HARZA ENGINEERING COMPANY INTERNATIONAL

SUPPLEMENTAL REPORT
ON
JOKULSA A FJOLLUM PROJECT - ICELAND

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HARZA ENGINEERING COMPANY INTERNATIONAL
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SUPPLEMENTAL REPORT
ON
JOKULSA A FJOLLUM PROJECT - ICELAND

The State Electricity Authority
P. O. Box 40
Reykjavik, Iceland

Gentlemen:

Introduction

This report supplements our report to you dated October 23, 1957 and presents our current cost estimate for a run-of-river power development of the Jokulsa a Fjollum from near Vestara-Land at elevation 37 m. to above Selfoss at elevation 340 m. No consideration has been given to enhancing the power production or economics of the Project by the inclusion of seasonal storage at potential sites referred to in the basic report.

The Project for which we have prepared cost estimates consists of (1) the Dettifoss Development which develops about 137 meters of head from above Selfoss to the foot of Hafragilsfoss, (2) the Vigabergsfoss Development which develops about 163 meters of head from above Vigabergsfoss to near Vestara-Land, and (3) transmission facilities extending from these two Developments to Svalbard, near Akureyri, a distance of about 90 kilometers where power and energy would be delivered to potential customers at 11

kilovolts. This plan of development was outlined in the original basic report referred to above.

We estimate that the Project will deliver annually at Svalbard 1780 million kilowatt hours of primary energy and 395 million kilowatt hours of secondary energy. The dependable peaking capability would be about 220,000 kilowatts. 206,000 kilowatts of average continuous energy would be available at the load center 92 percent of the time, with lesser amounts the remaining 8 percent.

Our estimates of the direct construction costs of the Project are as follows:

Dettifoss Development	$13,135,000
Vigabergsfoss Development	24,802,000
Transmission Plant	7,290,000
Contingencies & Omissions	6,813,000
Engineering	4,160,000
Direct Construction Costs	$56,200,000

We wish to point out that the plan of development and the construction cost estimates thereof should be considered of an appraisal nature aimed to establish general levels of technical and economic feasibility. More detailed field investigations and project planning studies to include consideration of seasonal storage reservoirs represent the next logical engineering step. The plan studied is considered as technically feasible and not involving any serious geologic or construction problems. A generally conservative approach has been unilised throughout. It is our present opinion that more detailed investigations and studies would tend to lower our estimate of construction costs, as estimated on the current basis.

Basic Data

Our construction cost estimates have been made in conformity with the memorandum of September 25, 1959, as amended, attached as Appendix A.

Most details of the designs basic to our estimates, except for the transmission lines, were prepared in Iceland. Planning drawings showing the general arrangement and details of the structures were prepared by the two consulting firms in Reykjavik, Almenna Byggingafelagid H. F. and Verklegar Framkvemdir H. F. The drawings and a cost estimate of the civil engineering structures are presented in a preliminary report by the two consulting firms, dated February 1959. The State Electricity Authority (SEA) estimated the cost of the electrical and mechanical machinery and equipment, presented in a report dated August 1959. These reports were made available to us, and extensive use has been made of them and of other basic data ~~computed~~ compiled by the Icelandic organizations. Conferences and discussions were held with representatives of SEAand the two consulting engineering firms.

These designs were checked by us for general technical adequacy and safety.

Construction Costs

The cost estimates prepared by us and presented herein represent our present best judgment of unit prices and lump sums for the various items, and are expressed in U. S. dollars. The various elements were arranged for presentation in a form which we have found convenient and more or less standard for estimates of this type.

In compliance with Paragraph 5 of Appendix A, taxes, duties, and cost of land and land rights have been omitted in our estimates.

Our cost estimates are presented in Appendix B which includes a summary estimate for the overall Project and detailed estimates for each of the three elements of the Project: the Dettifoss Development, the Vigabergafoss Development and the Transmission Plant, which includes the step-up and switching facilities at each Development.

Civil Engineering Features

Our estimate of the civil engineering works is based on computed quantities and unit prices for the principal construction items such as excavation, rockfill, concrete and steel. Appropriate lump sum items were used when sufficient information was not available to make an estimate of quantities or when the total cost of a structure or element of equipment could be established adequately without making a breakdown of quantities.

The quantities were computed from the drawings made by the Icelandic consulting firms. Overbreak from the theoretical rock line was taken into account when computing the excavation and concrete quantities in underground structures. Where not shown on the drawings concrete thicknesses were assumed, based on our experience with similar types of work. Our quantities, as a check, were compared with those previously computed by the Icelandic consultants and good agreement was found in all except a few minor items.

The design is considered to be adequate with respect to quantities. The velocities chosen for the pressure shafts and tailrace tunnel are somewhat lower than what normally are considered to be most economical. Inasmuch as the tunnel excavation represents a large element of the Project cost, considerable reduction may be effected by more advanced project planning.

The unit prices were computed in part on the basis of the labor rates

and cost of materials as given in the report by the Icelandic consultants. Our prices also include contractor's profit, the appropriate cost of construction equipment, temporary access and accommodation. A rate of exchange of 29.40 Icelandic Kroners to one U.S. Dollar was used in converting the expenditures of local currency into Dollars, as noted under Item 6 of Appendix A.

Turbines and Other Mechanical Equipment

Our estimate for turbines, governors and other mechanical equipment was based on equipment of Western European manufacture. All costs represent that for the items completely installed, and are presented generally on a lump sum basis.

Prices on turbines were obtained by SEA from the Swedish turbine manufacturer Karlstads Mekaniska Verkstad (KMW). Our independent estimate gave costs which were only slightly higher. Independent estimates were also made for all miscellaneous mechanical equipment and the results, where appropriate, agreed in general closely with previous estimates by SEA, which in part were based on prices from KMW.

Generators, Transformers, and Accessory Electrical Equipment

Our estimates for electrical equipment are based on equipment of Western European manufacture. All costs represent that for the items completely installed, and are presented generally on a lump sum basis.

Detailed quotations on costs of generators, transformers, switchgear, control equipment, and accessories were obtained by SEA from the Swedish manufacturer Almenna Svenska Elektriska Aktiebolaget (ASEA). In the limited time available to us it was not possible to make a complete independent analyses of the costs. We made, however, a study of the design assumptions,

and compared the costs with empirical values based on our experience from similar projects. It was concluded that the design provisions were adequate and that the costs were reasonable and adequate.

The power factor of 0.8 which was assumed by SEA is considered to be conservative. With the type of load expected, a value of 0.9 appears to be more realistic. The higher power factor would result in lower costs, but no adjustments were made in our estimate.

Transmission Lines

The transmission lines on which our estimates were based consist of a single circuit on steel towers between Vigabergsfoss and Dettifoss and a double circuit in single steel towers from Dettifoss on to Svalbard. In case of emergency each single circuit could carry the entire production to Svalbard, and this might not be feasible with a lower transmission voltage than the 220 kilovolts upon which the estimates are based.

Design assumptions include a maximum wind velocity of 100 miles per hour, and a temperature range of plus 25 to minus 40 degrees Centigrade. The Conductor size selected was 605 MCM, ACSR 54 x 7 (Code name "Duck").

The transmission line estimate was based on equivalent construction in the United States in conformity with Item 3 of Appendix A. SEA supplied a plan and profile to small scale of the selected route, but no previous cost estimates were made.

Contingencies and Engineering Costs

A contingency item of 15 percent has been applied to all costs as an allowance for omissions and possible increases in quantities or prices. In

appraisal estimates of this nature we would normally use a higher percentage, but in this case some contingency appears to be already included in the quantities and the design. The item for concrete lining of the tailrace tunnel for example, may in itself, be a contingency, because lining will only be used where required by rock conditions. The low power factor assumed is another example. We consider, therefore, that a contingency item of only 15 percent is justified.

Engineering and owner overhead has been estimated at eight percent of the direct construction costs. This value is based on our experience from similar projects, and includes the engineering supervision of construction.

Interest During Construction

The net cost for interest during the construction period is ordinarily estimated by the engineer when the interest rate on borrowed funds and on reinvested funds and other financing costs are known or can be closely approximated. These data are not currently available to us.

The rates and period of expenditure of construction funds represent essential data for estimating interest during construction. We believe that the construction of the Jokulsa a Fjollum Project can be accomplished in about three years. For projects of this type and for this stage of engineering study the expenditure rate can be approximated by an "S" curve graph of percent of construction expenditures versus time which begins at 0-0, passes through 15 percent expenditure at 25 percent of the time and 85 percent expenditure at 75 percent of the time, and terminates at 100 percent at the end of the construction period. On this basis and with usual interest rates the cost of interest during construction would normally be between seven and eleven percent

of the direct construction cost, including engineering.

In order to develop estimates of unit energy cost, we assumed the cost of net interest during construction to be ten percent of the direct construction cost.

This corresponds with an annual interest of 4 3/4 percent and reinvestment rate of two percent less and on the assumption of all funds being available at the beginning of construction and no allowance for other financing costs. This total amount would need to be checked and corrected for other financing assumptions or determinations.

Annual Charges

A determination of annual charges must be made in order to estimate the unit cost of energy. These charges ordinarily include:

1. Operation and maintenance
2. Interest
3. Amortization
4. Depreciation
5. Insurance
6. Taxes

We have estimated operation and maintenance of the two power plants and the transmission system to be $850,000 (US) per year, but have made no estimate of the other annual costs. Operations and maintenance expense could be lowered considerably by maximum utilization of supervisory control which was not considered in this estimate, but would be appropriate. Interest and amortization ordinarily represents the major portion of annual costs for a hydroelectric power project and are dependent on financing terms which for this Project, are unknown to us. Annual charges, other than operation and maintenance costs, will usually range between five and ten percent of total

investment (construction costs plus interest during construction plus financing costs), and the graphs of Appendix C have been prepared for this range.

Power and Energy

The two power plants, Dettifoss and Vigabergsfoss, are designed to be operated on the run-of-river flow. The turbines have each been sized for a flow of 22.5 cubic meter per second at point of best efficiency which was taken at 90 percent of full gate discharge. Since one unit was considered as being reserve capacity, we have considered that the primary energy level has an upper limit corresponding to station flows of 90 cubic meters per second, regardless of the available river flow. The flow duration curve on Figure 4 of the basic report shows that a river flow of 90 cubic meters per second is available 92 percent of the time. During the remainder of the time the river flow was less and the production level of primary energy will be reduced proportionally.

When the river flow exceeds 90 cubic meters per second, secondary energy can be produced assuming that all five units will be operating most of the time. The average maximum flow through the five units will be about 125 cubic meters per second at full gate. The utilization factor for secondary energy may, however, be rather low.

Based on the above considerations, we made the following assumptions:

a. Primary Energy Energy produced by a turbine flow of 90 cubic meters per second or by a turbine flow equal to the river flow during the time when the latter is less than 90 cubic meters per second. Utilization factor 98 percent.

b. Secondary Energy. Energy produced by the difference between 125 and 90 cubic meters per second in turbine flow, or by the difference between river flow and 90 cubic meters per second during the time when the river flow is less than 125 cubic meters per second (but more than 90 cubic meters per second). Utilization factor 80 percent.

The gross head between the intake pool elevation and normal operating level in the tailrace surge chamber was estimated to be 134.0 meters at Dettifoss and 150.7 meters at Vigabergsfoss. The hydraulic losses in the tailrace tunnel were taken into account when determining the water level in the tailrace surge chamber.

The following values for efficiencies were estimated:

Water conductors	0.99
Turbine	0.92
Generator	0.97
Transformers (2)	0.98
Transmission and Station Service	0.97
Overall efficiency	0.84

The annual energy in kilowatt hours delivered to Svalbard was estimated by the formula $E = 9.8 \times H \times e_1 \times e_2 \times Q \times T$, where:

H = Gross Head

e_1 = Overall efficiency (0.84)

e_2 = Utilization factor

Q = Turbine Flow

T = Time in hours

Our estimates of average annual energy delivered to Svalbard at 11

kilovolts are as follows:

PRIMARY ENERGY	Million Kwh
Dettifoss Development	835
Vigabergsfoss Development	945
Project Total	1780

SECONDARY ENERGY	Million Kwh
Dettifoss Development	185
Vigabergsfoss Development	210
Project Total	395

Peaking Capability

Under most conditions the peaking capability delivered to Svalbard of the two power plants will be that from the full gate operation of all five units in each plant less losses and are estimated as follows:

Dettifoss Development	127,000 KW
Vigabergsfoss Development	136,000 KW
Project Total	263,000 KW

Inasmuch as one unit at each plant has been considered as a reserve for maintenance outages, the dependable peaking capability of the two power plants delivered to Svalbard should be considered as that from the full gate production of four units at each plant less losses and are estimated as follows:

Dettifoss Development	104,000 Kw
Vigabergsfoss Development	116,000 Kw
Project Total	220,000 KW

Capacity-head reduction during period of flood flow will be relatively minor.

Unit Cost of Energy

The unit cost of energy expressed in U. S. mills per kilowatt hour is a common and convenient index for evaluating the general economic level of a hydroelectric project. We have made estimates for the unit cost of delivered primary energy for the Jokulsa a Fjollum Project as presented graphically in Appendix C, and for a range of annual costs between five and ten percent of the total investment which was our estimated direct construction cost including engineering plus an allowance of ten percent of that amount for interest during construction.

These estimates of the unit cost of energy are based on the following considerations:

1. No allowance for income from sales of secondary energy
2. Interest during construction assumed to be 10 percent of our estimated construction cost (or 9 percent of the total estimated investment including allowance for interest during construction).
3. Allowance of Operation and Maintenance expense annually to $850,000.

The unit cost of primary energy on this basis would vary from about 2 mills to about 4 mills per kilowatt hour, with a unit cost of three mills resulting from annual costs in addition to operation and maintenance expense amounting to 7.3 percent of the estimated total investment after inclusion of nine percent of that as an allowance for interest during construction, but not including financing costs.

Unit energy costs in this range should be attractive to some industrial users.

A tabulation of significant data for the project is included as Appendix D.

It has been a great pleasure to us to provide this additional engineering service to you on the Jokulsa a Fjollum Project.

Very truly yours,

Richard D. Harza
Vice President

Encls. Appendix A Memorandum
Appendix B Cost Estimates
Appendix C Unit Cost of Primary Energy
Appendix D Tabulation of Significant Data

November 20, 1959

APPENDIX A

MEMORANDUM

Discussion, September 25th 1959, between Mr. Willey and Mr. Briem about the Dettifoss and Vígabergsfoss projects.

1. Harza will check construction estimates.

2. Harza will also check cost estimates on machinery and electrical equipment. The FOB prices are estimated by ASEA and KMW in Sweden and should therefore be reliable. As many generating units, high transmission voltage and rather expensive transformer arrangement etc. has been selected, these cost estimates should be well on the safe side with regard to FOB prices (perhaps too much so?)

3. Harza will estimate the cost of the transmission and assume that the construction price of H.T. lines on steel towers are rather similar in USA and Iceland. This should assure an estimate well on the safe side in spite of ocean freight, as line material, especially steel towers, are somewhat cheaper in Europe and labour cheaper in Iceland than in USA.

   Rarik will send available cost data on an existing 138 kVA line in Iceland.

4. The present estimates do not include water and oil piping, ventilation systems and air pressure systems

in the power plants and not concrete foundations for the transformerstation at Svalbard. These items should be added.

5. All government taxes and duties on imported goods and all government purchase taxes on contractor work shall be omitted in the cost estimates.

   Cost of land and water shall also be omitted in the cost estimates.

   The present cost estimates do not include engineering which thus has to be added.

6. One cost estimate shall be made, assuming the rate of $ 1 = 29.4 Icl. kr. on local cost. (E. Briem)

7. Around November 15th Harza will submit a report on the cost estimates and estimated operation cost showing energy cost in U.S. mills per kWh as function of capital cost.

JOKULSA A FJULLUM PROJECT - ICELAND

COST ESTIMATE

SUMMARY

Item	Amount
Generating Plant	
Dettifoss Development	
Power Plant Structures and Improvements	$ 1,336,800 U.S.
Reservoir, Dams, and Waterways	8,148,200
Turbines and Generators	2,550,000
Accessory Electric Equipment	525,000
Miscellaneous Power Plant Equipment	400,000
Roads	175,000
Subtotal Dettifoss Generating Plant	$ 13,135,000
Vigabergsfoss Development	
Power Plant Structures and Improvements	$ 1,466,300
Reservoir, Dams and Waterways	19,450,700
Turbines and Generators	2,780,000
Accessory Electric Equipment	520,000
Miscellaneous Power Plant Equipment	435,000
Roads	150,000
Subtotal Vigabergsfoss Generating Plant	$ 24,802,000
Transmission Plant	
Substation Structures and Equipment	$ 3,660,000
Transmission Line	3,630,000
Subtotal Transmission Plant	7,290,000
Subtotal Direct Cost	$45,227,000
Contingencies and Omissions - 15%	6,813,000
Total Direct Cost	$52,040,000
Engineering - 8%	4,160,000
Total Construction Cost	$56,200,000 U.S.

JOKULSA A FJULLUM PROJECT - ICELAND

COST ESTIMATE

Item	Dettifoss Development Quantity	Unit Price $ U S	Amount $ U S	Vizabergfoss Development Quantity	Unit Price $ U S	Amount $ U S
Production Plant						
Power Plant Structures and Improvements						
Powerhouse						
Pumping		L.S.	25,000		L.S.	25,000
Excavation, Rock	30,000 m^3	10.50	315,000	34,000 m^3	10.50	357,000
Foundation Preparation		L.S.	20,000		L.S.	20,000
Substructures						
Concrete, incl. forms and cement	2,200 m^3	67.00	147,400	2,200 m^3	67.00	147,400
Superstructures						
Concrete, incl. forms and cement						
Walls, columns, beams	350 m^3	150.00	52,500	350 m^3	150.00	52,500
Roof arch	700 m^3	67.00	46,900	700 m^3	67.00	46,900
Access shaft	3,000 m^3	75.00	225,000	4,000 m^3	75.00	300,000
Architectural		L.S.	50,000		L.S.	50,000
Utilities		L.S.	150,000		L.S.	150,000
Reinforcement	420,000 kg	0.25	105,000	470,000 kg	0.25	117,500
Surface Control Building		L.S.	100,000		L.S.	100,000
Operators' Village		L.S.	100,000		L.S.	100,000
Total Power Plant Structures and Improvements			1,336,200			1,466,300
Reservoir, Dams, and Waterways						
Dam, Concrete						
Cofferdam and Care of Water		L.S.	400,000		L.S.	400,000
Excavation, Rock	22,000 m^3	1.80	39,600	17,000 m^3	1.80	30,600
Foundation Preparation						
Cleaning, wedging, barring, etc.		L.S.	10,000		L.S.	10,000
Drilling grout holes	6,000 lin.m.	10.00	60,000	10,000 lin.m.	10.00	100,000
Grouting	1,200 m	90.00	108,000	2,000 m^3	90.00	180,000
Concrete, incl. forms and cement						
Mass	31,000 m^3	30.00	930,000	95,000 m^3	30.00	2,850,000
Piers and Aprons	6,000 m^3	38.00	228,000	5,000 m^3	38.00	190,000
Deck	50 m^3	88.00	4,400	100 m^3	88.00	8,800
Reinforcement	200,000 kg	0.25	50,000	300,000 kg	0.25	75,000
Dam, Rockfill						
Excavation, Rock	2,000 m^3	1.80	3,600			
Foundation Preparation						
Drilling grout holes	8,000 lin. m.	10.00	80,000			
Grouting	1,600 m^3	90.00	144,000			

Jokulsa a Fjollum Project - Iceland

Cost Estimate

Item	Dettifoss Development Quantity	Unit Price $	Amount $	Vizabergsfoss Development Quantity	Unit Price $	Amount $
Reservoir, Dams, and Waterways						
Facing						
Concrete, incl. cement and forms	2,400 m³	34.00	81,600			
Reinforcement	240,000 kg	0.25	60,000			
Embankment						
Rockfill	40,000 m³	2.50	100,000			
Core						
Cut-off, Graben area		L.S.	500,000			
Dam, Appurtenances						
Spillway gate, frame, and hoist						
Taintor, 1 at 10 w x 12 h m		L.S.	95,000			
Outlet gates, frames, and hoists						
Ice gate 1 at 8 w x 3 h m		L.S.	10,000		L.S.	10,000
Sluice gate 1 at 4 x 4 m		L.S.	20,000		L.S.	20,000
Miscellaneous		L.S.	10,000		L.S.	10,000
Intake Dam						
Excavation, Rock	8,500 m³	1.80	15,300	6,500 m³	1.80	11,700
Foundation Preparation		L.S.	20,000		L.S.	20,000
Concrete, incl. cement and forms	5,750 m³	55.00	316,300	6,000 m³	55.00	330,000
Reinforcement	170,000 kg	0.25	42,500	200,000 kg	0.25	50,000
Rockfill	34,000 m³	2.00	68,000	20,000 m³	2.00	40,000
Intake gates and appurtenances						
Taintor 5 at 4.5 x 4.5 m		L.S.	122,000		L.S.	122,000
Trashracks and miscellaneous		L.S.	20,000		L.S.	20,000
Penstocks						
Excavation, rock	7,000 m³	13.50	94,500	8,000 m³	13.50	108,000
Concrete, incl. cement and forms	3,200 m³	25.00	80,000	3,700 m³	25.00	92,500
Steel Plate Liner	450,000 kg	0.77	346,500	560,000 kg	0.77	431,200
Draft Tube						
Excavation, Rock	3,000 m³	15.00	45,000	3,000 m³	15.00	45,000
Concrete, incl. cement and forms	1,200 m³	67.00	80,400	1,200 m³	67.00	80,400
Reinforcement	32,000 kg	0.25	8,000	30,000 kg	0.25	7,500
Gates, Frames, and Hoists		L.S.	33,000	[illegible]	L.S.	33,000
Tailrace						
Excavation, Rock, Tunnel	330,000 m³	8.50	2,805,000	1,180,000 m³	8.50	10,030,000
Pumping and Rock Bolts		L.S.	100,000		L.S.	450,000
Concrete, incl. cement and forms						
Lining, tunnel (25% of length)	17,000 m³	48.00	816,000	65,000 m³	48.00	3,120,000
Outlet structure	1,000 m³	60.00	60,000	1,000 m³	60.00	60,000
Reinforcement	500,000 m³	0.25	125,000	2,000,000 kg	0.25	500,000
Stop logs, outlet structure		L.S.	16,500		L.S.	16,500
Total Reservoir, Dams, and Waterways			8,148,200			19,450,700

JOKULSA A FJULLUM PROJECT - ICELAND

COST ESTIMATE

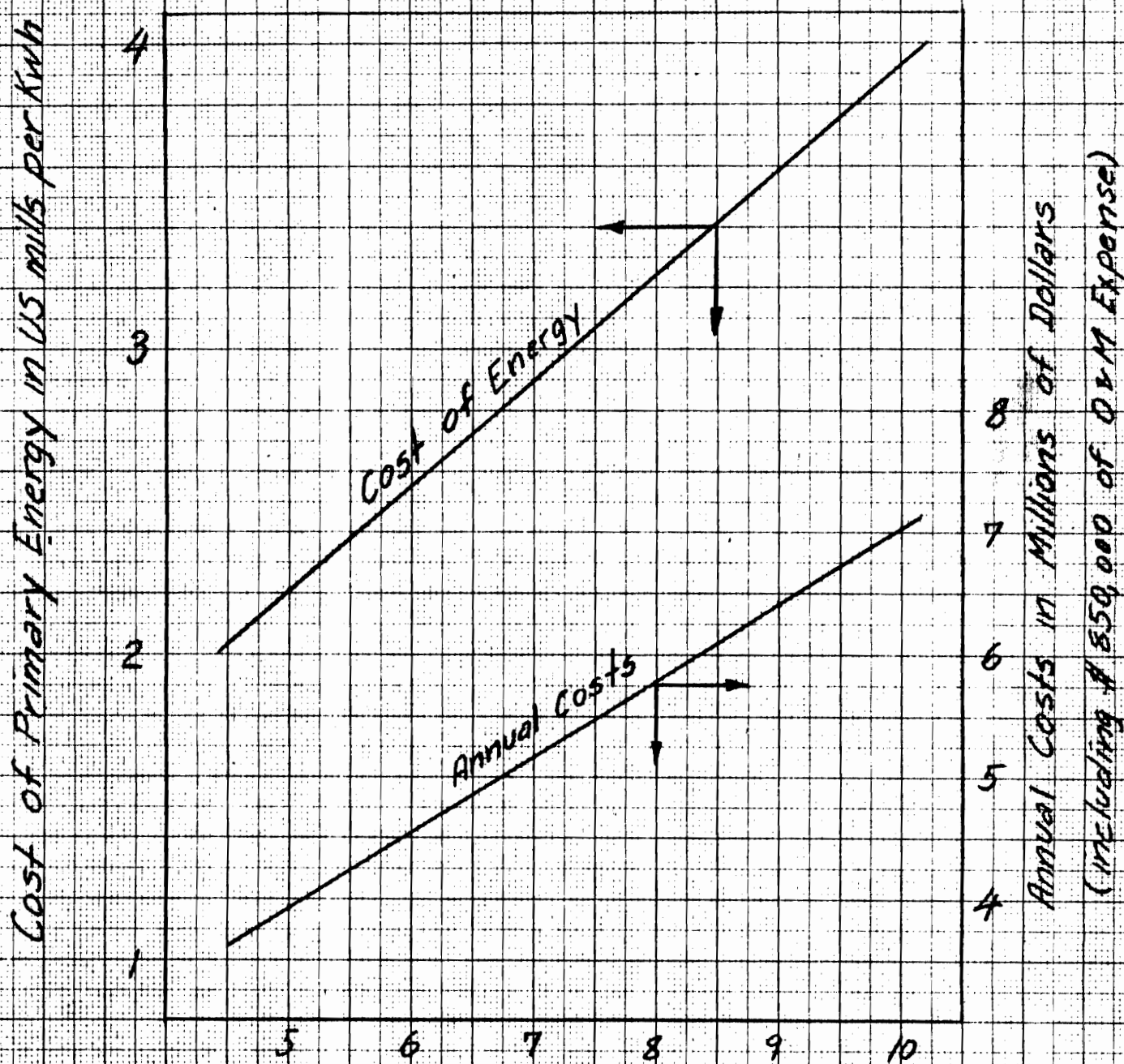
Item	Dettifoss Development Quantity	Unit Price $ U S	Amount $ U S	Vinsbormafoss Development Quantity	Unit Price $ U S	Amount $ U S
Turbines and Generators						
Turbines, Governors, and Auxiliary Equipment	5 units at 37,000 hp	200,000	1,000,000	5 units at 48,000 hp	215,000	1,080,000
Generators and Auxiliary Equipment	5 units at 26,000 kw	310,000	1,550,000	5 units at 30,000 kw	340,000	1,700,000
Total Turbines and Generators			2,550,000			2,780,000
Accessory Electric Equipment		L.S.	525,000		L.S.	520,000
Miscellaneous Power Plant Equipment						
Cranes		L.S.	145,000		L.S.	150,000
Elevator		L.S.	30,000		L.S.	35,000
Other Equipment		L.S.	225,000		L.S.	250,000
Total Miscellaneous Power Plant Equipment			400,000			435,000
Roads						
Improve existing harbors, roads & bridges		L.S.	100,000		L.S.	100,000
Access roads and parking areas		L.S.	75,000		L.S.	50,000
Total Roads			175,000			150,000
Total Production Plant			13,135,000			24,502,000

JOKULSA A FJULLUM PROJECT - ICELAND

COST ESTIMATE

Transmission Plant	Amount	
Substation Structures and Equipment		
Dettifoss		
Foundations and Structures	$ 150,000	U.S.
Transformers	580,000	
Switchgear and Auxiliary Equipment	290,000	
Vigabergsfoss		
Foundations and Structures	120,000	
Transformers	650,000	
Switchgear and Auxiliary Equipment	130,000	
Svalbard		
Foundations and Structures	300,000	
Transformers	980,000	
Switchgear and Auxiliary Equipment	460,000	
Total Substation Structures and Equipment	$3,660,000	
Transmission Line, 220 kv		
Double-Circuit, Dettifoss-Svalbard		
Towers and Fixtures	2,530,000	
Overhead Conductors and Devices	870,000	
Single-Circuit, Vigabergsfoss-Dettifoss		
Towers and Fixtures	180,000	
Overhead Conductors and Devices	50,000	
Total Transmission Line	$3,630,000	U.S.
Total Transmission Plant	**$7,290,000**	**U.S.**

JÖKULSÁ Á FJÖLLUM PROJECT
UNIT COST OF PRIMARY ENERGY



Annual Costs other than Operation and Maintenance in Percent of Total Investment (including 9% of total for Interest during Construction)

Note: No allowance made for income from sales of secondary energy.

Harza Eng. Intern.

Nov. 14, 1959 - ARE

SKP-202-1

JOKULSA A FJOLLUM PROJECT

TABULATION OF SIGNIFICANT DATA

	Dettifoss	Vigabergafoss
Stream Flow		
Drainage area - Km^2	7000	7050
Max. discharge of record - m 3/s	1540	1540
Min. discharge of record - m 3/s	16	16
Average flow - m 3/s	191	191
Average flow dry year - m 3/s	152	152
Average tailwater level - meters	200	37
Reservoir		
Normal operating level - meters	338	200
Min. operating level - meters	335	197
Normal tailwater elevation - meters	201	37
Head		
Gross head, overall - meters	137	163
Gross head, intake to draft tube outlet	134	150.7
Dam		
Material and type	Rockfill and Concrete Gravity	Concrete Gravity
Overall length, meter	950	350
Max. height - meters	15	23
Gates:		
Taintor crest gate, one w x h meters	10x12	none
Ice gate, one - w x h	8x3	8x3
Sluice gate, one - w x h meters	4x4	4x4
Spillway capacity:		
Main spillway - m 3/s	3000	3000
With emergency spillway - m 3/s	7500	7500
Intake Structure		
Type and structure	Five intake openings in one structure.	
Gates:		
Taintor gates, five w x h meters	4.5x4.5	4.5x4.5

	Dettifoss	Vigabergsfoss
Water Conductors		
Penstock		
Type	Steel lined vertical shafts excavated in rock.	
Length - meter	120	140
Inside diameter - meter	2.90	2.90
Tailrace tunnel		
Type	Unlined, free flowing	
Length - meter	4100	15250
Size - m^2	69	69
Powerhouse		
Type	Underground	
Means of access	By vertical shafts	
Turbines		
Type	Horizontal Francis	
Number	5	5
Rated net head - meters	132.5	150
Rated capacity - Hp.	37000	42000
Speed - rpm	375	375
Hydraulic capacity at 90% of full load - m 3/s	22.5	22.5
Generators		
Rated capacity - kva	33000	37000
Power factor	0.8	0.8
Transmission Line		
Voltage - kv.	220	220
Length double circuit line - km	85	85
Length single circuit line - km	10	10