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OF THE RIVER
JÖKULSÁ Á FJÖLLUM

REPORT

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Preliminary Run-of-River Project
and Cost Estimate, February 1959.
Appendix Letter to SEA, February 1960

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REYKJAVÍK, February 1960

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Hydroelectric Development of the river JÖKULSÁ Á FJÖLLUM

Preliminary Run of River Project and Cost Estimate

1. Introduction

The State Electrical Power Works assigned the work of making a preliminary project and cost estimate of the construction part og the hydroelectric development of Jökulsá á Fjöllum to Almenna Byggingafélagið h/f and Verklegar framkvæmdir h/f in the beginning of year 1958. The project and estimate should be based on the report of 23. Oct. 1957 by Mr. C. K. Willey, covering this subject.

Verklegar framkvæmdir h/f should cover the project of the development of the upper falls of river Jökulsá (i.e. the waterfalls Selfoss, Dettifoss and Hafragilsfoss) hereinafter called the Dettifoss Project and Almenna Byggingafélagið h/f the lower falls of the river (i.e. the waterfalls Réttarfoss, Vígabergsfoss and the rapids down to an elevation of 40 m above sea level) hereinafter called Vígabergsfoss Project.

The above projects are worked out in conformance with the recommendations of Mr. Willey, however, with minor modifications. They are therefore not projects for comparison of different alternative developments of the river but estimates covering the way of development which can be considered near the optimum plan.

For practical reasons a geological description of the area is disincluded here as this aspect is aptly covered in the report of Mr. Willey as well as in the detailed geological survey by Dr. Sigurdur Thorarinsson.

In the summer of 1958 the development area and sites were investigated by engineers of the firma Almenna Byggingafélagið h/f and Verklegar Framkvæmdir h/f.

2. Topography

Jökulsá á Fjöllum is located in the North-Eastern part of Iceland (see general map of Iceland, enclosure no. 1 and topographical map of NE part of Iceland, enclosure no. 2). The source of Jökulsá is the glacier Dyngjujökull and the source of river Kreppa, its main tributary, the glacier Brúarjökull. Both these glaciers are a part of the glacier Vatnajökull. The drainage area of Jökulsá above Dettifoss is 7000 sq. km whereof 1700 sq. km are glaciers and 3000 sq. km lava. During the summer season about 60% of the discharge is glacial melt-water from Vatnajökull. The drainoff from the lava fields has a regulating effect on the flow of the river.

Jökulsá flows northwards through an even slope from an elevation of 690 m above sea level through the highlands between Midfell and Lambafjöll, past Núpaskot, where the river Skardsá flows into it, continuing through the plain of Hólsmelar where the elevation is 340 m a.s.l. The length of this route is 130 km and the head 350 m.

South of Kvíar the fall of the river becomes steeper and the waterfalls and rapids mentioned in the introduction are formed, where the head is about 300 m for a run of 25 km. About 3 km north of the farm Land the river branches out to the sea. The estuary of the main branch Bakkahlaup is located about the middel of Axarfjördur.

The capacity of the development is based on a discharge of 90 m^3/sec as recommended in the report of Mr. Willey.

Discharge measurements have not been made for a sufficient period of time to enable us to determine maximum floods of the river. The greatest flood hitherto measured is about 1500 m^3/sec. In our estimate we assume that the maximum flood from normal meteorogical phenomena would amount to 3000 m^3/sec. For this discharge the maximum demands for safety are met.

In annals exceptional floods are recorded, the latest in year 1729. It has been assumed that such floods will not exceed 15000 m^3/sec. We have taken this danger of flood bursts in account in such a way that for a flood amounting to 7500 m^3/sec the combination of forces is not as rigid as the ultimate demand and for a discharge of 15000 m^3/sec major damage should not happen. More information about the hydrology of Jökulsá can be found in the report of Mr. Willey.

3. Run of River Projects

3.1 Dettifoss Project

The general lay-out of the project is shown on drawing no. 80-08 (Enclosure 3).

3.11 Dam (see drawings nos. 80-10, 80-11b, 80-14, 80-15, 80-16 and 80-17, enclosures 5, 6, 9, 10, 11 and 12 respectively).

The dam is built up of a spillway section, sluices, intake and rock filled dam. The spillway is a gravity dam of concrete, length 240 m, maximum height about 15 m.

The west bank of the river is rock, slightly higher in elevation than the crest of the spillway. East of the spillway a tainter gate 10x12 m is installed, then an undersluice 4x4 m and an ice sluice 8 m wide. The intake is positioned east of the ice sluice at right angles to the main dam, wherefrom the rock dam is situated on the east bank until the ground elevation has reached full height. The length of the rock filled dam is 700 m, maximum height 11 m and crest width 3 m. The water tight seal is a concrete membrane on the water side. The crest elevation of the rock filled dam, the intake and the sluice pillars is 342 m.

The location of the dam is about 800 m upstream of Selfoss just above rapids and islands in the river located there. A few comparative studies and site investigations indicate that the most economical dam site is above the rapids.

The elevation of the uncontrolled crest of the spillway has been selected 338 m. A study of the graben area did show that the elevation of the dam crest has to be considerably more than 340 m for use of it as a security spillway for glacial bursts. The capacity of spillway and sluices is 3000 m^3/sec. If the discharge reaches 7500 m^3/sec the river flows over the rock on the western bank and the water level rises to an elevation of 341.3 m.

3.12 Intake (see drawing no. 80-13, enclosure no. 8).

The number of intake openings is 5, each controlled by a tainter gate. The openings are submerged to eleminate intrusion of surface ice. Racks are installed in front of the openings as well as stop logs. A shelter is constructed over the intake to house the gate machinery.

3.13 Penstock

The penstocks are vertical, steel pipe lined, grouted out to the rock. Inside dia. 2.90 m, and the maximum water velocity therefore 3.4 m/sec. Normally four are operated, the fifth one used as a spare.

3.14 Power House (see drawing no. 80-12 and 80-13, enclosures no. 7 and 8 respectively).

The underground power house is located vertically under the intake. Inside dimensions are 11.2 by 60.0 m.

The ceiling is a concrete arch construction and the walls concrete lined.

Two shafts for elevator, power house crane, air ducts, cable ducts are provided and on the surface a building for crane machinery, machine repair shops etc. is constructed.
Air vents from the surge chamber are effected through one of the shafts. In the machine room 5 horizontal units are installed each 33 MVA, whereof one is operated as a spare. Further details about the machinery is described seperately.

3.15 Outdoor switchyard

The outdoor switchyard is located on the east bank of the river behind the intake as indicated on drawing no. 80-11b (enclosure 6).

3.16 Tail Tunnel (see drawing no. 80-09, enclosure 4).

The tail tunnel is designed for free flow, 90 m^3/sec flow in the tunnel and 1500 m^3/sec discharge of the river. In great floods the tunnel will be filled. Just below the power house a surge chamber is constructed as shown on drawing no. 80-13, (enclosure no. 8).

The tail tunnel runs through lava layers of uneven thickness, mostly of columnar nature. With regard to experience gained of such tunnels in Iceland a concrete lining is considered unneccessary, as a rule. However, considerable reinforcement is considered advisable and a cost increase of 25% is included in the cost estimate for this purpose.

The shape of the tunnel cross-section is selected with regard to our experience here of tunnels in similar rock formations. The length of the tail tunnel is 4,100 m and the cross section 69 m^2. The tailrace returns to Jökulsá about 350 m downstream from Hafragilsfoss.

3.2 Vígabergsfoss Project

The general lay out of the project is indicated on drawing no. 37301 (enclosure no. 13).

3.21 Dam (see drawings nos. 37302, 37303, 37304 and 37305, enclosures nos. 14, 15, 16 and 17 respectively).

The dam is a concrete gravity dam spillway. The length of the main spillway is 160 m, crest elevation 290.0 m above sea level, maximum height 23.0 m. The capacity of the main spillway is 1500 m^3/sec. On both sides of the main spillway reserve spillways are constructed, each 76.0 m long or totally 152 m. The crest elevation of the reserve spillways is 202.5 m. The total capacity of main spillway and reserve spillways is 7500 m^3/sec. For this discharge the water level elevation will rise to 205.6 m.

East of the eastern reserve spillway an 8.0 m wide ice sluice is placed, then a bottom outlet 4x4 m. A shelter for the dam machinery is constructed over the ice sluice and the bottom outlet. The intake is positioned on the eastern bank, nearly at right angles of the dam. West of the western reserve spillway a concrete gravity dam is constructed, length 41.0 m, crest elevation 207.0. The location of the dam is 400 m upstream of Réttarfoss.

3.22 Intake (see drawing no. 37307, enclosure no. 19).

The construction of the intake is practically identical to the Dettifoss Project intake (cfr. 3.12).

3.23 Penstock

The construction of the penstock is the same as in the Dettifoss Project and described under par. 3.13.

3.24 Power House (see drawings nos. 37306 and 37307, encl. nos. 18 and 19).

The power house is of a similar construction as in the Dettifoss Project (cfr. 3.14). except that the capacity of each generating unit is here 37 MVA.

3.25 Outdoor Switchyard

The outdoor switchyard is located on the eastern bank of the river as indicated on drawing no. 37303 (encl. 15).

3.26 Tail Tunnel

The construction of the tail tunnel is similar to the Dettifoss

Project tunnel described under paragraph 3-16 except for the length, which here is 15,250 m. The outflow in Jökulsá is below the farm Vestara-Land, outside the area whereof detail maps have been made.

4. Communication-Transport

4.1 Harbours

The nearest harbours are Húsavík where ships up to 3000 tons capacity and Kópasker, where ships up to 1000 tons capacity can be unloaded. Both harbours are free from ice all year round.

In the cost estimate Húsavík is assumed to be the main import harbour and Kópasker an auxilary harbour. Kópasker is a safe harbour for 70% of the duration of the year and it is considered more economical to transship some heavy shipments than to reinforce the bridge over river Jökulsá in Axarfjördur.

4.2 Roads and Bridges

The road from Húsavík is routed around Tjörnes through Kelduhverfi over the bridge of Jökulsá in Axarfjördur, and up along the eastern side of the river to the project sites.
The distance from Húsavík to Vígabergsfoss Project site is 90 km and to the Dettifoss Project site 98 km. The road is a filled up earth base gravel finish road with a 4.5 m wide driveway and 1 m shoulders. A total of 8 bridges is located on this road, seven of which are short with a span from 4-18 m and width of driveway 3 m. The greatest bridge is over Jökulsá in Axarfjördur a suspension bridge with 116 m span and 4.2 m wide driveway. The capacity of the bridge over Jökulsá is one 9 tons truck including a 18 tons trailer.
The road from Kópasker is of similar construction as the road from Húsavík. Distance 57 km from Vígabergsfoss Project site and 65 km from Dettifoss Project site. On this road there are also 8 bridges, none of which great, the shortest 4.0 m and the longest 27.0 m.

4.3 Airports

The nearest airports are at Kópasker, Húsavík and Akureyri respectively. The airport of Akureyri is equipped as an auxilary airport for transatlantic flight, but the airports of Húsavík and Kópasker are suitable for local flight only (DC-3).

5. Climate

Experience has shown that it is feasible to carry on with construction work of hydroelectric development in Iceland all year round.

Outdoor work is although reduced considerably during the months December through March. However, in this period underground work and indoor work can be carried out, and opportunities to carry out outdoor work are utilized.
It is also customary to carry out mass concrete placing during the winter. We have therefore assumed that the work will be organized as sketched above, also that necessary transport connection with Húsavík will be kept open, by clearing the road or by means of snow tractors if the clearing of the road becomes too expensive during the winter.

Generally the weather is calm and cold at the project sites, however, it has to be assumed that snow-storms will prohibit outdoor work during several days each winter.

In the following table the mean temperature of Grímsstadir á Fjöllum (elevation 380 m a.s.l.) and Húsavík is tabulated as well as the precipitation at Grímsstadir.
The temperature at the Dettifoss Project site will be very close to the temperature at Grímsstadir but at the Vígabergsfoss Project site somewhat higher. Accumulation of snow, however, is slightly greater at Vígabergsfoss Project site than at Dettifoss.

TABLE I - Monthly Mean Temperatures in Húsavík and Grímsstadir and Precipitation in Grímsstadir

	Grímsstadir Temperature Centigr.	Grímsstadir Precipitation	Húsavík Temperature Centigr.
Jan.	− 4.4	26 mm	− 0.9
Febr.	− 5.1	25 "	− 1.5
March	− 3.3	20 "	− 0.3
April	− 1.3	21 "	+ 1.3
May	+ 4.0	17 "	+ 5.9
June	+ 7.7	29 "	+ 8.9
July	+ 9.6	50 "	+10.6
August	+ 8.7	49 "	+10.4
Sept.	+ 5.2	47 "	+ 7.9
Oct.	+ 0.5	31 "	+ 3.8
Nov.	− 2.2	28 "	+ 1.3
Dec.	− 3.4	23 "	0.0

6. Concrete Aggregate

A survey covering the availability of concrete aggregate in the vicinity of the project sites was carried out during the summer 1958. Numerous samples were collected and sent to The University Research Institute in Reykjavík for analysis. Final reports have not yet been submitted but preliminary findings disclose that ample quantity of good concrete aggregate, comprising both sand and gravel of basaltic origin is available, within 20 km distance from the project sites.

In the cost estimate we have assumed that crushed rock will be used in the concrete, utilizing the blasted rock, and that sand will be collected from a distance about 8 km from the Dettifoss Project site and 18 km from the Vígabergsfoss Project site.

If necessary and convenient, gravel can also be obtained in the same area as the sand.

It has been assumed that 250 kg/m^3 of cement will be used for the concrete in gravity dams but 300-360 kg/m^3 for other concrete work.

7. Labour Conditions

It can be assumed that sufficient labour, both unskilled and skilled, will be available. Unskilled labourers as well as skilled labourers are organized in trade-unions.

The wage rates for unskilled labour are divided into 8 classes, but the wage rates for skilled labour are very similar for all trades.

When the cost estimate was prepared in August 1958 the relevant wage rates for daytime work were as follows :

TABLE II - Basic Wages for Daytime Work

A. Unskilled labour

I.	cl.	ordinary labour	kr. 19.54	pr. hour
II.	"	concreting, steel, hands	" 19.97	" "
III.	"	compressor, blasting	" 20.28	" "
IV.	"	motor vehicle operation	" 20.88	" "
V.	"	not applicable here	" 21.34	" "
VI.	"	operators of construction machinery	" 22.67	" "
VII.	"	cement work	" 23.26	" "
VIII.	"	not applicable here	" 24.17	" "

Direct addition to the above rates :

1.	Medical expense	1.0 %
2.	Vacation allowance	6.0 %
3.	Legal accident insurance	1.5 %
4.	Unemployment insurance	1.0 %

B. Skilled Labour

Carpenters	kr. 24.17	pr. hour
Masons	" 24.17	" "
Mechanics	" 24.03	" "

Direct additions are the same as for unskilled labourers, except that carpenters are allowed kr. 0.55 pr. hour extra for tools.

Normal working week in Iceland is 48 hours. However, for work at project sites for hydroelectric developments the working week is never shorter than 60 hours, and we have here assumed a 63 hours working week. In that case 12 hours are paid as overtime, which is 50% higher for unskilled labour and 60% higher for skilled labour than the day-time rates paid. All work in excess of 60 hours a week is paid at double normal rates. Shift hours for work for a longer duration than one month is paid with a 25% addition to the day-time pay. All underground work is paid with a compensation amounting to kr. 2.75 per hour and is the same for all kinds of work.

At hydroelectric development project sites work is carried out for 6 days one week and 5 days the other. After the 5 days week the employees are entitled to be transported to and from town for the 2 days weekend. In the case of the Jökulsá Project sites the towns will be Akureyri and/or Húsavík.

Accomodation has to be provided for all employees.
Skilled and unskilled labourers usually live four together in one room. Foremen, however, in single rooms. Engineers get apartments and probably also a few other employees.
Skilled labourers are entitled to free catering, but unskilled labourers have to pay the material cost of the food.
All expenses pertaining to kitchen and mess-hall operation are borne by the project.

8. Cost Estimate

8.1 Scope

The cost estimate does cover construction cost only.
Preparatory and planning cost, interest banking etc. are disincluded here. The cost estimate covering installed machinery as well as mechanical and electrical equipment and accessories is also disincluded in this estimate.

This cost estimate has basically been worked out as a tender.

For the time being the price level in Iceland is rather unstable. The official rate of exchange is not correct. Currency taxes as well as duties and taxes of different commodities and services make it rather difficult to convert the icelandic cost in foreign currency.

In order to obtain a basis independent of local price level fluctuations, official rate of exchange and changes of duties and taxes, we have in addition to the estimated cost in icelandic kr. listed a man-hour estimate covering the job and the cost of machinery and material in dollars, as described more in detail below. All man-hours are included, from the starting of the work until its finish including the set-up of the project site as well as erection of barracks. In addition to the work of the project units themselves, work covering unloading of material, transport, truck driving, stockkeeping, all machine and carpenter shop work etc. (including repair work of machinery and transport equipment) is included.

The man-hours have been classified into unskilled labour, skilled labour as well as surface work and underground work including compensation; and additionally in shift work, (underground work and surface work without differentiation). The average pay for each category of man-hours has been calculated in such a way that the different rates of pay are taken into account as well as overtime, social additions and team leadership. Supervision, both of supervisors and engineers is not included neither are the man-hours for the operation of barracks nor for clerical work.
The direct cost per man-hour was as follows in August 1958:

Unskilled labour	-	Surface work - designated	V	- 26.40
" "	-	Underground work	Vn	- 29.14
" "	-	Shift work	Vj	- 34.50
Skilled labour	-	Surface work	S	- 32.00
" "	-	Underground work	Sn	- 34.80

All duties and taxes are disincluded in the $-cost for mechanical equipment and material and the prices for these commodities therefore stated cif. However, in the cost in icelandic kr. all duties and taxes, except purchase tax are included. As stated above repair work of machinery and equipment are included in the man-hour calculation. In August 1958 cif price for the main construction materials was as follows :

Cement	$ 19.80	per ton
Reinforcing steel	$ 88.50	" "
Lumber	$ 1.52	per cuft
Dynamite	$ 0.55	per kg

8.2 Construction Cost

In the following tables III and IV the estimated cost of the main construction units for each project is tabulated. Related construction units are taken together in such a way that the surge chamber, the shafts, the outdoor switchyard and operators housing is included in the power house unit. In the cost estimate for the dam the cost of cofferdams and of the diversion of the river is included. In the cost of accomodation all cost for barracks and mess-halls is included as well as all utilities. In the estimated cost of site set-up, cost of provisory roads and bridges is included. Cost of field supervision is included in each construction unit. Direction and supervision of the project engineers is, how - ever, included in the overhead cost.

In addition to the estimated cost in icel. kr. the cost of mechanical equipment and materials in dollars are listed. In the accommodation cost which is estimated 15% of paid wages, the operation cost of barracks and mess-halls is included. Transport and catering cost for skilled labourers is also included therein.

DETTIFOSS PROJECT TABLE III

Summary of Cost Estimate

Construction Unit	Estimated Cost Icel. Kr.	Est. Materials Cost Dollars
Dam	61,991,000	1,166,100
Intake	15,980,000	287,200
Tunnel	57,099,000	1,187,700
Penstock	9,957,000	180,700
Power House	36,860,000	573,700
Site Set-Up	14,000,000	405,000
Barracks	5,000,000	
TOTAL DIRECT COST	200,887,000 Note 1	3,800,400
Accommodation Cost	13,276,000 Note 2	
Overhead	31,589,000 Note 3	
Subtotal	245,752,000	
Risk and Profit 10%	24,575,000	
TOTAL CONSTRUCTION COST	270,327,000	

NOTES

1. Of this cost kr. 88,504,800 is direct labour cost.

2. Accommodation cost is estimated 15% of the direct labour cost (i.e. of kr. 88,504,800).

3. Overhead is estimated 20% of kr. 101,780,800 (i.e. direct labour cost plus accommodation cost) and in addition 10% of kr. 112,382,200 (i.e. total direct cost less total direct labour cost).

VÍGABERGSFOSS PROJECT — TABLE IV

Summary of Cost Estimate

Construction Unit	Estimated Cost Icel. Kr.		Est. Materials Cost Dollars
Dam	91,655,000		1,724,300
Intake	16,346,000		318,900
Tunnel	220,959,000		4,337,200
Penstock	11,591,000		212,400
Power House	35,697,000		579,700
Site Set-Up	25,000,000		702,500
Barracks	8,000,000		
TOTAL DIRECT COST	409,248,000	Note 1	7,875,000
Accommodation Cost	28,112,000	Note 2	
Overhead	65,288,000	Note 3	
Subtotal	502,648,000		
Risk and profit 10%	50,265,000		
TOTAL CONSTRUCTION COST	552,913,000		

NOTES

1. Of this cost kr. 187,414,600 is direct labour cost.
2. Accommodation cost is estimated 15% of the direct labour cost (i.e. of kr. 187,414,600).
3. Overhead is estimated 20% of kr. 215,527,000 (i.e. direct labour cost plus accommodation cost) and in addition 10% of kr. 221,833,400 (i.e. total direct cost less total direct labour cost).

In the following table V the quantities of the principal work units as well as the different classes of man-hours are listed for each construction unit of each project.

DETTIFOSS PROJECT and VIGABERGSFOSS PROJECT

Summary of Main Work Units and of Man-hours TABLE V

Construction Unit	MAIN WORK UNITS: Blasting Thous cu-m	Concrete Thous cu-m	Forms Thous sq. m	Reinf Steel tons	Steel Lining tons	Grout Drilling m	UNSKILLED LABOUR (Thousand man-hours): Surf work V	Undg work V_n	Shft work V_j	SKILLED LABOUR (Thousand man-hours): Surf work S	Undg work S_n
DETTIFOSS PROJECT											
Dam	21.6	40.0	29.5	376	0	14000	742	0	0	131	0
Intake	8.1	5.8	8.1	138	0	0	115	0	0	55	0
Tunnel	228.3	NOT SPECIFIED IN DETAIL					39	0	634	86	0
Penstock	6.6	2.7	0	0	440	0	19	19	20	18	29
Power House	41.0	6.5	11.0	370	0	0	82	97	127	93	110
Site Set-Up	NOT SPECIFIED IN DETAIL				0	0	95	0	0	97	0
Barracks	NOT SPECIFIED IN DETAIL				0	0	15	0	0	50	0
TOTAL							1107	116	781	530	139
DETTIFOSS PROJECT							2004			669	
VÍGABERGSFOSS PROJECT											
Dam	17.1	96.0	38.5	380	0	3800	1208	0	0	166	0
Intake	6.2	7.6	12.8	190	0	0	118	0	0	67	0
Tunnel	1100.0	NOT SPECIFIED IN DETAIL					67	0	2546	399	0
Penstock	7.2	3.1	0	0	550	0	22	21	22	17	38
Power House	51.7	6.7	11.2	380	0	0	73	96	122	75	112
Site Set-Up	NOT SPECIFIED IN DETAIL						170	0	0	172	0
Barracks	NOT SPECIFIED IN DETAIL						24	0	0	80	0
TOTAL							1682	117	2690	976	150
VÍGABERGSFOSS PROJECT							4489			1126	

8.3 Duties and taxes

As mentioned above the present economical situation in Iceland is such that it is difficult to determine the true rate of exchange of icelandic currency. It is also difficult to draw a clear line between duties and such taxes which are intended for correction of the rate of exchange. Duties and taxes are also very varying for different kinds of commodities. However, there is one tax that is common for all material and equipment used in connection with these projects, that is the 55% currency transfer tax. All other levies except weight duty are calculated as a percentage of cif price + 55%. We have calculated the average percentage of duties and taxes in accordance with the kind and quantity of the commodities which will be used in connection with the construction part of these projects and found it to be about 24% of cif price + 55%. In a case of a construction contract a 9% purchase tax is not included in this cost estimate.

8.4 Dollar Cost

The cost estimate is built up in such a way that it is comparatively simple to revise it with regard to rates of pay, prices of commodities, changes of duties and taxes as well as change of the rate of exchange.

For ready reference a summary of the cost estimates covering both projects, in accordance with price level and duties of August 1958, has been prepared on dollar basis. In table VI below the local cost is calculated in the rate of exchange - 1$ = 25.40 kr. This rate of exchange, however, is ficticious, but presumeably not to low. This summary should therefore show the maximum estimated cost in dollars.

TABLE VI

Summary of Cost Estimates on Dollar Basis

Cost Item	Dettifoss Project Thous. $	Vígabergsfoss Project Thous. $
Materials + 24%	4,710	9,750
Direct Labour Cost	3,490	7,390
Accommodation Cost	524	1,107
Overhead	1,271	2,675
SUBTOTAL	9,995	20.922
Risk and Profit	1,000	2,092
TOTAL CONSTRUCTION COST	10,995	23,014

As stated above duties and taxes are included here and the rate of exchange for the dollar assumed 1 US $ = 25.40 icel. kr. It is thus presumed that the construction work would be carried out under the same economical and financial obligations as is generally accepted in Iceland to-day, with the sole exception that the 9% purchase tax is disincluded.

If duties and taxes are not collected and the calculation based on the rate of exchange 1 US $ = 29.30 icel. kr., i.e. the nominal rate + 80% which is the rate given for the bulk of Icelandic export products, the above totals would presumeably be reduced by about $ 1,800,000,- and $ 3,800,000,- for the Dettifoss and the Vígabergsfoss Projects respectively.

9. Final Remarks

As mentioned in the introduction the scope of this project is a part of a preliminary appraisal only as outlined in the report of Mr. C. K. Willey.

During our work on this project we have quite naturally become aware of several alternative solutions which would perhaps prove more economical.

Where there has been some doubt about the cost of individual cost items we have preferred to be on the safe side, which in turn should mean that the estimated cost of the entire project should also be on the safe side.

Finally it may also be mentioned that by regulation it should be possible to utilize considerably more power from river Jökulsá than through these run-of-river projects.
However, this aspect needs a further study.

ALMENNA BYGGINGAFÉLAGIÐ H/F
Ögmundur Jónsson (sign.)

VERKLEGAR FRAMKVÆMDIR H/F
Rögnvaldur Thorláksson (sign.)

LIST OF DRAWINGS

ENCLOSURE	1 - General Map of Iceland		
"	2 - Map of the NE part of Iceland		

Drawings from Verklegar framkvæmdir h/f

JÖKULSÁ Á FJÖLLUM: Dettifoss - Preliminary Project

ENCLOSURE	3 -	Dwg. No. 80-08:	General Plan of dam, tunnel and roads
"	4 -	Dwg. No. 80-09:	Longitudinal section through discharge tunnel
"	5 -	Dwg. No. 80-10:	Upstream elevation of spillway and sections through spillway and intake
"	6 -	Dwg. No. 80-11b:	Plan of dam and intake
"	7 -	Dwg. No. 80-12:	Plan of underground power house
"	8 -	Dwg. No. 80-13:	Section through intake, power house and surge chamber
"	9 -	Dwg. No. 80-14:	Tainter gate. Cross sections
"	10 -	Dwg. No. 80-15:	Icegate 3x8 m. Cross sections
"	11 -	Dwg. No. 80-16:	Undersluice. Cross sections
"	12 -	Dwg. No. 80-17:	Cross section of rock-fill dam

Drawings from Almenna byggingafélagið h/f

JÖKULSÁ Á FJÖLLUM: Vígabergsfoss - Preliminary Project

ENCLOSURE	13 -	Dwg. No. 37301:	General plan of dam and tunnel
"	14 -	Dwg. No. 37302:	Dam site
"	15 -	Dwg. No. 37303:	Plan of dam and intake
"	16 -	Dwg. No. 37304:	Downstream elevation of dam, intake and power house
"	17 -	Dwg. No. 37305:	Cross sections through dam
"	18 -	Dwg. No. 37306:	Plan of underground power house and surge chamber
"	19 -	Dwg. No. 37307:	Section through intake, penstock and power house

ALMENNA BYGGINGAFÉLAGIÐ H.F.
and
VERKLEGAR FRAMKVÆMDIR H.F.

Reykjavík, 16.2. 1960.

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

Gentlemen :

We have received the supplemental report on the Jökulsá á Fjöllum project of the Harza Engineering Company International, dated Nov. 20. 1959 for comments.

The report does not include any criticism covering the main arrangement of the Project. It is mentioned, however, that an increase of the water velocity in the pressure penstock and in the tailrace tunnel might be more economical. As regards the pressure penstock we have always been of the same opinion. However, the opinion of a turbine manufacturer should be sought. According to the cost estimates presently at hand there is no doubt about that an increase in water velocity, and consequently reduced cross section of the tailrace tunnel is advantageous and would reduce the cost quite considerably.

Harza has computed the quantities from our drawings. As mentioned in the Harza report there is no major difference in quantities and it can be said, that the basis of the cost estimates is the same. However, the Harza estimate includes a watertight cut-off core in the so-called "Graben Area" at Dettifoss. We did not include such core in this place. At present we can not either say for sure whether it is necessary. The estimated cost is $ 500,000, lump sum. In order to obtain comparable figures between the Harza estimate and our estimate this amount has to be deducted. In the Harza estimate the rate of exchange is assumed 1 $ = 29.40 Icel. kr. and import duties disincluded.

The estimated cost in the Harza cost estimate covering the same items as included in our estimate is as follows :

	U.S. $	U.S. $
DETTIFOSS		
Power Plant Structures and Improvements	1,336,800	
Reservoirs, Dams and Waterways	8,148,200	
Roads	175,000	
SUBTOTAL	9,660,000	
LESS : Core, Graben area	500,000	9,160,000
VÍGABERGSFOSS		
Power Plant Structures and Improvements	1,466,300	
Reservoir, Dams and Waterways	19,450,700	
Roads	150,000	21,067,000
	TOTAL :	30,227,000

In our cost estimate (February 1959, cfr. p. 18) the estimated cost in dollars was as follows :

Dettifoss	$ 10,955,000
Vígabergsfoss	$ 23,014,000

Here the local construction cost is computed into dollars at the rate of exchange 1 $ = 25.40 and import duties added to the price of materials. It is stated (p. 18) to what extent the estimate would be reduced in dollars if import duties were disincluded and the same rate of exchange assumed as in the Harza estimate.

We have revised our estimate to this effect and got the same result as before, viz.

Dettifoss	$ 9,153,000
Vígabergsfoss	$ 19,208,000
TOTAL :	$ 28,361,000

For the Dettifoss project the estimated cost figures are approximately the same, the Harza estimate being $ 7000 higher.
For Vígabergsfoss the difference is substantial viz. $ 1,859,000.

As the Harza estimate is built up in quite a different way from our estimate a direct comparison between individual items is not quite feasible. It is, however, evident that the main discrepancy is the cost of the tailrace tunnel. We have therefore studied this items a little closer.

In the Harza estimate covering Vígabergsfoss Tailrace Tunnel (cfr. Appendix B, Sheet 3) the items "Excavation Rock, Tunnel" and "Pumping and Rock Bolts" total $ 10,480,000. The quantity is 1,180,000 m^3 and the overall unit price therefore $ 8.90 pr. m^3. The comparable unit price in our estimate is $ 8.55 pr. m^3.

The estimated cost of rock excavation is therefore about $ 400,000 higher in the Harza estimate than in ours for the same number of units as in the Harza estimate.

The cost of securing the tunnel is in the Harza estimate based on the assumption that concrete lining would be necessary on 25% of the length of the tunnel, and the cost estimated $ 3,620,000.

Our estimated cost for securing the tunnel was $ 2,240,000 as an appropiate lump sum estimate about 25% of our estimated excavation cost. The difference of estimated cost for this item is thus $ 1,380,000.

The Harza estimate of the tailrace tunnel is therefore about $ 1,780,000 higher than ours which is almost the same as the total difference between these two estimates covering construction cost of the Vígabergs-foss development. Other items of difference almost cancel out.

As already mentioned the final figures of the cost estimates agree very closely for the same work units. Considering that the estimates are independent from each other and built up in entirely dissimilar way, it is almost surprising how well they agree, and the mutual support which they give to each other is therefore quite convincing.

We agree with Harza that more detailed investigation and study would tend to lower the estimate of construction costs. Only one general arrangement has been studied and it is quite possible that another arrangement might be more advantageous. Even if not so, the tendency towards reduction of cost is quite evident.

As mentioned above the cross section of the pressure penstocks as well as of the tailrace tunnel could be reduced with a corresponding reduction of cost. The project assumed gravity dams. However, other design of dam construction have very often proven to be considerably cheaper in this country. The corsory studies which have been done in connection with this particular hydroelectric development indicate that a reduction of cost might be obtained here. The number of generating units might be reduced which also would result in a reduction of cost.

The items which we have mentioned here are all major items and have therefore quite considerable effect on the total construction cost of the project.

In this connection we wish to extend our thanks to Mr. Willey and Mr. Engebretsen from the Harza Engineering Company, to Dr. Thorarinsson of the Museum of Natural History, to Mr. Gíslason, Mr. Briem and Mr. Sigurdsson and others on the staff of the State Electricity Authority for much valued information and help in connection with our work on the Jökulsá á Fjöllum Project.

Very truly yours,

Ögmundur Jónsson (sign.)

Rögnvaldur Thorláksson (sign.)