

RESTRICTED

Report No. T.O. 182a

CIRCULATING COPY
TO BE RETURNED TO REPORTS DESK
IN CENTRAL FILES

This report was prepared for use within the Bank. In making it available to others, the Bank assumes no responsibility to them for the accuracy or completeness of the information contained herein.

INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

APPRAISAL OF THE KOYNA HYDROELECTRIC PROJECT

INDIA

March 30, 1959

Department of Technical Operations

CURRENCY EQUIVALENTS

(rounded figures)

U.S. \$1	-	4.8 Indian Rupees (official rate 4.762)
1 Rupee	-	21 Cents (U.S.) or 100 Naya Paisa
U.S. \$ 1 Million	-	Rs 4,800,000
Rs 1 Million	-	U.S. \$ 210,000

APPRAISAL OF THE KOYNA HYDROELECTRIC PROJECT - INDIA

TABLE OF CONTENTS

	<u>Page</u>
SUMMARY	i
I. INTRODUCTION	1
II. THE ELECTRIC POWER INDUSTRY IN THE BOMBAY-POONA AREA	1
III. THE POWER MARKET	2
IV. THE KOYNA DEVELOPMENT	3
Description of the Project	3
Arrangements for Engineering and Construction	4
Status of Construction, March 1, 1959	4
Operation after Completion	5
Cost of the Project	5
Investment Costs per Kilowatt	6
Production Cost	6
Hydro versus Thermal Plant Investment	6
Schedule of Construction and Expenditures	7
Sources of Funds	7
V. FINANCIAL ASPECTS	8
Power Rates	8
Estimated Earnings	8
Forecast of Sources and Application of Funds	8
VI. ECONOMIC ASPECTS	10
VII. CONCLUSIONS	10
Annex 1 - Capacity and Consumption Statistics for the Bombay-Poona Area	
" 2 - Functions and Organization of the Bombay Electricity Board	
" 3 - Forecast of Load Growth	
" 4 - Detailed Description of the Project	
" 5 - Drawing of Project	
" 6 - Contracts Awarded	
" 7 - Detailed Cost Estimates	
" 8 - Power Costs	
" 9 - Return on Additional Capital in Hydro over Thermal	
" 10 - Forecast of Earnings	
" 11 - Forecast of Sources and Application of Funds	
" 12 - Map (Area)	

APPRAISAL OF THE KOYNA HYDROELECTRIC PROJECT - INDIA

SUMMARY

- i. This report covers an appraisal of the first stage of the Koyna hydroelectric power project, including a transmission line to Bombay and a transmission line south of the project to serve a number of small towns and villages and their small industries.
- ii. The project, which is located on the Koyna river about 130 miles southeast of Bombay, is to be carried out in three stages. Stage I, now under construction, will have an installed capacity of 240 MW; Stage II will provide an additional 240 MW and water storage for irrigation; and Stage III, which will utilize the tailrace waters of the Stage II power plant and irrigation water, will add an additional 90 MW.
- iii. The Bank has been requested to make a loan of \$25 million equivalent to assist in financing the foreign exchange cost of Stage I of the project, exclusive of interest during construction. The total cost of Stage I is estimated to be the equivalent of \$118 million, including interest during construction.
- iv. The Bank's loan would be made to the Government of India which in turn would finance the entire cost of the Koyna project through loans to the Bombay State Government. The Government of India's loans would have terms of 30 years, an interest rate of $4\frac{1}{2}\%$ and repayment would start in the eleventh year.
- v. The project is being constructed by the Koyna Control Board (an ad hoc agency of the Ministry of Public Works of the State of Bombay) but for operation the project would be turned over to the Bombay State Electricity Board (a State owned authority under the Ministry of Industries and Cooperation). The energy to be produced will be sold in bulk to the Bombay-Poona system, owned by the Tata Power Companies, and in the area of Koyna in the Maharashtra region. Initial energy is scheduled to be produced in late 1962 and completion of Stage I is expected in April 1964.
- vi. The rates proposed to be charged for the energy to be produced by the project would be adequate to provide revenues, after the completion of the first stage of the project, sufficient to finance 83% of Stage II and 50% of Stage III of the project. Debt service after the first year of operation of Stage I would be covered 1.4 times and the coverage would increase to 2.0 times in 1967/8. The return on the net investment after payment of income taxes (which would start after the fifth year of operation) would be about 7%.
- vii. The project is sound. The cost estimates are reasonable. The continually growing demand for power requires the provision of new generating capacity of the magnitude of Koyna and the development of this project is the most economical method of providing the power.
- viii. The project is suitable for a \$25 million loan with a term of 25 years including a 6 year period of grace on repayment of principal.

I. INTRODUCTION

1. This report covers an appraisal, as the basis for consideration of a Bank loan to the Government of India, of the Koyna hydroelectric development about 130 miles southeast of Bombay, India. The appraisal is based on information supplied by the Bombay State Government which is executing the project, by the Government of India, and on field studies and discussions by Bank missions which visited the site in November 1956 and February 1958.

2. The project is estimated to cost approximately \$118 million. The Bank has been asked to make a loan of \$25 million equivalent to assist financing the project. It would comprise Stage I of the Koyna development which would provide 240 MW of generating capacity. Successive stages would provide water storage for irrigation and increase the generating capacity to 570 MW. Power generated by the project will be supplied to the Bombay-Poona system operated by the Tata Power Companies^{1/} and to the area around Koyna in the Maharashtra region.

3. The Indian Government first submitted the Koyna hydroelectric project to the Bank for consideration for a loan in November 1953. A general review of the scheme at that time indicated that while the project was generally sound and while there was an obvious need for additional power sources in the Bombay-Poona area, the engineering and design work on the project had not progressed sufficiently to permit a proper appraisal. In the fall of 1956 the project was again presented to the Bank, and shortly thereafter a mission made an appraisal. The mission's report revealed the need for improving the arrangements for the construction of the project and for its operation after completion in accordance with sound utility practices. These findings were presented to the Government of India, and after agreement in principle had been reached on the questions raised by the Bank the necessary data to bring up to date the project appraisal was obtained early in 1959.

II. THE ELECTRIC POWER INDUSTRY IN THE BOMBAY-POONA AREA

4. The area around Bombay and Poona in the State of Bombay has had an integrated power system since 1915 and power from Koyna will supplement the supply to this system. The development of power for the area has been carried out primarily by the privately owned Tata Power Companies. By the end of 1958 the total installed capacity supplying the Tata integrated system was about 527 MW, of which a little more than half was hydro. Statistics of capacity and consumption are given in Annex 1. The high-tension transmission lines and stepdown substations are owned by the Tata Companies, who operate the system as an integrated unit. The Tata Companies sell power wholesale to 15 distributing licensees (both private

^{1/} The Tata Power Companies comprise the Tata Hydro-Electric Power Supply Co. Ltd., the Andhra Valley Power Supply Co. Ltd., and the Tata Power Co. Ltd.

companies and municipalities), to about 138 large industrial customers and exchange power with the Central Railway. Tata does not engage in the retail business.

5. In 1958, with a demand of 408 MW and sales of about 2,100 million kwh, the Tata system distributed about 18% of the entire sales in India although the area served contains only just over 1% of the country's total population. While the per capita annual consumption in the country is about 24 kwh, the consumption in the Bombay-Poona area, which is primarily industrial, is about 390 kwh per capita (Annex 1).

6. The Bombay State Electricity Board, established in November 1954 under the Indian Electricity (Supply) Act, is the rate regulating body for the electric utility industry in the State of Bombay. The Board also owns and operates electric facilities throughout the State, which at the end of 1957 totaled 175 MW in about 70 plants. In addition to its regulatory features in the State, the Board is responsible for promoting the coordinated development of electricity supply in the State. The functions and organization of the Board are given in Annex 2.

III. THE POWER MARKET

7. A power survey of the Bombay-Poona area was made by the Bank in early 1954 and revealed the desirability of proceeding with the construction of a 125 MW thermal plant at Trombay for Tata, to be followed by a 240 MW hydroelectric project at Koyna. Even with the completion of the 125 MW at Trombay it was realized that there would be a shortage of power between 1960 and 1962.

8. Forecasts prepared by Tata and the Bombay Electricity Board in 1956 indicated that the growth in power demand forecast in 1954 was being exceeded and, because of the delay in the construction of Koyna, a third unit at Trombay of 62.5 MW was needed. This unit is under construction with Bank financing^{1/} and is due to start operation by the middle of 1960.

9. The latest forecast of load growth and availability of generating capability is shown in Annex 3. This forecast, which may well be exceeded, shows that the shortage of firm capacity experienced since about mid 1957 would be expected to continue until the first stage of the Koyna project is completed in 1964. In 1965, about 1½ years after completion of the first stage of Koyna, additional capacity will have to be provided by either the second stage of Koyna or additional thermal capacity. Until the Koyna project is commissioned, because of the lack of reserve generating capacity, it will be necessary to schedule maintenance carefully. The shortage of firm capacity indicated during this period would be more drastic if there were an exceptionally dry year or if some of the large thermal units fail.

^{1/} Loan No. 164 IN - Tata Power Companies - \$9.8 million - May 1957.

10. The forecast is based on an average rate of growth of $7\frac{1}{2}\%$ annually for the Bombay-Poona system plus the estimated local loads that will be supplied from Koyna when the project is commissioned. A proposed fertilizer plant that will start operation in 1962 at Trombay has also been included. The system demand reached 408 MW in 1958 and the forecast shows an increase of over 120% during the next 10 years.

11. The average annual growth in energy sales was about 5% over the past 10 years in spite of restrictions imposed continually from 1948^{1/}. Because of the restrictions the monthly load factor has run as high as 78% and the average annual load factor 65% to 70%. The energy sales last year were as follows: 27% to textile mills; 20% to diversified large industries; 16% to railways; and 37% to distributors for resale.

IV. THE KOYNA DEVELOPMENT

12. In 1947 the Government of Bombay authorized the Government Electric Grid Department^{2/} to revive studies of the Koyna scheme made around 1915 by Tata and to carry on a full-scale exploration. In February 1953 the Government approved construction of the Koyna project^{3/}.

13. The development is to be carried out in three stages: Stage I, now under construction and for which the Bank loan is requested, will have an installed capacity of 240 MW; Stage II will provide an additional 240 MW of generating capacity; and Stage III^{4/}, which will have a potential of 90 MW, will utilize the tailrace waters from the main power plant and the flood and irrigation waters in the Koyna river. The total capacity installed will be about 570 MW. The design of the project is based on satisfactory topographical and geological surveys and hydrological data, some of which date back to 1898.

Description of the Project

14. Stage I of the project includes a gravity type dam across the Koyna river 130 miles southeast of Bombay (Map Annex 12). The dam will be about 2,600 ft. in length at its crest and 250 ft. high above the present river bed. The dam will create a reservoir with a capacity of approximately 57 billion cubic feet. Water from the reservoir will be diverted through tunnels and penstocks through the continental divide to an underground power plant in which will be installed four 60 MW generating sets. All tailrace water will be emptied into the Vashisti river, adjacent to the

^{1/} Average rate of growth for all India was 12%.

^{2/} Superseded by the Koyna Control Board in June 1954.

^{3/} Government Resolution No. GKP 1553.

^{4/} No definite plans as yet prepared but roughly estimated at a cost of Rs 116 million.

plant, 40 miles from the Arabian Sea. The intake tunnel, surge tank, pressure shafts and powerhouse, however, will be large enough for the installation of an additional 240 MW (Stage II). The plant will operate under an effective head of approximately 1,600 ft. A detailed description of the project is attached as Annex 4.

15. The project will include a 150 mile double circuit 220 KV transmission line and a substation adjacent to the Trombay thermal power plant. Energy from the substation will be fed directly into the Bombay-Poona system.

16. The project will also include a transmission system to serve the towns and communities in the Maharashtra region south and east of Koyna. Substations will be installed in about five locations to provide connections to the distribution systems supplying these towns and communities.

Arrangements for Engineering and Construction

17. Because of the size and importance of the Koyna project the Bombay Government in June 1954 established a special Koyna Control Board to have responsibility for its engineering, design and construction. The Board is an administrative and advisory body similar to eight other construction boards in India. The responsibility of the Board is to "take quick decisions on matters pertaining to the project and to exercise general supervision over its execution". The present Board consists of three members from the Central Government, eight members from the State Government and three industrialists. The Chief Engineer is the chief executive officer of the Koyna Control Board and is responsible for carrying out all policies and programs established by the Board.

18. The engineering, design work and issuance of specifications on the entire project have been completed by the engineering staff in the Koyna Control Board and its predecessors. The engineering work for the tunnels, penstocks and powerhouse, however, was reviewed by Societe Generale pour l'Industrie, Geneva, consulting engineers employed by the Koyna Control Board. They are being continued as consultants for the whole project, with a provision to keep resident consultants at the project site to ensure continuous independent technical supervision on all aspects of engineering and construction. They will review the works done so far and will assist and supervise to ensure the successful carrying out of the project.

Status of Construction, March 1, 1959

19. The Control Board with its own organization built the initial main river coffer dams and started the excavation for the dam foundations, but in April 1956 it turned the construction of these civil works over to a team of Indian and German contractors. To date full overburden and more than 93% of the dam foundations in rock have been excavated. 4.15 million cubic feet of rubble concrete has been placed.

20. An Indian contractor was awarded the construction contract for the headrace tunnel, surge chamber and adjacent valve house. The headrace tunnel has been completely excavated. Progress on this work is good.

21. Another Indian contractor was awarded the contract for the pressure shafts, powerhouse, lower valve chamber and transformer vault. About 75% of the underground caverns have been excavated and work is progressing satisfactorily on the pressure shafts.

22. A separate contract has been placed for European steel of special quality for the pressure shafts which will be fabricated by an Indian contractor. 75% of the steel has been received.

23. The Board is constructing the tailrace tunnel with its own organization. The tunnel has been completely excavated and is ready for the concrete lining.

24. Expenditure through January 1959 has amounted to about 25% of the total cost of the project. About 35% of the past expenditure has been in foreign currencies. International bidding has been practised for all major contracts and orders including construction contracts. (A summary of major contracts awarded as of March 1, 1959 is given in Annex 6.)

25. There were about 9,400 people employed on the project during 1958. It is expected that employment by the Board and the contractors will not exceed 10,000.

Operation after Completion

26. The project will be operated after completion by the Bombay State Electricity Board (described in paragraph 6 and Annex 2). The Bombay Government has agreed that the project will have its own management and that the accounts of the project, both as to construction and operation, will be kept separate from the other undertakings of the Electricity Board so that the financial results of the project can be ascertained at any time. The accounts will be kept in accordance with modern utility practices. Steps are to be taken to train an organization during the construction period so that the operating personnel can become familiar with the plant.

Cost of the Project

27. Practically all contracts have been awarded for the project and construction cost estimates were adjusted late in 1958. The Bank mission, on the basis of past experience in India, increased the contingency allowances on local expenditures to 12%^{1/} and on foreign expenditures to 8½%^{2/}, and added amounts to cover interest at 4½% per annum on all funds to be advanced during construction. (Details in Annex 7.) The resulting estimate of the cost of the project is realistic and amounts to Rs 566 million (\$118 million including interest during construction amounting to \$14.6 million). The

^{1/} 7% to cover possible physical changes and 5% for possible price increases.

^{2/} Practically all foreign orders are placed on a firm price basis.

foreign exchange costs are estimated to be Rs 138 million (\$28.5 million)^{1/} excluding the cost of ordinary steel which is obtained from a Government pool and excluding interest on the Bank loan during construction^{2/}.

Investment Costs per Kilowatt

28. The cost per installed KW in the first stage of the Koyna development is relatively high since practically all of the cost of civil works for Stage II is necessarily included. The estimated cost per KW, including the cost of the transmission lines to Bombay, of the first two stages of Koyna is as follows:

Stage I	-	240,000 KW,	\$491/KW
Stage II	-	240,000 KW,	\$ 95/KW
Stage I and II	-	480,000 KW,	\$293/KW

Production Cost

29. The expected cost of power from Koyna, delivered at Trombay upon completion of Stage I, is about 2.86 Naya Paisa (6.0 mills) per kwh, which should be reduced to about 2.52 Naya Paisa (5.3 mills) upon completion of Stage II. A detail of the calculation is shown in Annex 8. This compares very favorably with the estimated cost of power from the Tata Trombay third unit, a thermal plant using domestic coal, of about 4.5 Naya Paisa (9.5 mills) per kwh.

Hydro versus Thermal Plant Investment

30. Annex 9 indicates the expected savings from investment in Koyna hydro-electric facilities over an alternative investment in thermal plant. A thermal plant of the same capacity as the first stage of Koyna is assumed to cost about \$54 million, compared with \$118 million for Koyna. Koyna's annual operating costs are estimated as \$5,630,000 lower, which is equivalent to a rate of return of 8.8% on the additional capital investment of \$64 million. Similarly, a thermal plant equivalent to Stages I and II of Koyna is estimated to involve an investment of \$108 million or \$33 million less than the expected investment in Koyna. The annual savings in production cost is equivalent to 30.6% return on the additional capital investment in Koyna of \$33 million. The foreign exchange requirements of the thermal and hydro installations are approximately the same for Stage I but higher for thermal of Stages I and II capacity.

31. As an alternative to constructing the first stage of Koyna, a thermal plant of equivalent capacity built in the Bombay area would require 760,000 long tons of coal a year to be moved over a heavily congested railway system. If oil were used as a fuel it could be obtained directly by sea

^{1/} The Bank loan excludes expenditures prior to October 1, 1957 amounting to \$3.5 million.

^{2/} Interest during construction on the Bank loan was not requested.

but the fuel cost of energy would be about 30% higher than through use of coal and would require the equivalent of \$10 million annually in foreign exchange.

Schedule of Construction and Expenditures

32. The following construction schedules have been estimated by the Bank. The Koyna Control Board believes these dates can be improved.

<u>Facility</u>	<u>Completion Date</u>
Koyna Dam	September 1962
Power 1st Unit	October 1962
2nd Unit	January 1963
3rd Unit	August 1963
4th Unit	April 1964

33. The schedule of expenditures, including interest during construction, is estimated as follows:

	<u>Years ending March 31</u>							<u>Total</u>	
	<u>(Rs millions)</u>								
<u>Up to</u> <u>3/31</u> <u>1958</u>	<u>1959</u>	<u>1960</u>	<u>1961</u>	<u>1962</u>	<u>1963</u>	<u>1964</u>	<u>1965</u>		
Koyna I	92.5	83.7	115.4	95.8	78.6	57.6	31.6	11.0	566.0 ^{1/}

Sources of Funds

34. The Central Government of India will advance in the form of long-term loans the entire cost of the project to the Bombay State Government. The Central Government would borrow from the Bank to cover the foreign exchange requirements, in the amount of \$25 million equivalent^{2/}. Interest during construction was not requested in the amount of the loan. The Central Government has stated that the loans would be for 30 year periods (repayments starting at the end of 10 years and extending over a period of 20 years) and would bear interest at 4½% annually.

^{1/} Breakdown into Bank funds and local funds is shown in Annex 11.

^{2/} Does not include expenditures made prior to October 1, 1957 amounting to \$3.5 million.

V. FINANCIAL ASPECTS

Power Rates

35. The Government of India and the Bombay State Government have agreed with the Bank's views on rates, namely that they should be set at a level to ensure that the earnings derived from the operation of the project, after provision for all operating expenses including taxes, adequate depreciation and interest and repayment of all loans and advances ascribable to the project in so far as it is not covered by depreciation, are sufficient to make a reasonable contribution towards the cost of future expansion in the State. Rates proposed during negotiations by representatives of the State Government, which have been used for the financial analysis in this report, will provide average revenues of about Rs 0.035 (7.3 mills) per kwh during operation of the first stage of the project and about Rs 0.037 (7.8 mills) per kwh thereafter.

Estimated Earnings

36. A forecast of earnings and expenses of the project for the first eight years of operation is shown in Annex 10.

37. Revenues would not be sufficient to cover all interest charges during the first year of initial operation; net loss of about Rs 6 million, after charging $4\frac{1}{2}\%$ interest, would be incurred. In the second year, after the third unit has been put in service, operations would be profitable and net profits for that year, after interest charges, would amount to Rs 0.8 million. The following year, with all four units of Stage I in operation, the net profits would amount to Rs 11.1 million. Profits would increase after the successive commissioning of the four units of the Second Stage and would amount to Rs 33.7 million before income taxes, and Rs 16.4 million after taxes in the seventh year, the year in which all units would be operating. The rate of return on the investment would amount to 0.9% the first year, 4.3% the second year, and range between 6.6 and 8.8% thereafter. Under the conditions assumed in the forecast, no income taxes would be payable by the project during its first five years of operation.

Forecast of Sources and Application of Funds

38. A forecast for the eight year period, showing sources and application of funds, is given in Annex 11. In addition to making full provision for about Rs 566 million of capital expenditure estimated to be required for the construction of the proposed Bank project (Stage I), the forecast provides for additional investments totaling Rs 104 million, spread over the first six years of operation for construction of the second stage, and Rs 116 million, spread over the four year period beginning with the fifth year of construction of the third stage.

39. Stage I construction would be entirely financed from loans. A substantial part of the Stage II construction cost, about 83%, could, on the basis of the rates and expenses assumed in the forecast, be financed from revenues; for Stage III earnings would provide about 50% if the same

conditions are still prevailing. The balance of the funds required are assumed to be financed from additional Government loans.

40. Total debt service requirements during the first year of operation would not be fully covered. The following year (1963/4) the coverage ratio would be 1.4 and would increase to 2.0 in 1967/8. After completion of Stage II of the Koyna project total debt service would amount to Rs 36 million. Debt service in 1969/70 would be covered by net income from operations before depreciation, about 1.5 times^{1/}. The figure of Rs 36 million includes Rs 10.3 million for debt service on the proposed Bank loan of \$25 million (Rs 120 million equivalent) calculated on the basis of a term of 25 years including 6 years of grace, at an interest rate of 5-3/4% per annum. The Bombay State Electricity Board will actually pay only 4 1/2% interest. Consequently, the debt service coverage will be slightly higher than shown above.

41. Since the Bombay State Electricity Board, which will operate the project, has agreed to keep accounts of the project separate from the accounts of its other undertakings, Koyna will be equivalent in practice to a separate Government entity. If it is so considered, its capital structure would be:

After completion of:

	Stage I Proposed Bank Project (4 units)		Stage II (8 units)	
	(in millions of Rupees)			
Loans outstanding	575 ^{2/}	100%	608.13 ^{1/}	89.7%
Equity (retained earnings)	-	-	70.2	10.3%
	575	100%	678.3	100%

The above table shows that while the initial capital would consist entirely of debt, the equity accumulated from retained earnings by the time the second stage of the project was completed would amount to Rs 70.2 million. The debt/equity ratio would still be high, but in spite of this debt service would be covered by a sufficient margin as shown in the previous paragraph.

- 1/ Based on conservative estimates of earnings with Stage III in operation, total debt service, including debt service on estimated Stage III borrowings, would be covered 1.3 times.
- 2/ Includes about Rs 18 million for loans raised for construction works in progress for Stage II.
- 3/ Includes about Rs 39 million for loans raised for construction works in progress for Stage III.

VI. ECONOMIC ASPECTS

42. Koyna power will be sold principally wholesale to the Bombay-Poona system which is owned by the Tata Companies, one of the Bank's borrowers. The area served is heavily industrialized. About 27% of all the power consumed in the area is used in textile manufacture, which is India's third largest export industry. In addition, Bombay is a main center for the rapidly expanding engineering and chemical industries. The two largest oil refineries in India are located in the area, and there is a proposal for the construction of a fertilizer plant using waste products from these refineries. A large number of plants are substantially increasing their capacity: among them are the largest tire factory and rayon fiber plant of India. Other proposed developments are the expansion and rehabilitation of the harbor and drydock facilities. Practically all the existing plants, manufacturing greatly diversified products, have also requested additional supplies for expansion.

43. In addition to the energy to be supplied to the Tata system, limited supplies will be required to serve the area around Koyna where many small industries are located and rich agricultural lands require power for irrigation. While these supplies represent the smaller proportion of the load forecast, their contribution to the development of the economy cannot be neglected in appraising the Koyna project.

44. Koyna will be the main source of additional electricity supplies in these important areas over the next 10 years and its construction is therefore the keystone of their further development.

VII. CONCLUSIONS

45. The development of the Koyna scheme is the next logical step to provide additional needed supply of electricity in the Bombay-Poona-Koyna area.

46. The project is sound. The cost estimates are realistic. Considering that many features of the Stage II installation are embodied in Stage I, the estimated cost of the project is reasonable. The estimated cost of producing power from Stage I is also reasonable.

47. The rates proposed to be charged for electricity would produce revenues adequate to meet the criteria set forth in paragraph 35.

48. The project is suitable as a basis for a loan to the Government of India of \$25 million for a period of 25 years, including a period of grace of 6 years.

KOYNA HYDROELECTRIC PROJECT
CAPACITY AND CONSUMPTION STATISTICS
FOR THE BOMBAY-POONA AREA

A. Generating Capacity in Bombay-Poona Interconnected System

<u>Station</u>	<u>Type</u>	<u>Ownership</u>	<u>Capacity</u>	<u>Date Installed</u>
Khopoli	Hydro	Tata Hydroelectric Co.	62 MW	1915
Bhiwपुरi	"	Andhra Valley Power Co.	72 MW	1922
Bhira	"	Tata Power Co.	132 MW	1927
Chola	Thermal	Central Railway (old)	64 MW ^{1/}	1929-52
Chola	"	" " (new)	54 MW	1954
Trombay	"	Tata Companies	62.5 MW	1956
Trombay	"	Tata Companies	62.5 MW	1957
Chola	"	Central Railway	18 MW	1958

Hydro 274 MW
Thermal 253 MW

Total 527 MW

B. Per Capita Consumption of Electricity (Annual kwh)

	<u>India</u>	<u>Bombay State</u>	<u>Bombay-Poona System</u>	<u>Increase over previous year (%)</u>
1951	13.3	43.9	234	11
1952	13.8	43.0	262	9
1953	15.5	50.6	284	11
1954	16.9	54.3	316	11
1955	19.1	61.4	349	10
1956	21.8	51.3 ^{2/}	366	5
1957	24.1	56.9	390	7

^{1/} Should be derated because of age of equipment.

^{2/} Variation caused by enlargement of the State in 1956.

KOYNA HYDROELECTRIC PROJECT
FUNCTIONS AND ORGANIZATION
OF THE BOMBAY ELECTRICITY BOARD

The Bombay Electricity Board, a corporate body, was constituted by the Bombay State Government on November 5, 1954 in pursuance of the provisions of Section 5, Chapter III, of the Electricity Supply Act of 1948 to promote the coordinated development of the generation, supply and distribution of electricity in the State in an efficient and economic manner. To rationalize power production in the State, the Board under the Act has been given the right to regulate power rates and to approve all generating stations before they can be established or additions or replacements made to existing generating stations. The Board has the right to purchase the undertaking of a licensee on revocation or expiration of a licence or before a new licence is granted. Being a corporate body it has perpetual succession and a common seal, with powers to acquire and hold property both movable and immovable and can at the same time sue and be sued.

The Board is composed of not less than three and not more than seven members appointed by the State Government. The Act specifies that one member shall be (a) a person with experience in commercial matters and administration, (b) an electrical engineer, and (c) a person with experience of accounting and financial matters in a public utility undertaking. One of the members with any of the above qualifications is appointed Chairman by the State Government. The terms of office are prescribed by the Government.

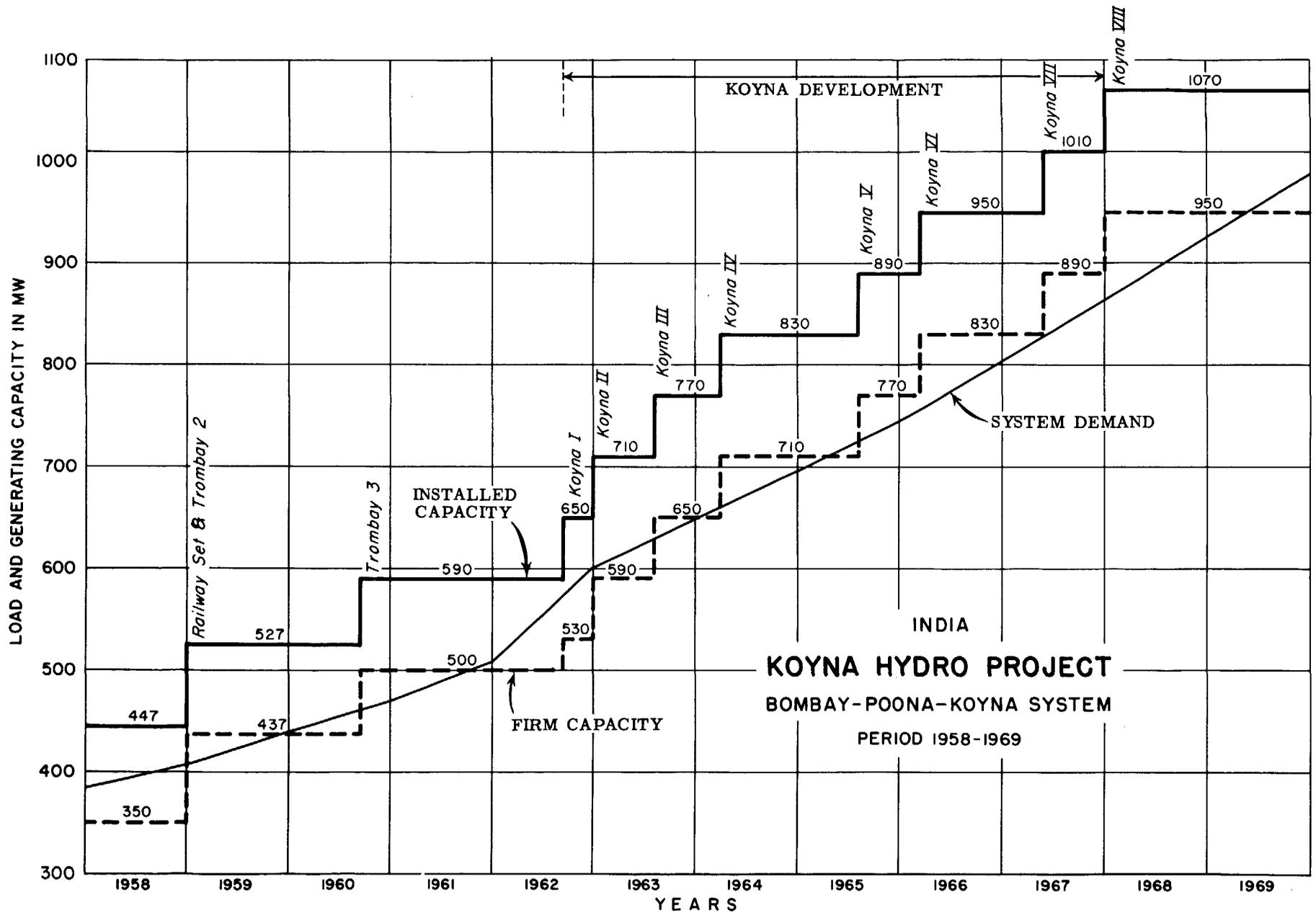
The Board formulates all the important policies and decides on problems of organization and administration. The Board has been meeting once a week.

On June 25, 1955 the State Government constituted the Bombay State Electricity Consultative Council under Section 16(1) of Chapter II of the Electricity (Supply) Act, 1948 to guide the Board in their work. The Chairman of the Board is the ex-officio Chairman of the Council and the other Board members are members of the Council.

The Council consists of the members of the Board and other persons numbering not less than seven or more than fifteen as the State Government may appoint after consultation with representative bodies representing the following interests: (a) local self government, (b) electricity supply industry, (c) commerce, (d) industry, (e) transport, (f) agriculture, and (g) labor.

The Council meets at least once every three months and has the following functions:

- (1) Advise Board on major questions of policy and major schemes.
- (2) Review the progress of the work of the Board from time to time.
- (3) Consider such other matters as the Board may place before it.
- (4) Consider such matters as the State Government may by rules prescribe.
- (5) Review annual financial statements before submission to State Government.



KOYNA HYDROELECTRIC PROJECTDETAILED DESCRIPTION OF THE PROJECT

The Koyna project is located about 130 miles southeast of Bombay on the Koyna river in the vicinity of Helwak bridge.

The Koyna river rises on the western slopes of the Malcompeth plateau which is one of the highest plateaus of the Western Ghats. The river flows almost parallel to the continental divide as far as Helwak, then turns sharply east and joins the Khrisna river which empties into the Bengal Gulf. The Koyna river bed falls to an elevation of about 1,900 ft. at Helwak. West of the divide the land falls to the Vashisti river bed to about 500 ft. above and 40 miles from the Arabian Sea.

The project is designed to use the high head between the rivers of about 1,430 ft. by impounding the Koyna river water behind a dam in the vicinity of Helwak and diverting 67,500 Mc ft. directly to the Arabian Sea through a series of waterways and an underground powerhouse. At an inter-state conference held in 1951 and attended by Bombay, Madras, Hyderabad and Mysore, all the States having water rights in the Koyna and Khrisna rivers, the State of Bombay was given the right to divert this quantity of water to the west for power generation during the minimum year rainfall. Only a relatively small amount of presently tilled land will be flooded by the reservoirs.

The catchment area above the dam site is 344 sq. miles and has a precipitation between 150 and 250 inches, which is very heavy rainfall. The area records date back to the year 1829 and are ample for design purposes. All designs are based on the minimum year rainfall.

The rock is generally good and consists of a large succession of basaltic lava. The nature of the ground is such that there is very little chance to meet major difficulties in the foundations, powerhouse cavern or tunnel excavations. The location is well suited for an underground power plant.

The entire development is to be executed in three stages: Stage I now under construction of 240 MW, Stage II an additional 240 MW, and Stage III 90 MW.

The project Stage I is designed to supply a minimum of 240 MW of energy at a 70% load factor, or 1,470 million kwh in Stage I and a minimum of 408 MW at a 60% load factor or 2,144 million kwh with Stage II. The Stage III generation has not been determined.

The dam for Stage I is to be of a gravity type, constructed of rubble concrete (Cyclopean), 250 ft. high above the river bed and 2,600 ft. long. The spillway section (400 ft.) will be designed to handle 227,000 cubic feet per second and have 6 tainter gates, 3 sluice gates, and 2 gates for irrigation purposes. Two blank penstock tubes will also be included for future power development. A reservoir of 57,000 Mc ft. over an area of 45 sq. miles will be created by the dam. Stage II is also considered a power project but

it will create a reservoir of about 98,780 Mc ft. providing 28,000 Mc ft. for irrigation. It will cover an area of 45 sq. miles.

A masonry weir and a concrete intake will be located in the Navja Nalla tributary about two miles above the dam. There will be an intake canal 20 ft. wide and 3,720 ft. long between the weir and the tower. The tower, 280 ft. high and 70 ft. in diameter, will be equipped with trash racks and two gates. The headrace tunnel, 12,072 ft. long and normally 21 ft. in diameter, will terminate in an underground surge system 320 ft. high and 39 ft. in diameter, with necessary expansion chamber and spill. An emergency valve house located 350 ft. from the surge chamber will house four butterfly valves. Four steel lined pressure shafts 2,100 ft. long, varying in size from 10 ft. to 8½ ft., will be constructed. The pressure shafts utilizing the rock for part of the pressure will go down to an underground powerhouse at a 45° angle.

The powerhouse 650 ft. long consists of three parallel caverns, the valvehouse (20 ft. wide), machine hall (50 ft. wide) and transformer and control hall (42.5 ft. wide). An underground powerhouse was decided upon because of difficult slope and deep erodable overburden. The access to the caverns is through a 2,800 ft. long tunnel 22 ft. high with a 6% slope. The powerhouse, as the waterways, is to be constructed large enough for the final installation of 8 similar units with 4 initially being installed.

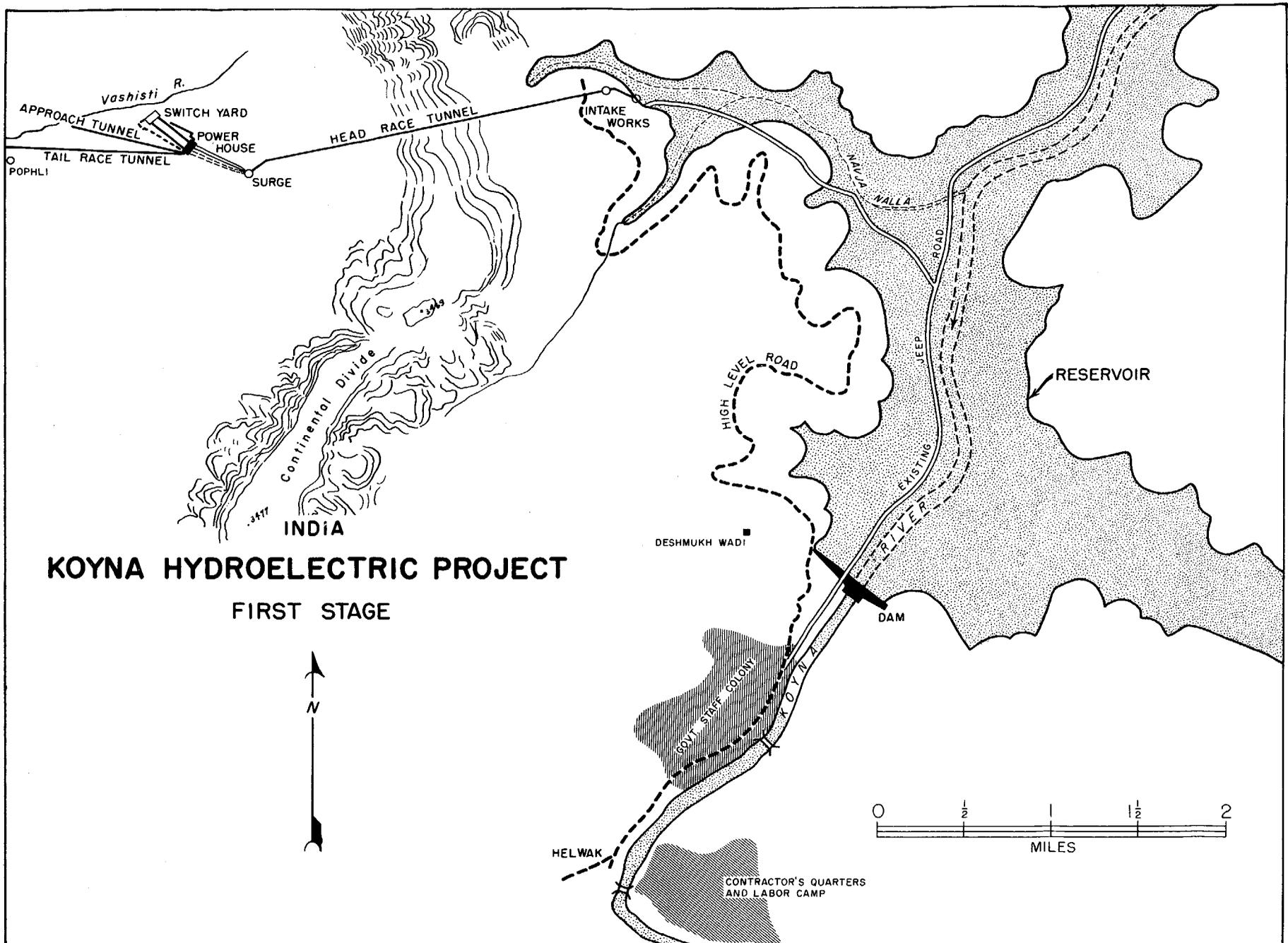
The generating units will be 60 MW with 87 mhp turbines with vertical shaft impulse wheels with one runner and four jets. The units will run at 300 RPM at an effective head of 1,600 ft., and generate 50 Cycle - 3 phase 11 KV current. A small 2,000 KVA house turbine will also be installed.

The transformer installation will consist of four banks of three 25 MVA each and voltages of 11/138/220 KV. The energy will be conducted through cables to an above-ground switchyard located just north of the powerhouse.

The tailrace, 7,450 ft. long and about 26 ft. wide, will be concrete-lined which is large enough for the final installation of 8 units.

The project will include a 220 KV double circuit steel tower transmission line to Bombay City. The line, 150 miles long, will terminate in a steel structure substation adjacent to the Tata Trombay thermal station. The substation will consist of two 3 phase 125 MVA, 200/100/11 KV outdoor transformers and two 30 MVA synchronous condensers and necessary switches and control equipment.

The project will also include a transmission system to supply the towns and communities south, east and around Koyna in the region of Maharashtra. A 220 KV line will be run to Karad (44 miles) where a substation will be installed to step the voltage down to 110 KV for transmission to Satara, Sangli, Miraj, Vishpambag, Pandharpur and Sholapur (200 miles). There will also be some lower voltage lines (210 miles) to serve some smaller communities in the area.



KOYNA HYDROELECTRIC PROJECT
FIRST STAGE

KOYNA HYDROELECTRIC PROJECTCONTRACTS AWARDED
UP TO MARCH 1

<u>Description</u>	<u>Country of Contractor</u>	<u>Value Rs Millions</u>
<u>Civil Works</u>		
1. Dam and appurtenances	India & Germany	78.90
2. Intake Structure and Tunnel	India	25.70
3. Approach and Ventilation Tunnels	India	31.50
4. Power House and Pressure Shaft (Excavation only)	India	27.00
5. Penstocks	India	11.00
<u>Mechanical and Electrical</u>		
1. Turbines	France	5.80
2. Generators	Germany	6.18
3. Generation Station Transformers	Italy	2.99
4. Switch Gear (outdoor)		
(a) Switches	Switzerland	3.50
(b) Potential transformer 220 KV	Italy	0.12
(c) Bus bars, etc.	Italy	1.68
(d) Lightning arresters	U.S.A.	0.38
	Sweden	0.20
(e) Circuit breakers, etc.	Sweden	0.22
(f) Isolators	Italy	0.77
(g) Potential transformers 110 KV	Sweden	0.02
5. Switch Gear (indoor)		
(a) Switches 11 KV	Germany	3.20
(b) "	Switzerland	0.39
(c) "	U.K.	0.37
6. Cranes		
(a) Jetty	France	0.39
(b) Generation Station	Yugoslavia	0.99
(c) Receiving Station cranes	Yugoslavia	0.32

<u>Description</u>	<u>Country of Contractor</u>	<u>Value Rs millions</u>
<u>Mechanical and Electrical (cont.)</u>		
7. Synchronous Condensers	Italy	2.07
8. Receiving Station Auto transformers	U.K.	2.96
9. Transmission Line		
(a) Insulators	Japan	1.57
(b) Aluminum ingots	not known	8.20
(c) Steel	Norway	4.00
10. Construction Power Plant	U.K.	2.20

KOYNA HYDROELECTRIC PROJECTSTAGE IDETAILED COST ESTIMATES

	<u>Local</u>	<u>Foreign</u>	<u>Total</u> Million Rs.
I. Works:			
A. Preliminary investigations	5.25	-	5.25
B. Land and rehabilitation	8.98	-	8.98
C. Works:			
1. Dam and appurtenances	74.50	29.10	103.60
2. Intake to Emergency Valve	28.87	8.33	37.20
3. Pressure shafts - Powerhouse	28.81	18.82	47.63
4. Tailrace	7.62	3.05	10.67
5. Powerhouse equipment and substation	9.58	29.64	39.22
6. Transmission lines	21.66	12.37	34.03
7. Receiving station	5.13	10.70	15.83
8. Koyna-Sholapur scheme	24.02	13.60	37.62
D. Construction and permanent camp	38.71	-	38.71
E. Construction camp running expenses	30.03	-	30.03
F. Consultants	-	1.00	1.00
	<u>283.16</u>	126.61	409.77
<u>Contingencies:</u>			
(Physical 7%)	19.82		
Local (
(Price increase 5%)	<u>14.16</u>		
	33.98		
<u>Foreign - 8.5%</u>		<u>11.00</u>	<u>44.98</u>
<u>Total Works</u>	317.14	137.61	454.75
II. Establishment, overheads, tools and plants			34.83
III. Indirect charges, Audit and secretarial			<u>6.15</u>
<u>Total</u>			495.83
Interest during construction			<u>70.20</u>
<u>Total</u>			566.03 =
			\$118 million

KOYNA HYDROELECTRIC PROJECT

STAGE I

PROPOSED LIST OF GOODS

	<u>Dollars</u> (Millions)	<u>Rupees</u>
I. Construction equipment and spares	3.4	16.5
II. Civil Works including gates, trash-racks and hoists	1.1	5.0
III. Materials and equipment for power plant and substations	8.1	39.0
IV. Steel for pressure shafts and transmission towers	3.1	15.0
V. Aluminum ingots and insulators	1.3	6.0
VI. Materials and equipment for transmission and distribution around Koyna	2.9	14.0
VII. Explosives and other miscellaneous identifiable items	1.2	6.0
VIII. Consultants, erectors and other foreign services	1.9	9.0
IX. Unallocated	<u>2.0</u>	<u>10.0</u>
Total	25.0	120.5

(The total sum does not include Rs 17.5 million spent prior to September 30, 1957)

KOYNA HYDROELECTRIC PROJECTPOWER COSTS(For first full year of operation)

Stage I	Installation 240,000 KW @ 74% load factor = 1,550 million kwh	
		<u>Rs Millions</u>
	Sales assuming 5% loss - 1,470 million kwh	
	Project cost - Civil Works	400.00
	Electrical and Mechanical	<u>166.00</u>
	Total	<u>566.00</u>
	<u>Fixed Charges</u>	
	Interest @ 4½%	25.40
	Depreciation Straight Line @ 2% ^{1/}	<u>11.30</u>
	Subtotal	<u>36.70</u>
	<u>Operation and Maintenance (based on Tata figures)</u>	
	Civil Works 0.47% = 400.00	1.90
	Electrical and Mechanical 1.70% = 166.00	2.82
	General and Overheads (25% of above)	<u>1.10</u>
	Subtotal	<u>5.82</u>
	Total	42.52
	Unit cost delivered 2.86 Naya Paisa or 6.0 US Mills	
Stage II	480,000 KW @ 56.5% load factor = 2,340 million kwh ^{2/}	
	Sales assuming 8% trans. losses = 2,150 million kwh	
	Project cost - Stage I 566.00	
	Stage II <u>112.00</u>	678.00
	<u>Fixed Charges</u>	
	Interest @ 4½%	32.50
	Depreciation @ 2%	<u>13.60</u>
	Total	46.10
	Operation and Maintenance assuming an increase of 37% over Stage I operation	<u>8.00</u>
	Total	54.10
	Unit cost delivered 2.52 Naya Paisa or 5.3 US Mills	

^{1/} Straight Line method used so as to be comparable with Tata power costs.

^{2/} Availability of water limits the output to 2,340 million kwh.

KOYNA HYDROELECTRIC PROJECTRETURN ON ADDITIONAL CAPITAL IN HYDRO OVER THERMAL

		<u>1st Stage</u>	<u>1st and 2nd Stages</u>
Installed Capacity	- in KW	240,000	480,000
Net available	- million kwh	1,470	2,150
Cost of Thermal	- million \$	54	108
Cost of Hydro	- million \$	118	141
Additional investment in hydro	- million \$	64	33
<u>1/</u> Operation and maintenance and fuel for Thermal	- mills/kwh	5.17	5.17
Depreciation Thermal	- mills/kwh	<u>.69</u>	<u>.71</u>
Production cost	- mills/kwh	5.86	5.88
Annual production cost	- thousands \$	7,600	12,600
Operation and maintenance for Hydro and transmission	- mills/kwh	.83	.78
Depreciation Hydro and transmission	- mills/kwh	<u>.51</u>	<u>.37</u>
Production cost	- mills/kwh	1.34	1.15
Annual production cost	- thousands \$	1,970	2,480
Annual savings	- thousands \$	5,630	10,120
Return on additional investment in Hydro over Thermal	-	8.8%	30.6%

1/ Operation and maintenance - .47 mills, Fuel 4.7 mills = 5.17 mills.
Calculations are based on Tata Power data.
Depreciation (sinking fund basis) Interest $4\frac{1}{2}\%$, average life -
Hydro 50 yrs. (.0056), Thermal 30 yrs. (.0164).
Fuel has been calculated assuming a cost of Rs 38 per long ton, a
thermal value of 9,000 BTU per lb. and a heat rate of 11,500 BTU
per kwh delivered to the outgoing bus.

KOYNA HYDROELECTRIC PROJECT

INCOME STATEMENT

(in millions of Rupees except if otherwise stated)

<u>Fiscal years ending March 31:</u>	<u>1962/63</u>	<u>1963/64</u>	<u>1964/65</u>	<u>1965/66</u>	<u>1966/67</u>	<u>1967/68</u>	<u>1968/69</u>	<u>1969/70</u>
<u>Power Sales</u> (in million kwh)								
Total	345	1182	1470	1654	1800	2150	2150	2150
<u>Gross Revenues</u>								
Total	14.0	37.0	52.7	60.1	65.9	80.0	79.9	79.8
Average Rate (Rs/kwh)	0.040	0.031	0.035	0.036	0.036	0.037	0.037	0.037
<u>Cost of Operations</u>								
Operating and administration expenses	4.6	4.9	5.8	6.5	7.0	8.0	8.0	8.0
Provision for depreciation	<u>4.7</u>	<u>10.2</u>	<u>11.3</u>	<u>12.1</u>	<u>12.6</u>	<u>13.0</u>	<u>13.4</u>	<u>13.4</u>
Total	9.3	15.1	17.1	18.6	19.6	21.0	21.4	21.4
<u>Net Income from Operations</u>	4.7	21.9	35.6	41.5	46.3	59.0	58.5	58.4
Less: taxes*	--	--	--	--	--	5.7	17.3	17.3
<u>Net Profit after taxes, depreciation, and before interest</u>	4.7	21.9	35.6	41.5	46.3	53.3	41.2	41.1
<u>Less interest charged to operations</u>								
Bank loan (4-1/2%)	2.5	5.0	5.3	5.3	5.2	5.0	4.7	4.7
Advance government Stage I	8.5	16.1	19.2	19.4	19.3	19.3	19.1	19.1
Advance government Stage II	--	--	--	1.0	1.0	1.0	1.0	1.0
Total	<u>11.0</u>	<u>21.1</u>	<u>24.5</u>	<u>25.7</u>	<u>25.5</u>	<u>25.3</u>	<u>24.8</u>	<u>24.8</u>
<u>Net Profit after taxes, depreciation and interest</u>	(-) 6.3	0.8	11.1	15.8	20.8	28.0	16.4	16.3
<u>Value of plant in operation</u> (end of year)	492	524	564	609	630	660	672	672
Less: accumulated depreciation	<u>4.7</u>	<u>14.9</u>	<u>26.2</u>	<u>38.3</u>	<u>50.9</u>	<u>63.9</u>	<u>77.3</u>	<u>90.7</u>
Net Depreciated Value	487.3	509.1	537.8	570.7	579.1	596.1	594.7	581.3
<u>Net Income from Operations</u>	4.7	21.9	35.6	41.5	46.3	59.0	58.5	58.4
Less: Taxes	--	--	--	--	--	5.7	17.3	17.3
Net After Taxes	4.7	21.9	35.6	41.5	46.3	53.3	41.2	41.1
<u>Rate of Return on Investment</u> (after taxes)	.9%	4.3%	6.6%	7.2%	7.9%	8.8%	6.9%	7.0%

* No income taxes would be due during the first five years of operations since development rebates and initial losses during the first year, which can be carried forward, would offset the profits.

KOYNA HYDROELECTRIC PROJECT

FORECAST OF SOURCES AND APPLICATION OF FUNDS

(In millions of Rupees except if otherwise stated)

	Up to 3/31/1958	1958/59	1959/60	1960/61	1961/62	1962/63	1963/64	1964/65	1965/66	1966/67	1967/68	1968/69	1969/70
I. SOURCES OF FUNDS													
<u>Cash from Operations</u>													
Net Income from Operations						4.7	21.9	35.6	41.5	46.3	59.0	58.5	58.4
Add: Depreciation allowance						4.7	10.2	11.3	12.1	12.6	13.0	13.4	13.4
Total						9.4	32.1	46.9	53.6	58.9	72.0	71.9	71.8
Less: Taxes						-	-	-	-	-	5.7	17.3	17.3
Net Cash from Operations						9.4	32.1	46.9	53.6	58.9	66.3	54.6	54.5
<u>Borrowing</u>													
Koyna Stage I:													
Government Advance	92.8	83.8	45.7	70.2	69.0	52.0	25.0	6.2					
Proposed IBRD Loan	-	-	69.8	25.6	10.0	6.5	5.2	3.4					
Difference of rate of interest on IBRD Loan financed by Central Govt. Subsidy	-	-	0.4	1.0	1.3	1.3	1.4	1.5	1.5	1.4	1.4	1.3	1.3
Koyna Stage II						6.1	11.9	-	-	-	-	-	-
Koyna Stage III										24.2	15.0	9.4	8.7
Total Sources of Funds	92.8	83.8	115.9	96.8	80.3	75.3	75.6	58.0	55.1	84.5	82.7	65.3	64.5
II. APPLICATION OF FUNDS													
<u>Construction Requirements</u>													
Koyna Stage I - Including interest during construction	92.8	83.8	115.9	96.8	80.3	57.6	31.6	11.0					
Koyna Stage II - Including interest on borrowing where needed during construction						6.1	19.5	21.0	19.0	19.0	19.0		
Koyna Stage III- Including interest on borrowing where needed during construction										30.5	31.4	31.9	27.5
Total	92.8	83.8	115.9	96.8	80.3	63.7	51.1	32.0	19.0	49.5	50.4	31.9	27.5
<u>Debt Service</u>													
Stage I - IBRD Loan - Interest 5-3/4%						3.1	6.4	6.8	6.8	6.6	6.4	6.2	6.0
- " " - Amortization						-	-	-	3.5	3.7	3.9	4.1	4.3
- Government Advance - Interest 4.5%						8.5	16.1	19.2	19.4	19.3	19.3	19.1	19.1
- " " - Amortization						-	-	-	0.4	0.9	1.7	3.0	5.6
Sub-Total						11.6	22.5	26.0	30.1	30.5	31.3	32.4	35.0
Stage II- Government Advance - Interest 4.5%						-	-	-	1.0	1.0	1.0	1.0	1.0
Total I and II						11.6	22.5	26.0	31.1	31.5	32.3	33.4	36.0
Total of Expenditures	92.8	83.8	115.9	96.8	80.3	75.3	73.6	58.0	50.1	83.5	82.7	65.3	63.5
Cash Surplus for Year						0	2.0	0	5.0	1.0	0	0	1.0
Available Beginning of Year						0	0	2.0	2.0	7.0	8.0	8.0	8.0
Available End of Year						0	2.0	2.0	7.0	8.0	8.0	8.0	9.0
III. DEBT SERVICE COVERAGE													
Net Cash from Operations (after Taxes)						9.4	32.1	46.9	53.6	58.9	66.3	54.6	54.5
Debt Service						11.6	22.5	26.0	31.1	31.5	32.3	33.4	36.0
Number of Times						0.8	1.4	1.8	1.7	1.9	2.0	1.6	1.5

