Bokaro Thermal power Station

Bokaro is the biggest power station in India.

Pari of the capital coat of Bokaro Steam Power Station estimated at RS 13.8 crores Law been met by a World Bank loan tumnmting to 18.5 million dollars, or Rs 9 crores,

Bokaro Station will obtain coal from a part of Bermo seam, Kargalli colliery, which has been leased by DVC. This seam consists of low grade coal for which there is normally no market. Ash content is high, varying from 26 to 31 per cent. India's deposits of high grade coal are limited and require to be conserved for iron and steel industry and Bokaro helps tills conservation.

Bokaro Station is connected to the DVC transmission network covering 375 miles of 132 kv line, 32 milas of 66 kv and 96 miles of 13 kv lines, serving an area of about 25,000 square miles.

AS a result of a recent load survey of the DVC area total prospective maximum demand on DVC system was asseftsed at 282,000 kw, 459.000 kw and 550.000 kw during next live, ten and fifteen years.

Bokaro Steam Station order placed on international General Electric Company on February 23, 1949, ground broken at site December 29, 1949, Station opened on February 21, 1913.

BOKARO, unlike Tilaiya, does not constitute a first step in the scheme for taming the Damodar river. It does constitute, however, a milestone in the country's progress. Situated on the river Konar just below where it meets the Bokaro river, the power station has been located close to the coal mine from which it gets its coal supply. Bokaro is 50 miles from Hazaribag and 233 miles from Calcutta by road. The power station has been designed for base load operation for about 37 weeks of the off-monsoon period and as a peak load station for the remaining 15 weeks in the monsoon. The later period of high load will provide an opportunity for general overhaul and inspection of machinery.

Designed for ultimate capacity of 200,000 kw, three units of 50,000 kw each have already been set up, of which the first goes into operation today and the other two will follow soon- by June next, according to present expectations.

Why a thermal station should conic first in a multi-purpose project which is primarily intended to control and utilise water power, one may naturally ask, though after the bitter experience" of Bombay, even a layman will hardly need much persuasion to believe that a grid system depending exclusively on rain-fed rivers or lakes is not the best possible arrangement. Admitting the necessity for a thermal station for balanced supply and distribution of electricity through different seasons of the year, the 'priority that Bokaro enjoyed and the fact that it happens to be completed first, Still needs to be explained, though the result, in view of the existing demand for power in the valley, has been entirely happy. There is a fortunate and very favourable co-relation between the peak load demand for electricity in the valley and the availability of power from hydro-electric installations. The mining belt, a major consumer, has its peak demand in monsoon for pumping out water from the mines just when the hydro-electric stations are in a position to give peak production. In the following seasons it is necessary to conserve water for purposes of irrigation and generation of electricity has necessarily to be stepped down and here the thermal station at Bokaro comes so very handy.

LOWER COST OF ELECTRICITY AT BOKARO

"Cost per kw at Bokaro compares favourably with the current cost of thermal power stations in the UK and the USA as well as with the cost of stations recently erected in India. In the USA the cost per kw of a steam plant of comparable size and specification would, at 1951-52 cost level, be around $200 which, at current exchange rate, amounts to Rs 950. Cost at Bokaro is thus lower by Rs 150 per kw, although normally, we would expect the cost in India to be about 15 per cent higher owing to freight and insurance charges as well as import duty.

"At present there is a proposal to erect a thermal station in Bombay with an installed capacity of 100,000 kw to alleviate the acute power shortage in the industrial areas of Bombay. The cost, as estimated recently, is supposed to be in the neighbourhood of Rs 12 crores. The actual capacity of the proposed station may be higher than 100,000 kw. Even its kw cost will be much higher than at Bokaro."

—Dr Sudhir Sen, Secretary, Damodar Valley Corporation. (*Indian Journal of Power and River Valley Development*, DVC Number, p 11.)

The boilers at the power station arc designed to use inferior grade coal which is obtained by open cut mining of the Burmo seam at Kargali about 5 miles from the power station. The colliery belongs to Messrs Bokaro and Ramgarh Ltd and was under lease to the GIP railway. It has now been sub-leased to DVC for a period of 35 years. The mining will be mechanised and coal transported by aerial ropeway with a capacity of 150/200 tons per hour. The colliery is also connected to Bokaro power station by rail and road, to be utilised in the event of a breakdown of the ropeway. The leased area contains, it is estimated, about 17 million tons of coal, of which the following is an analysis:

Moisture	1.16	per cent
Volatile matter	20.2b	.. M
Fixed Carbon	53.15	„ „
Ash	26.6	
Calorific Value (dry basis)	11,200	BTU
Fusion Point of Ash	2/282	deg. F

The entire power station was designed by the International General Electric Company who also supplied the main plant and equipment while the designing and supervision of const ruction was done by the Kuljian Corporation of USA.

Coal is fed from the ropeway bunker or rail track hoppers by means of reciprocating feeders. The tilling of the coal into buckets at the mine and its discharge into the bunkers at the power house is done automatically. Alter passing over a magnetic pulley, coal is fed into a crusher capable of reducing the run of mine coal into three-fourths of an inch. From here it is conveyed either to the bunker on the top of the boilers or to a stock-pile in the coal yard, A drag-scraper piles coal to a height of 26 ft and also packs it in such a manner as to eliminate spontaneous combustion. The yard holds stock to last 2½ months. A reverse drag bucket reclaims the coal from the stock pile when necessary. It can be dumped into reclaim hoppers and led back into the conveyor system,

STEAM GENERATING UNITS

The plant has been laid down on the unit system of each generating set with two boilers and each boiler is supplied by two coal bunkers. For the three units all the six steam generating units are alike. Steam generating units are of 300,000 lbs per hour capacity, pulverized coal fired, and consist of two drum, bent tube boiler and a water-cooled furnace manufactured by the Combustion Engineering Super-heater Inc., USA, and supplies steam at 895 psig with total temperature of 910 F. The boilers are provided with forced and induced draft fans and air pre-heaters. Each steam generator is equipped with four burners. Two pulverizers are provided per boiler, one feeds the two lower burners and the other feeds the two upper burners. Each pulverizer is sized to cany 80 per cent of the full load. The station has been designed for pulverized fuel only, but heavy duty lighting-off" equipment has been supplied to act as pilot torches in case of coal failure.

The present-day practice where large steam turbine-generators are involved makes use almost universally of pulverized firing for coal burning in boilers, due primarily to the lower initial investment per kilowatt of plant capacity realised with large size boilers, for which any other means of firing becomes boilers also offer the added advantages of generally higher efficiency; due to mote complete combustion less ash residue, more rapid pick-up or dropping of load, and better temperature control over wide load limits.

The selection of steam pressure and temperature for the boilers and turbines, higher than had previ- impractical. Pulverized coal fired ously been employed in India, followed the most conservative practice in the United States for turbines of this capacity. 'The advantage in using higher pressures and temperatures lies in the improved station efficiency, reduced unit cost of power generation, reduced requirements of steam and coal, and reduced size and weight of equipment generally, all of which factors are of importance In India,"

ELECTRICAL ENERGY IN THE DAMODAR VALLEY

Under the DVC Act, no person is allowed, without the permission of the Corporation, to generate, in the Damodar Valley, any electrical energy at an installation having an aggregate capacity of more than 10,000 kilowatts or to sell energy to any consumer in the valley at a pressure of 30,000 volts or to transmit energy in the valley at such pressure. There are certain provisos to this clause. The Damodar Valley Corporation itself is not permitted to sell energy to any consumer at a pressure of less than 30,000 volts except with the permission of the State Government concerned. It may, however, with the permission of the State Government concerned, extend its transmission system beyond the Damodar Valley. These provisions are made notwithstanding anything contained in the Indian Electricity Act 1910.

Licences granted under the Indian Electricity Act are deemed to be revoked or modified to the extent necessary for the purposes of the DVC Act and the Corporation is required to purchase the undertaking concerned or to pay fair compensation, at the option of the licensee.

The Corporation is required to fix the schedule of charges for the supply of electrical energy, both bulk and retail supply. The Corporation may also impose such conditions as it may deem necessary or desirable to encourage the use of electrical energy.

AUTOMATIC CONTROL

Incorporating the most modern practice, units are designed to operate normally on automatic control under constant as well as varying load conditions. The turbine governing system is actuated hydraulically by oil pressure generated by a centrifugal pump on the turbine shaft. In general, other mechanical control systems are operated by compressed air.

The combustion control system automatically distribute the effect of fluctuating requirements of steam by the turbine-alternator on the two boilers equally, controls the fuel *iced* of each boiler to maintain the desired steam pressure at any load, controls the furnace draft maintaining a negative pressure under normal operating conditions, controls the forced draft to maintain the fuel-air ratio, controls the pulverizer mill temperature so as to avoid lire hazards or inefficient grinding due to wet coal.

Other controls provide control of steam leaving the superheater, feed water, water levels in feed water heater and hot wells.

Main station controls are centralised and control boards arc fitted with indicating and recording instruments, automatic and manual control devices, alarms and push-buttons.

OUTDOOR SWITCHGEAR

The use of forced-oil, water-cooling for the 65,000 KVA main transformers resulted in lower cost, size and weight, and made possible transport over the railway from Calcutta. The 138-KV outdoor substation is remotely controlled from the duplex switchboard. A main and transfer bus arrangement is provided. The main bus is sectionalised by disconnecting switches so that one section of bus can be removed from service for maintenance and repair. A bus tie breaker is also provided so that any line breaker may be taken out of service for routine maintenance or repair. The disconnecting switches are motor operated and are interlocked with their respective breakers to ensure proper operation.

Altogether 11 — 138-K V, 1200 amp., 3500 MVA pneumatically operated outdoor type oil circuit breakers have been used. These are of General Electric Co, of USA manufacture as are all the transi formers, switchgear and control equipment both inside and outside the power station, relays and control, power cables, bus and ground equipment. Indoor switehgears are metal-enclosed of most modern design, completely factory assembled.

STATION SERVICE ELECTRICALS

Each generating unit is provided with a 3150-volt and a 400-volt station auxiliary bus. The 3150-volt bus derives its power directly from the generator through the 5000/6250 KVA, 132000/3150-volt transformer. The 400-volt bus in turn derives its power from the 3150-volt bus through the 1250-KVA, 3150/400-volt transformer. These two unit buses serve all the auxiliaries for their respective generator units.

In addition to the normal auxiliary supply there is a 5000/6250 KVA, 138000/3150-vok reserve transformer which is connected directly to a breaker on the. 138-KV bus. This transformer is connetted to the reserve 3150-volt bus. This reserve bus supplies power to the station essential auxiliaries such as coal handling, ash handling, lire pumps, etc. In addition this bus provides standby and starting-up power.

All the auxiliaries of this station are electrical.

STATION PROTECTION

A separate differential protective scheme, is used for the generator, main step-up transformers, and the 3150-volt station service transformers, ensuring high speed tripping and selectivity. The generator is protected by high speed product restraint differential relays. The 138-KV outdoor substation bus is protected by high speed differential relays which operate in from two to three cycles. Each 138-KV feeder is protected against phase-to-phase and three-phase faults by directional distance impedance relays, and against phase-to-ground faults by directional ground relays.

The control voltage for this station is 250 volt dc from lead cell acid storage battery with motor generator sets for charging, which battery also supplies power for emergency lighting.

The station has been provided with communication systems in two parts, loudspeaker and the plant telephone. Carrier Current telephone system is used for commucation with outside the Bokaro Power House.

(Continued on page a 18)

Damodar Valley Project — First Phase

TILAIYA

THIS first all concrete dam in India is to be opened today by the Prime Minister along with Bokaro Power Station. Construction began in January 1950 and water from Barakar river has been impounded, producing a lake of about 20 sq. miles surface area which will provide kharif irrigation for 24,000 acres and rabi irrigation for 75,000 acres.

The hydro-electric station at Tilaiya will consist of two units of 2,000 kw each. Power production will be stepped up to 6,000 kw by installing a third unit later on. There are diesel sets at Tilaiya at present which are supplying to Kodarma Mica Mines and Hazaribad town. These will now be taken up by the Hydro-electric station.

KONAR

The concrete-cum-earth dam which is being constructed on the Konar river, a tributary of the Damodar, consists of a concrete section across the bed of the river and earth dams in the banks. The dam is expected to be completed by June. The project was designed by Gruner Bros and the contract for it has been given to a Bombay firm of engineers, Hind Constructions Ltd and Patel Engineering Co Ltd. The impoundment will be 2,60,000 acre ft. The main purpose of the dam is to supply cooling water to the thermal power station at Bokaro which will need 400 cusec for running the steam power plant, but it has been located in order to take advantage also of a steep gradient of 440 ft and an underground hydro-electric station of 40,000 kw will be installed here to utilise this gradient. The tail-race water will be discharged by tunnel into the lower reaches of the river. Konar will also supply kharif irrigation for 36,000 acres and rabi to 68,000 acres.

MAITHON

Maithon, on the Barakar river, the third of the first phase dams, is designed primarily for flood control. Scheduled for completion by 1954, it is being constructed all departmentally. The dam will be a composite construction partly concrete and partly earthen. It will have an attached underground generating station with an installed capacity of 40,000 kw and will provide irrigation for 270,000 acres in the lower valley.

PANCHET HILL PROJECT

The last of the DVC dams on the Damodar is also primarily for flood control and the two together, in proportion of ⅓rd to ⅔rd, with some help from the upper reservoirs, will give the lower valley full protection against the worst floods recorded so far. In design also Panchet will be similar to Maithon. The hydro-electric plant here will have a capacity of 40,000 kw and the dam will provide perennial irrigation for 683,850 acres. A diversion channel is being driven through the left bank to pass the dry season flow from October to June and to serve as a tail-race tunnel for the underground power station. The open cut works on the approaches and discharge ends is being done departmentally while the contract for the construction of the tunnel has been given to the Hindustan Construction Company. The tunnel is 34 ft wide, 42 ft high and 1,140 ft long. All air compressors, rock drills and allied equipments used by Hindustan Construction as well as by the DVC on this and various other projects were supplied by Consolidated Pneumatic Tool Company, the British counterpart of the Chicago Pneumatic Tools of USA who have their Indian head office in Bombay.

With the completion of Panchet in 1955, the first phase of the programme for dam construction of the DVC will come to an end.

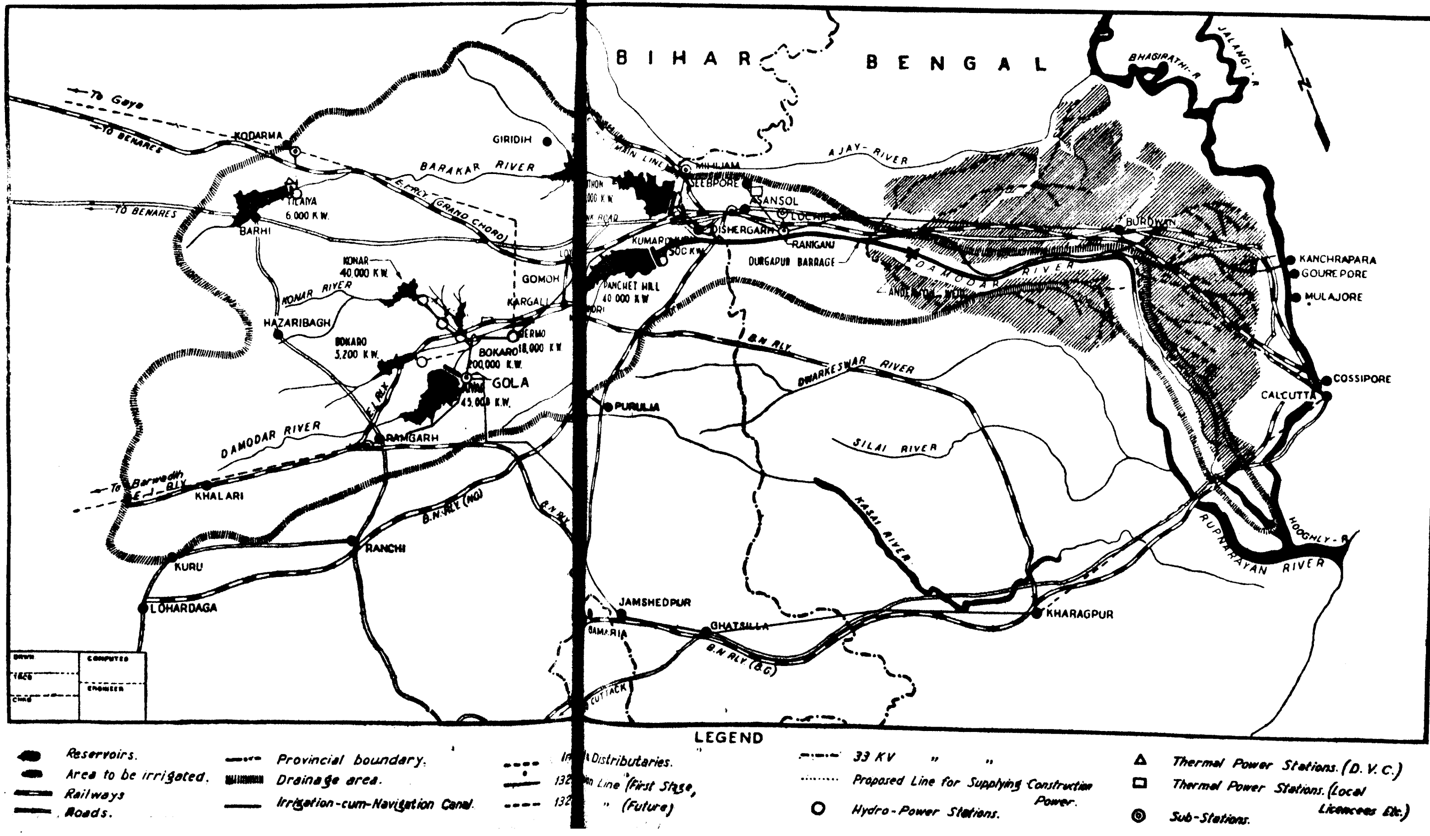
DVC GRID

The DVC power transmission system, apart from transmitting its own hydro-electric and thermal power, has already taken on the surplus power of Sindri power station, and will consist of 350 miles of 132 kv double circuit main transmission lines with adequate substations and sub-transmission lines. The system will be capable of serving an area of 25,000 sq. miles. To enable Sindri power being made available in advance of the supply from the main grid, temporary works consisting of five 66 kv substations and 32 miles 66 kv lines were completed along with a portion of the permanent 132 kv of 33 kv main transmission lines. This section is now supplying power to:

(1) Chittaranjan Locomotive Works
(2) Dishergarh Power Supply Co Ltd
(3) Associated Power Co Ltd
(4) Sijua (Jherriah) Electric Supply Co Ltd
(5) Indian Iron & Steel Co Ltd
(6) Government of Bihar

Elsewhere will be found an estimate of the power requirements and supply, realised and potential, of the Damodar Valley area. The DVC grid will supply power to Jamshedpur, Ghatsila, Kharagpur, Burdwan and eventually to Calcutta. Electrification of the Calcutta suburban railway is one of the projects which will be surveyed in the next financial year, the Rai[lway] Minister announced, while pre[sent]ing the railway budget this [week]. This by itself does not mean [any]thing for DVC but it may we[ll be] an indication of the line of fu[ture] development.

The huge galvanised transmi[ssion] towers required for the grid, w[eigh]ing thousands of tons, have [been] supplied by Messrs Alcock, [Ash]down and Co Ltd of Bombay. [They] have also supplied the pipes, a[nd] masts and other structures for [the] transmission system. The cons[truc]tion of the 132 kv grid trans[mis]sion and distribution lines and installation work at grid sub-sta[tions] have been carried out departm[ent]ally. Such a major heavy [con]struction work had never [been] undertaken by any Governm[ent] departments hitherto.



DURGAPUR BARRAGE

The last of the projects in the first phase is the barrage across the Damodar River which will receive water from the four storage dams for distribution over a million acres of irrigable land. The site is located at Durgapur in Burdwan district. Construction has begun on the irrigation-navigation canal which has a bed of 172 ft width in the upper reaches. About 15 miles of subsidiary canals which will be connecting the main canal has also been excavated. The barrage is expected to be completed by June 1955.

DVC FANS OUT

This is only a very brief outline of the major projects that will complete the first phase. Simultaneously with the constructional work the DVC lias fanned out its activities in different directions the foremost of which are soil conservation and an intensive survey of the mineral resources of the valley which are rich and far from being fully exploited. Development of agriculture and fisheries in the valley, town planning, road building all these have been taken up. In fact, the logic, of development is such that the last had naturally to come first!

Now that the foundations have been laid, it is not only the remaining dams which will have to be taken up in the second phase—the complete project has provision for 8 dams in all, of which only 4 come in the first—the social and economic aspects of development must be given the next priority. For, the problem of development is not primarily one of engineering. The human aspect of the problem is the primary concern. It is being pin-pointed by the necessity of town planning and housing, to accommodate, in the first instance, the huge staff, and even more by the necessity of moving whole villages from the areas that have been or are going to be sub-merged by the dams.

It is not the problem only of moving people from one place to another. A village is something more than a collection of people who constitute it. A study of the village community, of the. social organisation which provides a satisfying life to the. people, is just as necessary for the success of the project as the solution of the technical problems of construction and power generation. For the rehabilitation of the valley, not only have new town-ships and villages to be set up, mineral resources and industries will have to be developed which will utilise the power, work will have to be provided for people in Small industries For DVC commercial exploitation of power resources may not be a problem but its utilisation for enriching the life of the people of the valley still remains one.

Damodar Valley Power Budget

THE total installed electrical generating capacity in the Damodar Valley area is now approximately 391,600 kw., excluding the Sindri Fertiliser Factory which has a plant of 80,000 kw. The installations consist of:

	kw
1. Small plants in 12 towns and villages	24,000
2. Industrial concerns	269,300
3. 39 power stations and 3 major licensees distributing power in the coalfields	98,300
Total	391,600

The aggregate maximum demand on the existing generating stations is 200,000 kw. But most of these sources of supply will be replaced by power from the DVC. The town installations except one are inadequate and uneconomical. The colliery power stations are likely to close down gradually. Power stations of licensees in the colliery area are inadequate[1] for the load awaiting to be served-and would be utilised to supplement bulk supplies from the DVC. The generating plants of most of the industrial users are incapable of coping with the increasing demand for power due to expansion of the industries. The aggregate total installed capacity of steam and oil engines used for purposes other than generation of electricity is estimated at 136,000 IIP. These engines are old and are likely to be replaced by electric motors when electric, supply becomes available.

The total prospective maximum demand on the DVC system had been assessed by the Central Technical Power Board very conservatively at 282,000 kw, 459,000 kw and 550,000 kw in the next five, ten and fifteen years respectively. The prospective maximum demand that can be catered for in the first stage of the DVC is only 198,500 kw, 281,600 kw and 332,700 kw at the. end of five ten and fifteen years respectively.

The initial power installations aggregating to 294,000 kw of installed capacity are made up as follows:

	kw
Bokaro thermal plant	150,000
Hydro-installations at Konar, Maithon and Panchet Hill	140,000
,, Tilaiya ..	4,000

Of these the first and the last will be fully in commission this year. The hydro installations at Maithon and Panchet Hill arc likely to he ready by 1955-56. The Konar power station will be ready in the next year, 1956-57. In an estimate of prospective demand for power, the fact should not be lost sight of that the Damodar Valley is one of the most industrialised regions in the country, and contains 80 per cent of India's coal, 94 per cent of her iron ore, 100 per cent copper, 70 per cent chromite, 70 per cent mica, 100 per cent kyanite, 45 per cent China clay and asbestos.