. Another 500 MW capacity gas-based power plant is coming up near Agartala.

**(3) Nuclear Power**

For the fourth year, from 1996 onwards, in succession, nuclear power generation in the country continued to improve its performance. The N-power stations in 1999 not only generated the highest monthly generation (1160 million units) but highest in any calender year—nearly 11400 million units.

Out of 10 N-power reactors, six performed at a capacity factor of 0.77 to 0.9 and other two at 0.65 to 0.7. This gives an average capacity factor of 0.75. Another major achievement during the year was the successful replacement of coolant channels at second station of Rajasthan station which was highly sophisticated process.

Nuclear Power Corporation of India is constructing two PHWRs of 220 MW capacity each, one at Kaiga (Karnataka) and Rawatbhata (Rajasthan) and two PHWRs of 500 MW capacity each at Tarapur (Maharashtra) costing Rs. 6421 crores. Two units at Kaiga and one unit at Rajasthan went critical by this time. After commisioning these three units, installed nuclear capacity of India will be 2720 MW. The work at Tarapur for 3rd and 4th units is already started and criticality dates are fixed in Oct. 2005 and July 2006.

Govt. of Andhra Pradesh has finalised a nuclear plant of 2000 MW capacity at Srikakulam. This will be the biggest plant in the country.

The nuclear power sector comprising of the N-power stations, heavy water plants and N-fuel fabrication facilities continued to maintain its growth record of the past few years. Despite no addition to the N-power during the past five years, till the recently commissioned reactors at Kaiga and Rajasthan, gross N-power generation in the country touched a record high of over 13200 million units in 1999.

This marks an average compounded growth rate of about 14% per year since 1995-96. The N-power reactors achieved a plant load factor of 0.8.

The heavy water and fuel to N-power programme also achieved an all time high during 1999-2000. To meet the heavy water requirements of Indian PHWRs, eight plants are installed in the country at Talcher (Orissa), Manuguru (Andhra), Tutiorin (Kerela). Thal (Maharashtra), Hazira (Gujarat), Baroda (Gujarat) Nangal (U.P.) & Kota (Rajasthan). The production of heavy water during the year 1999 was close to the target. The plants at Tuticorin, Kota, Thal and Hazira achieved a five-year high. Manuguru plant achieved the highest ever production to date.

The production of N-fuel bundles for PHWRs has been steadily increased by an average compounded growth rate of 35% per year during past four years. With the commissioning of new mines at Narwapahar and the addition to its mill processing capacity at Jaduguda, the Uranium Corporation of India Ltd. (UCIL) achieved 92% of its production target during 1999-2000.

With the detailed project report with regard to purchase of two 1000 MW Advanced Light Water Reactors (ALWR) from Russia to be set up in Kudankulam already under way, India will have its fingers in all technologies related to nuclear power production. The experimental Fast Breeder Test Reactor (FBTR) has been performing satisfactorily. A prototype (PBTR) is also being designed and developed and is "progressing well". Also, the experience of indigenising the Canadian pressurised heavy water reactors (PHWR) is giving way to advanced heavy water reactor (AHWR) being designed by the Bhabha Atomic Research Centre. The AHWR is different from the PHWR in the use of source fuel. While PHWRs use natural uranium, the AHWR is being designed to use a fuel mixture of plutonium and Uranium-233.

**Russia, India Join Hands to exploit Thorium as Reactor Fuel**

India and Russia have signed a protocol for cooperation in developing thorium-based nuclear fuel for use in the pressurised light water reactors (VVERs) being supplied by the Russians for Kudankulam.

Signed on August 2, 2000, the protocol of the meeting of specialists of the Bhabha Atomic Research Centre (BARC) and the Nuclear Power Corporation of India (NPC) and Kurchatov Institute (KI) of the Russian Federation (RF) also envisages development of the fuel that can be used without altering the design of the reactors that Russia would supply. At present, the VVERs are designed for use with enriched uranium as fuel.

India however wants a fuel to be developed which could be used in the VVERs that exploits thorium available in the country in abundance. According to the protocol, the fuel, a mixture of thorium and uranium dioxides, must be so designed that the advanced heavy water reactors (AHWRs) can use the same fuel. It, in a sense, aims to break new ground because hitherto the fuel used in heavy water reactors was natural uranium and the LWRs used enriched uranium.

This protocol concretised the "Proposal on R & D on Thorium Utilisation in Russian VVER-1000" signed on April 29, 1999, at Moscow, by chairman-designate Atomic Energy Commission (AEC) and secretary-designate Department of Atomic Energy (DAE), Anil Kakodkar and N Ponomarev-Stepnoi of KI.

The Moscow proposal has two interesting assertions. The "proposal" recognises that "an agreement between RF and India on the construction in India of a Series of reactors of VVER-1000 does exist". This confirms that the Russian deal to construct the VVER-1000 at Kudankulam was not restricted to two as put out by the DAE so far, but a "series of reactors"—six, in fact, as blurted out by Vice-Minister of RF for Atomic Energy EA Reshetnikov on September 29 at Rajasthan Atomic Power Station while addressing Indian scientists there.

Fig. 1.32.

The second interesting aspect of the proposal records that the KI had developed "a safe, low cost, nuclear fuel design with thorium utilisation for Russian VVER reactors that offers a nuclear fuel" that has five features.

It is 20 per cent less expensive than traditional fuel (enriched uranium), can be inserted in Russian VVERs without modification to the reactors, reduces nuclear waste by half in volume when compared to traditional fuel, reduces risk of fission material proliferation, and allows for effective thorium utilisation without reprocessing.

**Thorium (Th-232)—it has no isotopes—is non-fissile element, it has a thirst for capturing a neutron to convert itself into uranium-233, which is a fissile material and can be used as fuel in the reactors (see**

figure 1.32). Funded by the US Department of Energy, the Los Alamos Laboratory in USA has already developed a model for commercial operation of reactors using a closed, thorium-uranium-oxide (ThUOX) fuel cycle light water reactors (TULWRs) "to satisfy a US demand that increases linearly from 80 GWe in 2020 to 200 GWe by 2100."

The question now is who is going to go commercial with the technology first ; the US ? or the Indian-Russian collaboration ?

**(4) Non-conventional Power Generation in India**

The major sources of non-conventional energy are wind, tide, biomass, agricultural waste and solar energy.

Twenty-one companies including NTPC & NHPC have proposed to setup wind power projects in six states. The largest new wind power capacity of 68 MW is planned to come up in Tamil Nadu where NTPC & NHPC would be setting up plants of 20 MW and 25 MW respectively. The other companies setting up plants in the state include Mohan Breweries and Distilleries Ltd. and Dalmia Cements with capacities of 15 MW and 3 MW respectively.

About 757 MW of the wind power capacity in the country was from Tamil Nadu, mainly from Tirunelveli, Kanyakumari and Coimbatore districts. Muppandal near Kanyakumari has emerged the wind energy capital of the country.

In Maharashtra, wind energy projects of 324 MW are planned. It is expected that four-fold increase is expected in wind energy by Dec. 2001 with a capital investment of Rs. 2100 crores. 110 MW projects are already commissioned in Satara district. The total capacity will be 434 MW by the end of 2001. Maharashtra has installed 1 MW wind electric generator at village Supa in Ahmedanagar district. Present wind energy generating capacity of the generator lies between 350 to 600 kW. The project which will feature 40 MW of one MW capacity each is expected to be commissioned by 2001.

The Bharat Forge Ltd. is setting up a 9 MW plant and Suzlen Energy Ltd and Vestas-RRB Ltd. are setting up plants of 25 MW and 5 MW capacities respectively.

A wind farm of 1.5 MW capacity financed by Maharashtra and India Governments was commissioned in 1999 in Sindhudurg district and more than a million units are generated. One more project of 2 MW capacity is being installed at a village Chalkewadi in Satara district.

The Pune based MEDA is exploring ways to tap the enormous wind energy potential (2000 MW) in the Konkan belt of Maharashtra. The agency in association with Indian Institute of Meteorology has identified 21 windy sites which could be developed as wind farms. These sites are located in the districts of Satara, Sangli, Ahmednagar, Sindhudurg, Kolhapur and Nasik.

Solar photovoltaic (SPV) technology has opened a way to generate electricity from the sun, unlimited source of energy. India's sunny climate is prompting both the Government and private industries for both high value applications like offshore installations and refrigeration and small value applications like rural street lights, domestic lights and water pumping. SPV conversion is achieved by way of silicon, when wafers of silicon treated with dopants can be used as individual cell with a voltage of 0.5 V each. Each cell of 10 cm diameter contributes about 0.8 watts. Since the conversion efficiency is hardly 10%, the cost of the system is considerably high. We may hope that this technology may come up in future to use on large scale.

During the year 1999, 36198 home lighting systems, 64581 Solar Lanterns, 2703 street lighting systems, 56 kW solar power plants and 396 solar energy operated pumps were developed by using SPV-technology.

The society moving from consumption-to-waste and waste-to-power forms an important route to a sustainable future. Gasification, as a way of transforming urban solid waste or agricultural wastes into electricity, was first worked out during world war. If idealistically considered, 5000 tons of solid waste (that a city like Mumbai) generates 100 MW. Across the world, these technologies are slowly developing. The Eye Power Station in UK, the worlds first commercial power plant using poultry litter generates 12.7 MW and provides sufficient electricity to 22000 homes. The plant consumes 1,50,000 tonnes of pultry litter per year. Another notable example is Gosaba, a small island village off the coast of West Bengal, which saw the light when India's Ankur Scientific setup its gasifiers there. Today, the village which wallowed in darkness only a few years ago, is litup by 50 kW electricity produced from fuel wood and agricultural waste.

As planned by Brihanmumbai Municipal Corporation (BMC), Mumbai will have its garbage converted into electricity in the next two years. Three Indian companies are going to construct conversion plants near Deonar dumping ground. With an investment of Rs. 490 crores, the BMC initially will divert 1000 tonnes of garbage out of 6000 tonnes/day to generate power. This will generate 10 MW power.

The Maharashtra Energy Development Agency (MEDA), Pune, has drawn up an ambitious plan to promote power generation by sugar factories in the state using bagasse which is produced as a waste material. MEDA has estimated that the 119 sugar factories in Maharashtra can generate 1100 MW power using co-generation technology. MEAD, in association with Renewable Energy Development Agency (IREDA) and Housing and Urban Development Corporation (HUDCO) has decided to put demonstration plants at two prominent sugar factories in Western Maharashtra—Vasantdada Co-operative Sugar Factory (Sangli) and Krishna Co-operative Sugar Factory (Satara). A 12.5 MW plant with estimated cost of Rs. 41 crores has been proposed at Vasantdada factory and a Rs. 105 crores plant with power generating capacity of 35 MW at Krishna factory. Both factories are among the largest in the state with a daily cane crushing capacity of over 5000 tonnes. Another largest biomass power project in the country (12 MW) is also coming up at Chengalpathu in Tamil Nadu.

Looking into very bad performance of all state electricity boards and debts withstanding against them, the Govt. has decided to allow the private sectors in the power industry. The power plant developed by Reliance Salgaonkar Power Co. in Goa was inaugurated by Dhirubhai Ambani in 1999. This plant costing Rs. 180 crores, working on combined cycle, is located at Sancole. This plant is of 48 MW and its capacity can be increased in future if required as it can develop 1000 MW maximum. The present power requirement of Goa is 340 MW and out of that 210 MW is supplied by NTPC grid. Tamil Nadu's first private sector Vasavi's 200 MW power plant at Basin Bridge, Chennai is to be inaugurated by chief minister of Chennai.

**NTPC and Its Role in Power Generation**

NTPC is one of the largest and best power utilities of the world. NTPC developed its first 20 MW unit at Singruali in 1982, presently became world's sixth largest thermal power generating company.

A corporate plan for the period 1997-2012 has been adopted to integrate the company vision. Corporation intends to install 40,000 MW by 2012. It has initiated prepratory works on all the mega projects identified by the Govt. The corporation has also entered in renovation and modernisation of ageing plants. Uttar Pradesh State Electricity Board has sold Tanda Thermal plant (400 MW) to NTPC. The MoU is signed on 29th Dec. 1999 by UPSEB and NTPC. In early 90s, the board had sold off Unchahaar Thermal plant of 420 MW capacity.

The company has added 1556 MW during 1999-2000 including Tanda plant of UPSEB. With commissioning of steam power plant of 144 MW of Faridabad Gas project in July 2000, the total installed capacity has reached to 19435 MW (20% of total national capacity). The company has achieved a high generation figure of 118.7 billion units, with the availability of 90% for the coal stations, the highest since inception and with an all time high LF of 80.4%. The financial performance of the company continues to be strong. NTPC has achieved an improved turnover of Rs. 17184 crores in 2000 which is 19.6% higher over the previous year and post tax profit of Rs. 3424.5 crores (in 2000), an increase of 21.6% over the previous year.

NTPC provides cheapest power at an average rate of Rs. 1.45/kWh. The company has introduced combined cycle plant in India for the first time. Petronet is setting up the Rs. 1500 crores Dahej project in Gujarat to import five million tonnes of LNG annually from 2002-03. NTPC has already signed a MoU with Pipavav LNG company to supply LNG to Kawas and Gandhar power plants. The Corporation is also considering the draft MoU with Petronet for supplying LNG to Anta, Auraiya and Kayamkulam power plants.

NTPC is pursuing a 1000 MW gas-based thermal plant in Bangladesh because that country has the advantage of having abundant and cheap-gas.

NTPC will complete its prestigious 2000 MW Talcher plant in Orissa costing 7000 crores by 2004. It will be completed in four stages, beginning with the commissioning of first 500 MW by November 2004, as its work is two month's ahead of schedule (4th Nov. 1999), Already the NTPC has a plant producing 1000 MW of power. Both the plants put together will consume 80,000 tonnes of coal per day and emit 25000 tons of flyash in the air.

The Institute of Policy Studies, a Washington based organization warned against setting up of so many thermal power stations in the Talcher region which is already regarded India's hottest spot with temperature rising as high as 50°C during summer. Too many thermal plants would cause extensive ecological damage and add to the atmospheric carbon build-up. It is further added that 0.4% of global warming will spring from single state of Orissa, if more such powerhouses came up in the area.

NTPC is taking sufficient care to avoid further pollution by setting up second plant at Kaniha. The existing 1000 MW plant at Kaniha has 275 m high chimney, three times taller than Qutab Minar to discharge flyash into the sky. Two more such chimneys would be constructed in the II-stage and entire flyash would be collected on a 250 acre ash pond which would be used for brick making. The NTPC has also earmarked Rs. 760 crores for fighting pollution in the area.

In major exercise towards capacity addition and augmentation of its generation in southern region, the Rs. 12740 crores Navaratna power giant of NTPC has linedup several projects totalling nearly 5000 MW. The various projects proposed during IX and X plan period, the first unit of 350 MW Kayankulam combined cycle plant based on naphtha fuel was commissioned on 17th Jan. 1999 by prime minister.

The second unit of 115 MW was synchronised with diesel on Feb. 28, 1999. The Kayankulam project will be expanded by 1950 MW based LNG as fuel in stage-II.

The ever increasing demand for power and the discovery of LNG in the Western Offshore of the country resulted in the need for the possible utilization of gas for power generation. In Oct. 1986, NTPC was asked to setup three combined cycle gas-based plants along HBJ pipeline. One such plant of 656 MW capacity was conceived at Kawas near Hazira to meet the power shortages in the Western region.

Another combined cycle plant of 650 MW capacity is going to be established at Zanor-Gandhar at Gujarat (Dist Bhadoch).

One major advantage of combined cycle plant in addition to higher efficiency is its environment friendliness. The combined cycle plant not only mitigates thdust and $SO_2$ emission but also reduces the $CO_2$ emission and there are absolutely no harmful solid residues. The very absence of coal and ash considerably eliminates air and water pollution. The $NO_x$ emission is also low and well within the GPCB norms.

The NTPC has reached an agreement with Coal India Ltd. (CIL) for supply of coal for its three up-coming plants of 5500 MW capacity. CIL has agreed to supply fuel for Barh and north Karampura each of 2000 MW capacity in Bihar and 1500 MW at Khelgaon power project. An average 10 million coal is required per 1000 MW of power capacity. NTPC had already tied up its coal linkage with CIL for its 2000 MW Talcher thermal plant in Orissa and 1000 MW Sapat power project.

NTPC has decided to buy two power plants at Rourkela and Durgapur from Steel Authority of India (SAIL) as they are not properly managed. No decision has been taken with regard to Bokaro plant of 302 MW capacity.

The power generation shared by NTPC on national basis is shown in Fig. 1.33.

Another major problem faced by NTPC is the outstanding dues with the State Electricity Boards. The present dues as on end of July 2000 are shown in Fig. 1.33.

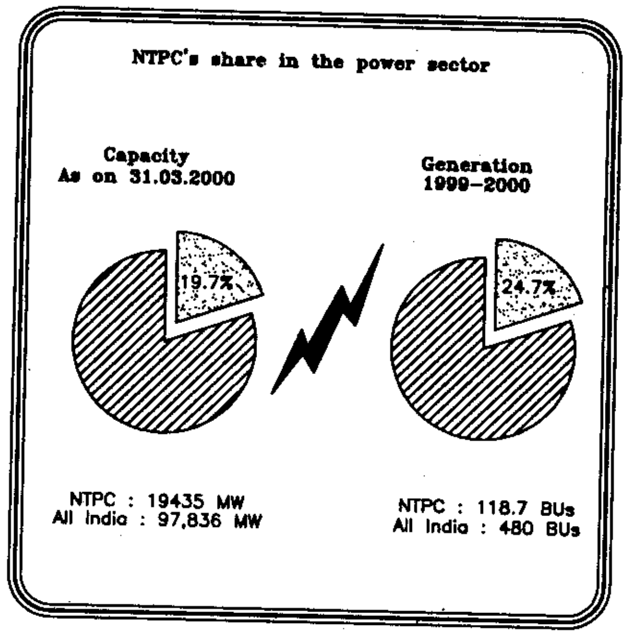



Fig. 1.33.

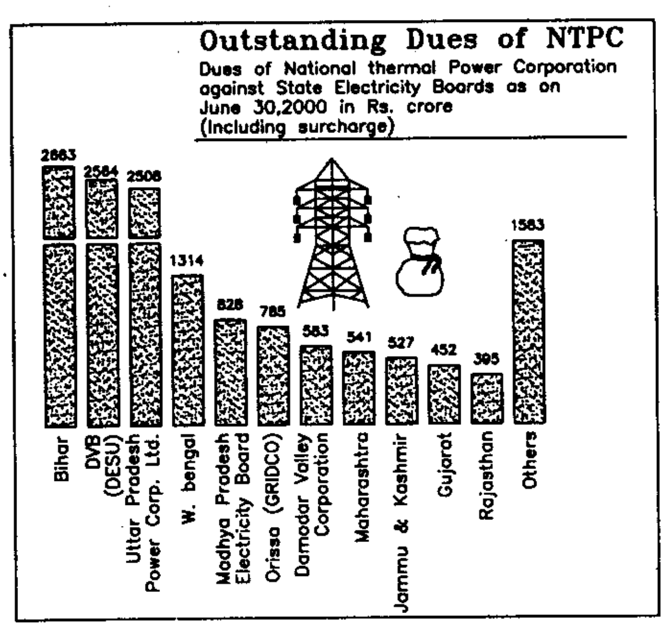



Fig. 1.34.

## EXERCISES

**1.1.** What are the basic resources in India for power generation ? List out their capacities in different regions.

**1.2.** What do you understand by commercial and non-commercial energy sources ? List out the changes from non-commercial to commercial during the last nine plans.

**1.3.** Describe the hydel power development in India.

**1.4.** What is the importance of thermal power development in the country ? Describe its development during the last nine plan periods.

**1.5.** Why the development of nuclear power is slow in India ? Give a list of its development.

**1.6.** What is the present position of power in India ? Why India will not face power crisis in future ?

**1.7.** What will be the future planning of power in India ?

**1.8.** What is the present power position of the world ? What will be future planning ?

**1.9.** What do you understand by non-conventional sources of power generation ? What is the scope of these sources in India ?

**1.10.** Why non-conventional sources are considered as future major power resources to face power crisis in the world ? Which of them are more prominent ?

□□□