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INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

TOKKE HYDROELECTRIC PROJECT

NORWAY

April 25, 1956

Department of Technical Operations

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TABLE OF EQUIVALENTS

Conversion Rates for Norwegian Currency

U.S. \$1.00	▪	7.143 Kroner
1 Kroner	▪	\$0.14 U.S.
1 Million Kroner	▪	\$140,000 U.S.

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TOKKE HYDROELECTRIC PROJECT

NORWAY

SUMMARY

1. This report covers an appraisal of the Tokke hydroelectric project submitted by the Government of Norway as a basis for a loan of \$25 million.
2. The project consists of dams and tunnels in the upper reaches of Tokke and Vinje rivers to create reservoirs having a storage capacity of 1,220 million cubic meters, diversion dams in the Tokke and Vinje rivers, a 15 kilometer tunnel to an underground power plant in which four 100,000 kw high head Francis turbines will be installed. Annual generation will be about two billion kwh. The energy generated will be fed into the Southeastern Grid over a high voltage transmission system with two new substations and an enlargement to an existing substation. The project is scheduled to be put in operation before the middle of 1963. The project will be engineered and constructed by the Norwegian Watercourse and Electricity Board (NVE). Part of the construction is to be done by contractors.
3. The NVE was created as a part of the Ministry of Industry by the Storting (Parliament) in 1920 to carry out among other things all Government owned hydroelectric developments. The NVE has engineered and constructed similar types of projects but this project is larger than any previously built. However, the organization when properly staffed can successfully execute and operate the project.
4. The cost of the project is estimated to be Kr. 500 million, (equivalent to about \$70 million U.S.). The cost per kilowatt installed will be equivalent to \$137.00 which is very low considering the storage which will be provided. It is calculated that the energy will be generated for 1.2 Ore (1.7 mills) per kwh. The NVE will operate the plant and sell all power wholesale.
5. Projections of the power market in the area served by the Southeastern Grid show that the production to be generated by the Tokke project can be absorbed in a relatively short period.
6. It is proposed to finance the project by a Bank loan, loans by counties, municipalities, power companies and industries, and appropriations from the general revenue of the State Government. The Government would be the Borrower in all cases and all money would be appropriated to the NVE in the National Budget.
7. The financial projections show that the electric operations of the NVE will be self-supporting.

8. The project is considered to be suitable for a Bank loan of \$25 million with a term of twenty years and a period of grace of five years.

I. THE ELECTRIC POWER INDUSTRY OF NORWAY

9. Norway has substantial natural resources in waterfalls and timber, but its natural endowment in other respects is rather limited. These factors have been of great significance in shaping the economic development of Norway. The plentiful availability of electric power at low cost, coupled with the lack of an indigenous fuel supply has encouraged investment in industries where power is a substantial cost factor, such as the electro-metallurgical and electro-chemical industries. The conjunction of power and timber has fostered pulp and paper productions.

10. Norway has about 20% of the total hydro potential in Western Europe while its population (3.4 million) amounts to less than 1 $\frac{1}{2}$ %. The combination of large availabilities, low unit costs and a small population results in Norway having the largest generation of electric power per capita in the world, about 6400 kwh per capita in 1954. This compares with 3800 in Canada, 3300 for Sweden and about 2500 for Switzerland and the U.S.A.

11. Of the present installed capacity (end of 1955) of 4.3 million kw, only about 2% is in thermal units. No major thermal installations are planned because practically all fuel would have to be imported and would result in high cost energy (fuel cost alone exceeding total cost of hydro electric power).

12. On the basis of present projected plans, it is anticipated that approximately 5.2 million kw will be developed by 1959, giving a total production of about 30 billion kwh. This total represents only about 30% of the firm capacity potential for generation for hydro power in Norway.

13. Energy production in 1955 amounted to approximately 23 billion kwh or about 22% of the potential. Of this amount 41% went to the electro-chemical and electro-metallurgical industries, 10% to woodworking, 1% to mining, 1% to transportation and the balance of 47% went for general use including small industry, homes and agriculture.

14. The cost of hydroelectric power in Norway is about the lowest in the world because of the terrain which provides high heads within relatively short distances. Natural lakes provide low cost storage. The average cost of production in Norway, about 1.45 mills per kwh (U.S. equivalent), is considerably less than about 3.5 mills in the U.S., 2.45 mills in Canada and 2.4 mills in neighboring Sweden. This low cost energy is attractive to electro-chemical and electro-metallurgical industries. For example, in the aluminum industry alone, four new plants are planned or under construction whose annual capacity of 70,000 tons will increase the total national production to 170,000 tons of aluminum. On the basis of a use of 10 kwh per pound of aluminum, this additional production alone will require a consumption of 1,500 million kwh annually.

15. Despite an annual increase in kwh output of almost 10% per year in the past decade, a shortage of generating capacity in recent years has required that the use of energy be severely rationed. In the Oslo area, the supply was cut this winter to 80% because of unfavorable water conditions and has only recently been restored to 90%.

16. Negotiations have recently been completed for the export of power to Sweden from the Trondheim area. There is also the possibility of export to Denmark by a direct current submarine transmission line. With the availability of a large number of undeveloped storage lakes and reservoirs in southern Norway, peaking power in winter and secondary power in summer could be disposed of to Denmark at attractive prices.

17. In the past, the supply of power for general purposes has been undertaken by towns and municipalities but the greatest part of the industrial energy required has been supplied by the wood processing, electro-chemical and electro-metallurgical industries themselves. However, the greatest part of the hydro-electric expansion is now being undertaken by the State and local authorities or a combination of authorities.

II. DESCRIPTION OF THE PROJECT

18. The development of the Tokke power scheme has been under consideration since the establishment of the Norwegian Watercourse and Electricity Board (Norges Vassdrags - og Elektrisitetsvesen or NVE) in 1920. The Storting (Legislature) has been periodically appropriating money for study and acquisition of waterfall rights for this large project and finally in 1955 appropriated money for some preliminary work such as roads and a temporary power plant for construction.

19. The over-all Tokke scheme for the development of about 800,000 kw, one of the largest in Norway, will use the waters primarily accumulating in the catchment area in the southwesterly part of the Hardanger plateau in the central part of southern Norway. The principal catchment area consisting of expanses of moor land with countless lakes is located more than 1000 meters above sea level. There is only a very small amount of settlement in the valleys. (Exhibit C).

20. The first stage of development of the Tokke power scheme will be confined to the Tokke and Vinje rivers, which are the largest and cheapest sections for development of the watershed. The first stage consists of the construction of seven storage dams at the ends of lakes, provision of natural storage by draining some of the lakes through tunnels, diversion dams in the Tokke and Vinje rivers and a connecting tunnel all of which will provide seasonal storage of 1220 million cubic meters. Headworks will be constructed in the Tokke river, and a tunnel leading to a surge tank and gate house and two 45-degree steel lined pressure tunnels will be drilled which will terminate in an underground power house at Dalen, 170 km west of Oslo. The gross head at the plant will be 392 meters with a net operating head of 370 meters at full load.

21. The powerhouse will contain four 100,000 kw Francis type high head turbo-generators, and auxiliary equipment. The transformers (seven 80,000 Kva) will also be located underground adjacent to the powerhouse. The energy will be conducted through high voltage cables to an above ground switching station.

22. The energy (about 2 billion kwh annually) will be delivered to the Southeastern network over approximately 280 km of single circuit steel transmission line, part of which is designed for 300 kv but would be operated initially at 130 kv. New substations will be installed in the vicinity of Skien, and Saner and an addition including transformers and switching equipment will be made to the existing Flesaker substation.

III. PRESENT STATUS OF THE PROJECT

Hydrology

23. Water flow records have been made practically daily by private companies, the Government, and the NVE hydrological department from 1884 on the Tokke river and from 1913 on the Vinje river and are considered satisfactory for design purposes.

24. The average flow from the valley measured between 1913 and 1951 is as follows:

Annual average flow from Totak Lake	990 Million Cubic Meters			
" " " " Vinjevatn Lake	1,238	"	"	"
" " " " Area between Lakes	80	"	"	"
Total	2,308	"	"	"

The distribution of the recorded run-off to the various catchment areas has also been checked against precipitation measurements.

Waterfall and Land Rights

25. The first appropriation by the Storting for purchasing waterfall rights was in 1918/19. To date 97% of the total waterfall rights between the headworks and the power plant have been acquired. The small amount of remaining water rights for Tokke may have to be expropriated in accordance with the concession law.

26. Agreement on the details of the regulating plan for the reservoirs has not yet been finalized. This matter is before the Storting and no doubt will be approved before the end of the year. However, the total storage capacity of 1,220 cubic meters will be assured by the project proposition submitted to the Storting.

Design and Engineering

27. Topographical, geological and geophysical surveys have been completed at important locations on the project. Rock structures have so far been found satisfactory. Additional borings, however, should be made along the tunnel line, valve house and powerhouse.

28. Only preliminary designs have been worked out by NVE; but are considered to be sufficient for general design and estimating purposes. Details will not be established for the storage dams until regulation of the storage reservoirs has been finalized. Tunnel design has been established. Details for the surge tank, valve house, valve chamber and powerhouse will be established when the machinery dimensions and characteristics have been more definitely established and the exact rock conditions have been more completely explored.

29. It is considered essential that the proposed expansion of the transmission system, to supply the power from Tokke to the network, should be analyzed on a transmission system board analyzer before designs are finalized. NVE has assured the Bank that it will be done.

Construction Work

30. The only construction work started has been on the temporary hydroelectric power plant to supply energy for construction purposes and incidentally to supply power to the immediate general area. Two machines of 4,000 kw are to be obtained from other NVE provisional plants. Some houses and road work have been started.

Approval of the Project

31. The project was formally approved by the Storting on April 23, 1956.

IV. ORGANIZATION OF WORK DURING CONSTRUCTION

32. All engineering will be done by NVE, but it is contemplated that the dams and tunnels at the storage sites will be constructed by contract under the supervision of the NVE. The Government considers that the NVE is the most suitable organization to construct the main plant and headworks. This is considered feasible providing additional experienced engineers and construction men can be recruited.

33. NVE has had considerable experience in the construction of transmission lines and substations and undoubtedly can handle the proposed transmission system, without any difficulty or large recruitment of personnel.

34. The letting of contracts for construction will be handled in the usual Norwegian way. Specifications and drawings will be prepared by NVE and requests for bids will be submitted to qualified contractors.

35. Major equipment specifications will be drawn up by the NVE construction department, and will be issued to a selected list of Norwegian and foreign manufacturers. Norwegian products are given preferential treatment if delivery dates are acceptable.

36. It is considered that the present plans are sound, that sufficient experienced Norwegian personnel can be obtained, that Norwegian factories can produce satisfactory equipment for the project with the possible exception of the electric generators. Due to the fact that the size of the installation is larger than anything heretofore built in Norway, all designs except the turbines should be reviewed by the patent owners before manufacture is started. The turbines would be built by the patent owners.

V. ESTIMATED COST

37. The estimated cost of the Tokke Hydroelectric Project is as follows:

	<u>Kr. (In millions)</u>
Land and Waterfalls	12.90
Construction Camp - construction equipment, and transportation	111.60
Dams	50.20
Headworks, tunnel, surge tank and penstock	60.40
Power house, valve house - Transformer cavern and Tailrace	12.40
Plant equipment, Gates and Valves	77.85
Transmission System	100.00
Administration	28.65
Interest during construction	<u>50.00 *</u>
	504.00
Salvage Value of Construction equipment, etc.	<u>4.00</u>
Net Cost	500.00

(* Contains Kr. 10 Million for the transmission system)

38. This estimate is based on information supplied by NVE with adjustments considered necessary in the light of wage increases and other factors. In this estimate contingencies of 5% are included on machinery and 10-20% on most civil works resulting in an average overall contingency of 10%.

39. It is estimated that the timing of net expenditures will be as indicated in Exhibit D and that the proposed Bank loan will be used to finance a part of the expenditure over the first 5 years.

40. Up to March 1 about Kr. 3.3 million had been spent on acquiring land and water rights and it is expected that an additional Kr. 1.7 million will be spent for the same purpose by the end of June 1956. About 4 million will be charged to the project between January 1 and June 30, 1956 for materials, equipment and preliminary work. These amounts have been included in the estimates. Damages to land are to a large extent paid on an annual basis.

VI. SCHEDULES OF CONSTRUCTION

41. The NVE have considered the time required for the hydroelectric project as about six years, to be done primarily on a three-shift basis. NVE agrees that if the storage dams were all to be built by the Department, a longer period would be required than if built by contract. The Bank considers it is possible to get the four units in operation in six years but that it might take longer to completely finish the dams and the underground works such as linings of powerhouse, painting, etc. There is no question about the ability of NVE to construct the transmission system within six years but for economic reasons some of the transmission lines may not be completed until 1963.

42. The project is divided into two principal parts, namely, the first will be two units in operation with the required amount of storage dams by the end of 1961 and the second the last two units in operation with the required addition to dams around the end of 1962. (Details in Exhibit D)

VII. THE NORWEGIAN WATERCOURSE AND ELECTRICITY BOARD (NVE)

43. The Storting created the NVE in March, 1920, to handle all matters in connection with watercourses and electricity. The NVE is administered by a Board of five members who are chosen by the Storting for a period of three years and the Director General who is appointed by Royal Decree and has two votes. The daily administration is under the direction of the Director General and a Director, but important matters of policy and operations are usually submitted to the Board. At the end of 1955, NVE had in all Norway about 1,016,500 kw of generating capacity in operation and 188,000 kw under construction.

44. The various hydroelectric projects of the NVE in the area around Oslo are interconnected and operate under a cooperative Grid organization called Samkjoringen. The NVE has constructed transmission lines and substations and operates them in order to deliver the energy to their customers, about all of which are bulk customers.

45. The generation of power by the Board plants has increased from 883 million kwh in 1945/46 to 3.9 billion in 1954-55 or about 17% of the total production in the country. Including the plants under construction, it is anticipated that by the end of 1959 the total available firm capacity, slightly lower than the installed capacity, will be about 1,441,000 kw and reach at least 1,441,000 kw by the end of 1962. These plants will partially eliminate the shortage of power in Norway.

VIII. THE POWER MARKET

A. National

46. The consumption of power in Norway has risen from 10.1 billion Kw hours in 1946 to about 23 billion Kw hours for 1955 or an increase of about 9½% per annum compounded.

47. The national consumption has been distributed as follows:

	1946	<u>Percentage</u> 1950	1954
General Consumption	39.5	33.0	36.0
Traction	1.5	1.5	1.0
Electro-chemical and electro-metallurgical industries	38.0	44.5	41.0
Wood Processing	9.5	10.0	10.0
Mining	1.0	1.0	1.0
Light Industry and Handicrafts	10.5	10.0	11.0

48. It has not been possible to satisfy fully the demand. The allotments to customers have been steadily restricted during normal water years but severely restricted during poor water years. The national kilowatt demand has followed the pattern of installed capacity with an increase from 1946 to 1955 of about 65%. It is noted that the consumption in Kwh has risen much faster than the demand in Kw. The high load factor is accounted for by the continuous operating type of industries and the rationing of power demand in Kw either directly or by the design of rates. The average load factor in 1955 was 70%.

49. It is anticipated that the load factor will remain high through about 1960 because of the limited amount of new generating capacity to be made available in the intervening years. The following is a tabulation of all generating plants in Norway already in service and under construction:

<u>Owner</u>	<u>At end of</u> <u>War 1945</u>	<u>Construction</u> <u>during 1945/54</u>	<u>To be effected</u> <u>between 1955/59</u>	<u>Total</u>	<u>%</u>
State	318 Mw	545 Mw	373 Mw	1236 Mw	27.3
Municipalities	710 "	800 "	830 "	2340 "	44.9
Private	1300 "	174 "	159 "	1633 "	31.4
Total	2328 "	1519 "	1362 "	5209 "	

At present there is about 100 Mw installed in thermal power plants in the country, with the majority in the city of Oslo and various paper mills.

B. Southeastern (SE.) Grid

50. All the power generated at Tokke will be fed into the SE. Grid which at present is supplied from various hydroelectric generating plants with a total capacity of 1,775,700 Kw. The area served by the grid consumes more than 55% of all energy generated in Norway. In 1954, 34% went to large industry, 59% to general consumption and small industry, 6% to electric boilers (off peak) and 1% to railways.

51. The operating agency (Samkjoringen) of the SE. Grid controls the generation and delivery in order to maximize the utilization of the facilities in the area. The Samkjoringen owns no real property. All participants can supply their customers over their own lines. The Samkjoringen handles the sales of all surplus power at prices commensurate with the time and quantity required and to the satisfaction of the participants.

52. A detail study of the load growth on the SE. Grid was made by the participating members between January 1953 and October 1955. This study resulted in conclusions that the general class of customer use would increase at the rate of 7% cumulatively. The industrial growth was taken into account on the basis of individual industry growth and railway increase was based on the railway forecast which showed only a very slight increase in consumption. The result was projection of rate of growth of 5½% cumulatively which is considered reasonable.

53. The results indicate that by 1965/66 the general consumption will be 14.1 billion Kw hours annually, large industry 6.4 billion and transportation 0.18 billion making a total of 20.7 billion Kw hours with a corresponding demand of 3.25 million kilowatts.

54. A chart of load growth of the SE. Area and the proposed sources of additional power up to 1965/66 is shown in Exhibit A. (Tokke is shown as Dalen). In addition to that construction now planned it will be necessary to construct an additional 1.32 million Kw providing a winter output of 4.5 billion Kwh and summer production of 3.7 or a total of 8.2 billion Kwh annually. The total capacity would generate 29.7 billion Kwh, assuming an average year in 1965/66 which is adequate to meet requirements during this period.

55. On the basis of these projections the entire output of Tokke will be utilized by 1963.

IX. COST OF PRODUCTION AND RATES

A. Production

56. The average cost of hydroelectric generating capacity in Norway that is being constructed today is approximately Kr. 1200 (\$168 U.S.) per Kilowatt. In the case of Tokke it amounts to about Kr. 980 (\$137 U.S.), excluding transmission, which is somewhat below the average.

57. Actual operating data of existing NVE projects show the following total production costs:

Nore	=	0.73 Ore/Kwhr	(1.02 Mills)
Mar	=	1.20 " "	(1.68 Mills)
Aura	=	1.30 " "	(1.72 Mills)
Rossaga	=	1.20 " "	(1.68 Mills)

These figures include cost of administration, operation and maintenance, allocation to renewal funds required by law, taxes, pension fund allocations and interest on investment as stipulated by the State. On a comparable basis of calculation it is estimated that the costs of generating power at Tokke will be about 1.20 Ore (1.68 Mills) at full capacity.

58. The allotments to the renewal fund on a sinking fund basis were fixed by the Storting and the assumed life in all of the categories are conservative as the generators and turbines are given a life of only 25 years, and underground power stations are taken at only 50 years. Interest on the sinking fund is at 5%.* Interest on government appropriations has been about 3%.

B. Rates

59. The budget for 1956/57 now before the Storting includes a provision for an increase in rates that are to be applied to the standard contracts for general consumption. The rates are as follows:

Rates for General Consumers

<u>Old Rate</u>	<u>New Rate</u>
40 Kr. / Kw year of Contract Demand	40 Kr. / Kw year of Contract Demand
.5 ore / Kwh in 5 summer months	.8 ore / Kwh in 5 summer months
1 ore / Kwh in 7 winter months	1.6 ore / Kwh in 7 winter months

The resulting rates from the new schedule are as follows:

2.01 ore (2.81 Mills) / Kwh for 6000 Kwh/kw/yr
2.14 " (3.00 ") / " " 5000 " " "
2.34 " (3.28 ") / " " 4000 " " "

60. The average rate of consumption for the general class of customer is about 5000 hours per Kw of contract demand so that the average general consumer's rate will be increased from about 1.6 to 2.1 ore (2.24 to 2.94 Mills) per Kwh.

61. It is believed that the new general consumer's rates could in 1956-57 result in an increased earning for NVE of about 10 million kroner. General consumer class bills are rendered quarterly so increased earnings during

*It is expected that from 1956/57 the rate may be changed to 3%.

1956/57 because of increased rates will only be received during three-quarters of the year.

62. NVE supplies energy to two large government-owned plants in north-west Norway under special Industrial power rates which represents possibly 30% of the overall energy sold. The new contracts for these plants being drawn up for approval of the Storting will give an average rate of return of 1.2 ore (1.68 Mills) per kwh at a 90% load factor at the powerhouse. This rate is considered on the low side and decreases the overall rate of return to NVE.

63. Energy generated by NVE in the Oslo area above the total contracted energy supply to NVE customers is sold to the Grid for prices ranging from 1.2 to 3 ore (2.68 to 4.2 Mills) per Kwh, depending on the time of day or season. Summer power throughout Norway is usually sold at about 1.2 ore (1.68 Mills), a large amount being used for heating water in industrial plants. Energy at this low rate is lower than competitive fuels.

64. It is calculated that from the Tokke plant 1,760 million Kwh will be sold as firm power, at a rate of return of 2 ore (2.8 mills), 90 million as intermediate power at 1.5 ore (2.10 Mills) and 150 million at 1.2 ore (1.68 Mills), in the normal year, giving a revenue of 38.35 million Kroner or about 1.9 ore (2.65 Mills) per Kwh. The large proportion of power will be sold at the highest rate (standard general rate) due to the fact that practically all of the new industries requiring large blocks of low cost energy are being located in western Norway and not connected to the Tokke-Oslo grid.

4. SOURCE OF FUNDS

65. NVE is entirely a Government entity coming under the control of the Ministry of Industry. It has no autonomous existence and although it prepares a type of balance sheet (see Exhibit B-1), this balance sheet records only the total capital expenditure, balanced by an item of Government appropriations from which the investment was made, and shows also reserve funds, the counterparts of which are shown as deposits with the Treasury. NVE has no separate funds of its own. Its income and expenditures, its surpluses and the counterpart of its Renewals Reserve, are all included in the Government's accounts, and all money for new construction is provided from the Government budget.

66. The results of the operations of the power plants are recorded in a profit and loss account which up to now has been charged with a provision for renewals of plant on the basis of the provisions being invested in a sinking fund ^{1/} which, allowing for interest accruing at 5% per annum, would at the end of about 35 years amount to the original cost of the assets. This is the method prescribed by law. The profit and loss account is also charged with interest on the capital provided by the Government at rates which are set annually; at present the rate paid is 3% per annum. On the basis of this accounting the power plants have shown a profit in all years since 1946/47; in 1950/51 it was over Kr. 10 million but in the last two years has run at about Kr. 2 million a year.

^{1/} Although this is called a renewals fund, only a very small amount of expenditure on renewals is charged against it, so that it becomes in effect a depreciation reserve.

The Government

67. The sources from which the Government has obtained or will obtain the Kr. 500 million estimated to be required for the Tokke project are stated to be approximately as follows:

	<u>Kr. Million</u>
Proposed IBRD Loan	179
Bonds to be issued to counties, municipalities, etc.	200
General Government Funds	<u>121</u>
	<u>500</u>

Of this amount about Kr. 3 million had been spent prior to July 1, 1955, leaving Kr. 497 to spend from that date.

68. In considering the amount of new financing for NVE it is, however, necessary to look at the overall position and to recognize that in the eight years from July 1955 to June 1963 capital expenditure on projects other than the Tokke project is estimated to amount to Kr. 453 million, giving a total capital expenditure of Kr. 950 million.

69. On these assumptions the financing by the Government of the Kr. 950 million would be as follows:

	<u>Kr. Million</u>
Proposed IBRD Loan	179
Bonds issued to counties, etc.	200
General Government Revenues	<u>571</u>
	<u>950</u>

70. Each bond of Kr. 1,200 which the Ministry of Industry is offering to the counties, the Municipality of Oslo, etc., will carry the right and obligation of the holder to one KW of power from the Tokke plant and its use for 6,000 hours a year. The replies to the offers already received have been sufficiently favorable for the Ministry in its submission to the Storting to state that it is confident that at least Kr. 200 million worth of bonds will be sold. This would represent a contracted demand of about 170,000 KW, more than one half of the firm capacity of Tokke.

71. Although the Government will advance Kr. 571 million to NVE from general funds, it will, according to the estimates, have retained out of NVE's earnings over the period July 1955 to June 1963 interest at 3% on its advances to NVE amounting to about Kr. 276 million and the net profit (after interest) of NVE totalling about Kr. 55 million, and in addition will have been repaid about Kr. 80 million of advances through the machinery of plant amortizations, described in paragraph 73. The net advance is thus Kr. 160 million.

XI. FINANCIAL RESULTS

72. The financial estimate of sales and operating expenses supplied by NVE has served as a basis on which to prepare the statement of NVE's net operating revenues from July 1955 onwards which is attached as Exhibit B-2. The revenue for 1956/57 and subsequent years are based on the increased rates included in the 1956/57 budget now being considered by the Storting. Interest on funds supplied by the Government has been taken at 3% per annum.

73. Beginning in the year ending June 30, 1956, NVE is proposing to change its method of writing off assets by amortizing on an adjusted straight line basis, but the new method will be applied initially to a few only of the existing plants (selected for contractual and technical reasons) and to Tokke. The renewals fund will continue in operation for the remaining plants, but the rate of interest on the sinking fund from 1956/57 is expected to be reduced to 3%. During the transition period, therefore, two methods of writing off assets will be employed. For any given asset, the sinking fund basis requires a smaller annual charge against revenues, because the amounts set aside earn interest: the charge on the straight line amortization basis is higher, but this is offset by the fact that the Government retains in its free funds an equivalent amount of money which is credited to the NVE capital budget and thus reduces the total of the Government advances to NVE and the interest paid thereon. The depreciation provided by the combination of the two methods appears to be more than adequate.

74. It is estimated that the net operating revenues (before charging interest) will fluctuate between 2.8% and 5.0% of gross fixed assets in operation. The lower returns are found in years when large investments first come into operation, causing substantial increases in the provision for renewals and amortization; and although gross revenues rise also, the increase in the first years of operation is not proportionate to the increase in assets employed.

75. Although statements of cash flow and generation, and pro forma balance sheets showing future liquidity and debt/equity ratios, are usually attached to Technical Reports, the complete integration of NVE's finances with those of the Government makes this impracticable in the present case.

76. The estimated financial results are presented on the basis that all funds required for the project will be in the form of government appropriations to NVE and that interest payments would be on the basis of the average interest so far paid by the Government on all borrowings (3%). This is less than the average rate of interest which would be paid by the Government on the proposed foreign and local borrowings amounting to a little under $4\frac{1}{2}\%$. Upon completion of the Tokke project, net revenues are estimated to rise to about 4% of the total fixed assets of NVE in operation, which would be more than adequate to cover higher interest charges (which averaged over the total of money supplied by the Government would be unlikely to exceed $3\frac{1}{2}\%$) if the Government decided to pass on to NVE the increased cost of money.

XII. ECONOMIC JUSTIFICATION AND ANALYSIS

77. The present power shortage and the strong probability that demand will grow regularly and substantially in view of heavy new investment in industrial facilities having large additional power requirements afford a strong economic basis for further investment in hydro power facilities. Present and estimated future power costs are lower than in most other areas of the world and are a magnet for attracting industry and capital, both domestic and foreign, to Norway, especially where a low power cost offers significant benefits.

78. Under existing power rates the return on gross fixed assets in operation has been somewhat under 4% in recent years. As indicated in Section XI, estimated returns at the projected higher rates will vary between 2.8% and 5.0%, averaging a little under 4% in the next decade. These financial rates of return on power investment in Norway do not however properly reflect the real return which accrues to the Norwegian economy from investment in the power industry.

79. The power industry occupies a strategic position in the Norwegian economy. The significance of the power industry in Norway is far greater than its direct measurable contribution to national income which has risen from 550 million kroner in 1953 to 700 million in 1955, or about 2½% of the gross national product. Industries primarily dependent on abundant and cheap power, such as the electro-chemical and metallurgical industries, in addition accounted for over 600 million kroner of national income. These industries contribute substantially to the improvement of Norway's trade balance.

80. For example, Norway in the two years 1953-54 imported 90 million kroner of alumina, converted it into aluminum, of which about 80% was exported. These exports were valued at 293 million kroner, thus providing a substantial net export earning of over 100 million kroner per year, in addition to providing about 13,000 tons of aluminum per year for internal consumption. Fertilizers, ferro-alloys and nickel are other industries where similar calculations might be made to show the importance of power consuming industries for Norway's balance of payments.

81. There is direct evidence to support the view that projected power rates substantially understate the real contribution of power. Many, if not most, of the heavy power consuming industries in Norway could pay higher rates for power without reducing their demand for power and without any resulting loss in their own sales. Power rates relative to other prices are so much more favorable in Norway than elsewhere that heavy power-consuming industries have a significant competitive advantage.

82. It seems reasonable therefore to conclude that the contribution of power investment to the national income, and especially to the balance of payments, is far greater than is revealed by the financial return on investment calculated on the basis of projected power rates. Even though the financial return is not high, the desirability of investing additional resources in power is thus not questioned.

83. Further consideration should however be given to the advisability of increasing certain power rates even further. The real cost of capital to the Norwegian economy is clearly greater than the expected financial return in the power industry. Norway is on balance a capital importer and controls have been imposed on capital issues, bank lending, dividend payments, etc. Taking into account the extent to which capital must be rationed in the Norwegian economy and taking into account the rates of return which appear to prevail in other high priority sectors of the Norwegian economy, the real cost of capital must be substantially higher than the present or prospective rates of return for NVE.

84. To the extent that NVE's earnings are below the real cost of capital, it would appear that consumers of electricity as a class are being favored by paying less than the full costs of service. While many classes of power customers could pay higher power rates without reducing their demand, as noted above, a further increase in power rates to some customers might reduce the demand for power and lead to a better allocation of resources. Although an increase in rates to power consumers whose demand would not be affected would not necessarily directly improve the allocation of resources, it might do so indirectly by reducing the drain on the Norwegian Government budget.

85. Measures now being taken to increase power rates are a move in the right direction. The desirability of further upward rate adjustments to increase the financial rate of return on investment in hydro power facilities merits serious consideration.

XIII. Conclusions and Recommendations

86. The Tokke power scheme has been under consideration by the Government since 1920 but, because of the large size of the undertaking, it has been deferred in favor of smaller installations. The load has now grown in the eastern area to a point where the size of the installation fits into the normal scheme of power development. It is considered that the load estimates are realistic.

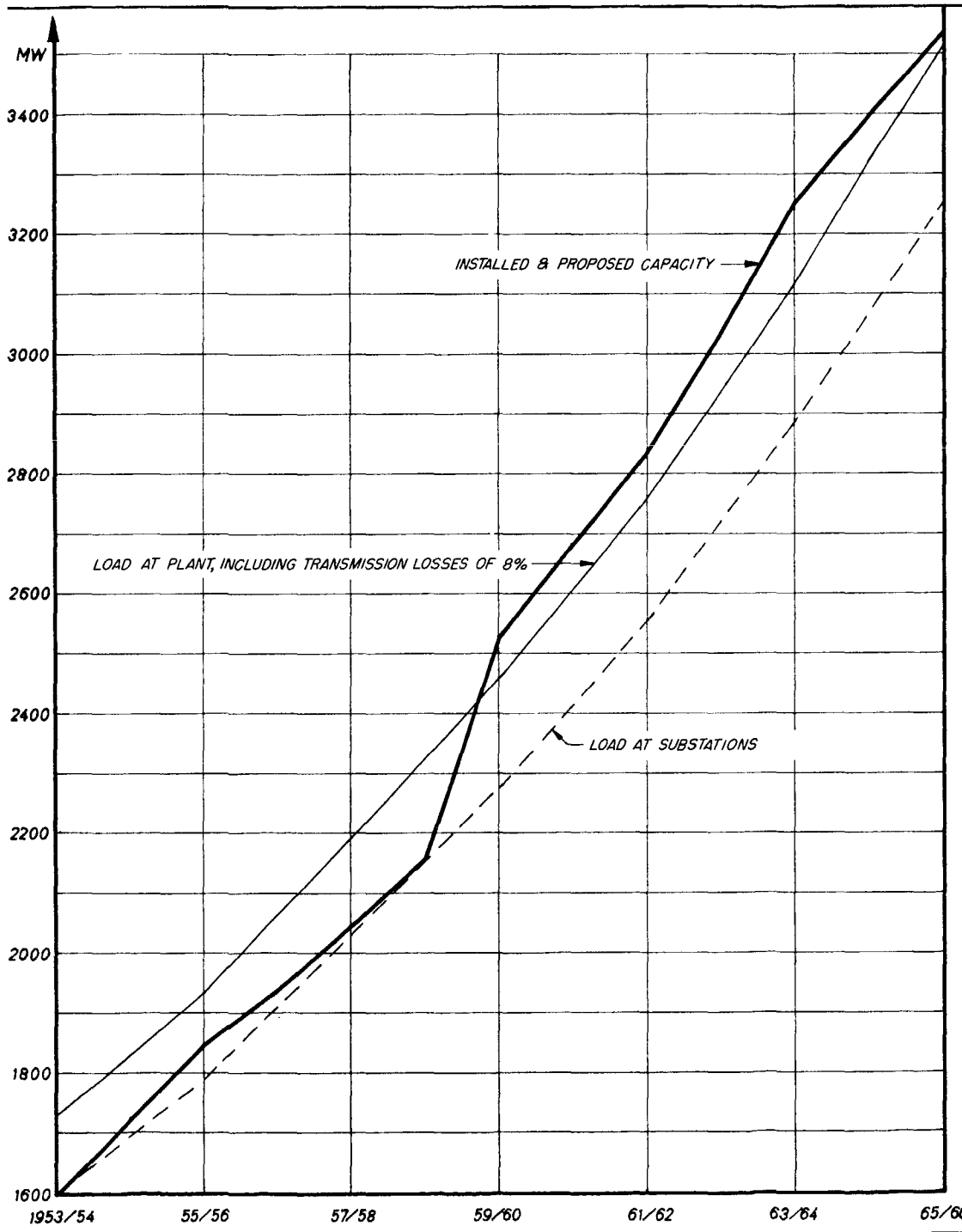
87. The project is sound. The NVE has had experience in this type of construction and is capable of executing and operating the project.

88. The cost estimate is reasonable and a construction period of seven years should be the maximum required. Operation of the first two units should be in about five years.

89. The project deserves a high priority. There is a need for the power in the area and the overall cost per kilowatt installed is low.

90. If rates are increased as proposed in this year's budget the NVE would be able to earn a small net profit.

91. The project is considered suitable for a Bank loan equivalent to \$25 million U.S. Based on the useful life of the equipment and the financial prospects of NVE, a term of 20 years appears reasonable. The construction schedule indicates a grace period of five years.



1954/55	Mår gen. 5	35,0 MW
	Hogstad	27 "
	Vinstra gen. 3	45,0 "
	Utv. reg. i Glomma	3,0 "
	Skafså II	14,5 "
	Bægna	3,6 "
	Moflåt (Rjukan III)	20,0 "
		<u>123,8 MW</u>

1955/56	Hol I gen. 3	48,0 MW
	Nore I gen. 8	25,0 "
	Øvre Tessa	8,0 "
	Tinfos I	3,5 "
	Tistedalen	10,0 "
	Kistefoss	0,6 "
	Dalsfoss	2,1 "
	Åbjöra gen. 3	23,0 "
	Langfoss (Kragerøelva)	2,5 "
	Tveitereidfoss	3,0 "
		<u>125,7 MW</u>

1956/57	Hol I gen. 4	48,0 MW
	Hol II	27,0 "
	Keggefoss gen. 3	14,0 "
		<u>89,0 MW</u>

1957/58	Mesna utvidelse	4,0 MW
	Vinstra gen. 4 ^{xj}	35,0 "
	Hol III	59,0 "
	Gjuva	10,0 "
		<u>108,0 MW</u>

1958/59	Rjukan IV	25,0 MW
	Hjartdöla gen. 1	51,0 "
	Tessa og Eidefoss utv	26,0 "
	Lurdöla	10,0 "
		<u>112,0 MW</u>

1959/60	Hjartdöla gen. 2	51,0 MW
	Mydalen	5,0 "
	Viulfoss	10,0 "
	Mykstufoss	30,0 "
	Øvre Vinstra gen. 1 og 2	130,0 "
	Geithusfoss	9,0 "
	Hemsil I gen. 1 og 2	59,0 "
	Hemsil II gen. 1 og 2	76,0 "
		<u>370,0 MW</u>

1960/61	Uste I	53,0 MW
	Uste II gen. 1	42,0 "
	Tinnelv ombygging	10,0 "
	Brufoss	4,0 "
	Bagn	44,0 "
		<u>153,0 MW</u>

1961/62	Uste II gen. 2	42,0 MW
	Nes gen. 1 og 2	115,0 "
		<u>157,0 MW</u>

1962/63	Dalen gen. 1 og 2	<u>200,0 MW</u>
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1963/64	Dalen gen. 3	100,0 MW
	Nes gen. 3 og 4	115,0 "
		<u>215,0 MW</u>

1964/65	Dalen gen. 4	100,0 MW
	Harpefoss	15,0 "
	Hunderfoss	30,0 "
		<u>145,0 MW</u>

1965/66	Vinjevatn	100,0 MW
	Sundsårm	38,0 "
		<u>138,0 MW</u>

^{xj} Vinstra ialt	180,0 MW
Vinstra I-III	145,0 "
Differens	<u>35,0 MW</u>

ØSTLANDET FORECAST OF DEMAND UP TO 1965-66 WITH PROJECTED GENERATING CAPACITY	STUDIESELSKAPET KRAFTOVERFØRINGSUTVALGET 1955 A3-2
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EXHIBIT A

EXHIBIT B-1

N. V. E.

Condensed Balance Sheet of Power Undertaking
as at June 30, 1955

<u>ASSETS</u>		<u>Thousands of Kroner</u>
Fixed Assets		812,259
National Treasury:		
Renewals and Insurance Funds		53,578
Inventory Fund		372
Current Account		<u>9,340</u>
		<u>875,549</u>
<u>LIABILITIES</u>		
Government Capital:		
Capital paid in	812,201	
Surplus	<u>9,340</u>	821,541
Grants and Subsidies		59
Renewals Fund		50,770
Insurance Fund		2,807
Inventory Fund		<u>372</u>
		<u>875,549</u>

N. V. E.

Forecast of Net Operating Revenues and Profits

(Figures in millions of Kroner, except where otherwise stated)

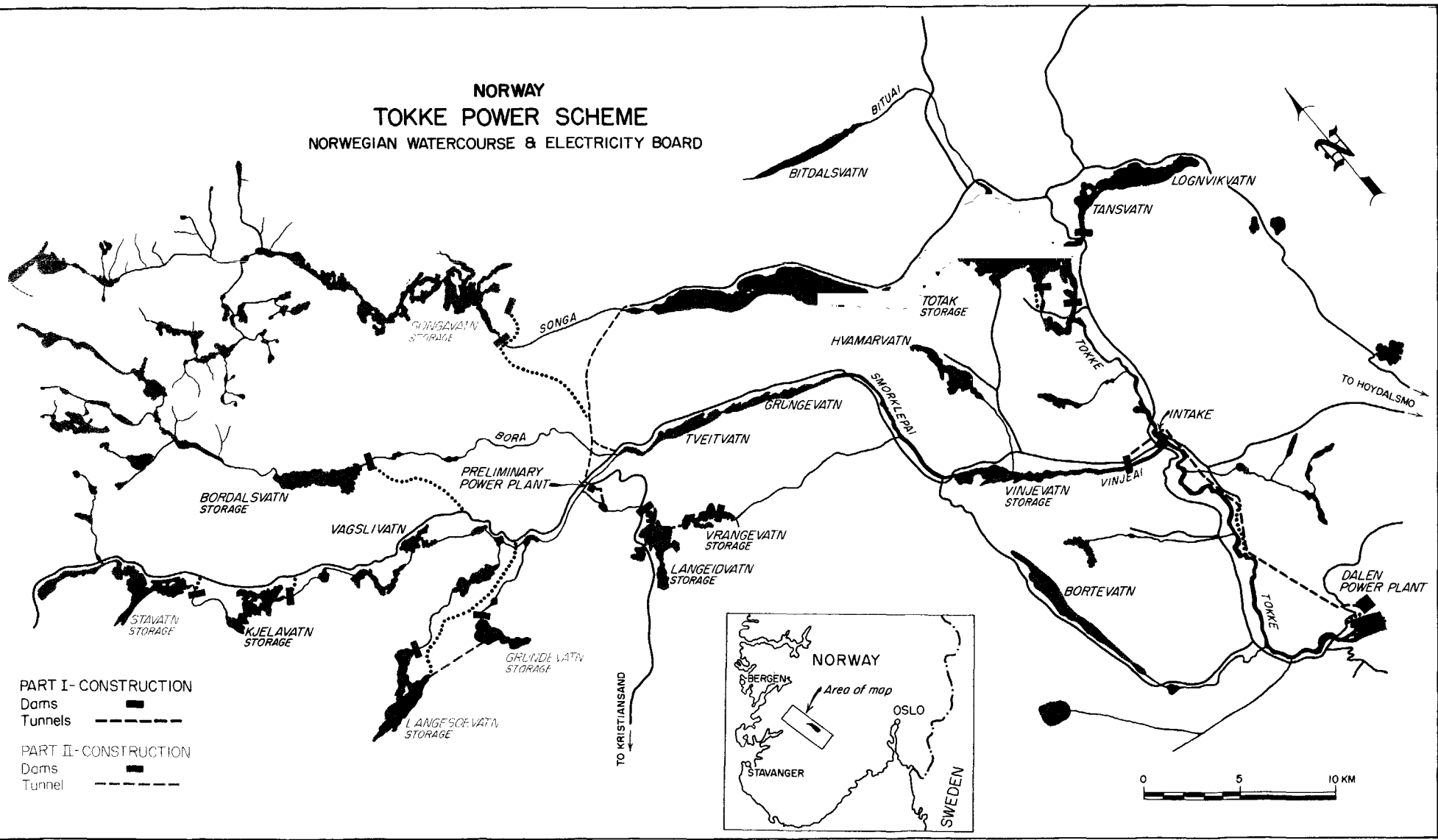
<u>Years ending June 30</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>	<u>1959</u>	<u>1960</u>	<u>1961</u>	<u>1962</u>	<u>1963</u>	<u>1964</u>	<u>1965</u>
Millions of KWH sold	4,550	5,000	5,200	6,000	6,600	6,900	7,450	8,000	8,300	8,600
Average price in ore	1.3	1.42	1.44	1.47	1.49	1.49	1.53	1.55	1.57	1.58
Revenue from sales of power etc.	59.5	71.3	75.1	88.7	98.4	103.3	114.2	124.4	131.6	136.6
Operation, Maintenance and Administration	17.4	19.5	20.2	22.4	25.2	27.1	29.3	31.3	32.3	32.9
Purchased Power	.2	.3	.3	.7	.7	.7	.7	.7	.7	.7
Insurance Fund	1/	1.0	1.0	1.4	1.7	2.0	2.3	2.6	2.6	2.6
Renewals Fund	2/	14.5	11.4	11.4	12.7	17.4	17.5	17.7	17.7	17.7
Amortization of assets	3/	7.6	8.8	8.8	8.8	8.8	16.8	17.2	17.6	18.0
	33.0	42.9	41.7	44.7	49.1	56.0	66.6	69.5	70.9	71.9
Net Operating Revenue	26.5	28.4	33.4	44.0	49.3	47.3	47.6	54.9	60.7	64.7
Interest Payable to Government	21.4	23.8	26.4	31.7	36.7	41.7	45.8	48.7	49.1	49.1
Balance	5.1	4.6	7.0	12.3	12.6	5.6	1.8	6.2	11.6	15.6
Net Operating Revenue as a percentage of Fixed Assets in operation at beginning of year	4.4%	3.5%	4.1%	5.0%	4.2%	4.0%	2.8%	3.2%	3.5%	3.7%

1/ 1956 - actual; 1957 onwards - computed 3% annuity basis.

2/ 1956 and 1957 - actual and budget; 1958 onwards - computed 3% annuity basis.

3/ From 1962 onwards amortization of Tokke, based on the capital repayments of the Bank loan, is included.

NORWAY
TOKKE POWER SCHEME
 NORWEGIAN WATERCOURSE & ELECTRICITY BOARD



MARCH, 1956

IBRD-253

EXHIBIT C

Schedule of Expenditures

Hydroelectric Project and Transmission System

Prior to July 1, 1956	Kr.	10 million
1956/57	"	60 "
1957/58	"	80 "
1958/59	"	80 "
1959/60	"	80 "
1960/61	"	80 "
1961/62	"	70 "
1962/63	"	<u>40</u> "
Total	"	<u>500</u> "

Construction Schedule

A. Regulation Works

1. Totak	July 1960
2. Kjelavatn	December 1960
3. Bordalsvatn	October 1961
4. Langeidvatn	June 1958
5. Songavatn	December 1962
6. Stavatn	November 1963
7. Langesevatn	November 1963

B. Tveito Dam - Leirli Dam -
Surge Basin and Tunnel November 1961

C. Pressure Shaft June 1961

D. Powerhouse Excavation December 1959

E. Turbines and Generators
Part I - Units 1 and 2 December 1961
Part II - Units 3 and 4 Around the end of 1962

F. Transmission System
(Principal System, December 1961) Total December 1963

In the Starting proposition the NVE have been conservative and stated that the project would be completed by the middle of 1963.