BURFELL PROJECT

60 MW PLANT

AN APPRAISAL REPORT

FOR

THE STATE ELECTRICITY AUTHORITY

GOVERNMENT OF ICELAND

HARZA ENGINEERING COMPANY INTERNATIONAL

DECEMBER 1962

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DECEMBER 1962

HARZA ENGINEERING COMPANY INTERNATIONAL
CONSULTING ENGINEERS • RIVER PROJECTS

December 11, 1962

Air Mail

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

Subject: Burfell 60 MW Plant
Appraisal Report Summary

Gentlemen:

We are pleased to present our Appraisal Report on a 60 megawatt power development at Burfell. This project is approximately in the same location as the "Upper Alternative" presented in our Appraisal Report of March 30, 1962, and will develop essentially the same gross head of about 118 meters by a diversion of the Thjorsa north of the mountain, Burfell, into the Fossa. The general project plan is also similar. The 60 megawatt installation will, however, utilize a flow of only 58 cubic meters per second at best efficiency as compared to 145 cubic meters per second for the 156 megawatt project considered in the March 1962 Report. The detailed studies presented in the main body of this report are on the basis of an installation of two units of 30 megawatts each. Information obtained from the field investigations carried out this past summer is reflected in the project layout and the cost estimates.

Our estimate of the Total Construction Cost of the Project including transmission to Reykjavik and tie-in with the existing system is $17,980,000. This amount includes allowances for omissions and contingencies, escalation, and such indirect cost as preliminary investigations, engineering supervision of construction and owner overhead. It also includes import duties and taxes on imported materials and equipment where applicable. Our estimate of Total Project Investment is $19,800,000. This amount was determined by adding the estimated cost of interest during construction to the Total Construction Cost. The cost of establishing working capital and interest reserves was not included and may not be required. We have estimated that the requirements for foreign currency will be about $10,800,000. Import duties and taxes will amount to about 148,000,000 Icelandic Kronur or about 17 percent of the Total Investment. The investment required for an initial installation of one 30 MW unit only is estimated at $18,000,000.

The flow of 58 cubic meters per second is less than the estimated minimum flow of the river and will therefore be available 100 percent of the time. The delivered annual primary energy is estimated at 470 million kilowatt hours. This estimate includes allowances for all losses and 98 percent utilization of the flow of 58 cubic meters per second. Some high grade secondary energy will be available by turbine operation between best gate and full gate but was not evaluated. The peaking capability at Reykjavik will be about 62,000 kilowatts.

Our estimates of the annual costs include operation and maintenance, reserves, water rights, and debt service. The debt service will depend on ultimate financing terms which are not known at the present time. Our estimate of unit energy costs are based on: (1) the sale of the annual primary energy of 470 million kilowatt hours, (2) annual cost other than debt service of $430,000, and (3) a range of level debt service expressed as a percentage of the Total Project Investment. We found on this basis that the unit cost of primary energy varies on a nearly straight line relationship from 3.0 mills U.S. for five percent to 4.7 mills for nine percent of debt service expressed as noted above. An amortization period of 25 years and six percent interest rate would result in a unit cost of about 4.2 mills U.S.

This 60 megawatt project appears to represent a suitable increment of power to meet the normal future load growth in Southwest Iceland. We believe that it will compare favorably with alternative sources of power available, especially in view of the fact that future expansions and increased production will reduce substantially the aggregate cost of power and energy from this large resource.

We appreciate very much the opportunity of providing the engineering service, represented by this Report, to you.

Very truly yours,

HARZA ENGINEERING COMPANY INTERNATIONAL

C. K. Willey

C. K. Willey

BURFELL PROJECT - 60 MW PLANT
TABULATION OF SIGNIFICANT DATA

Drainage Area	6380 sq. km
Average Discharge	338 cms
Probable Maximum Flood	7750 cms
Normal Headwater Elevation	242.5 ±
Normal Tailwater Elevation	125.0 ±
Length of Headrace	3000 m
Width of Headrace Canals	20 m
Penstock Diameter	3.8 m
Penstock Length	135 m
Powerstation, type	Underground
Tailtunnel, type	Submerged, Concrete Lined
Length of Tailtunnel	1750 m
Tailtunnel Diameter	4.5 m
Headlosses at normal flow	4.0 m
Headlosses at peaking	5.0 m
Turbine	
Number	2
Type	Francis
Capacity at 114 meters rated head	49,000 Hp
Discharge at best gate, rated head	29.0 cms
Speed	333 rpm
Generators	
Number	2
Type	Vertical-shaft
Rating	33,333 kva
Power Factor	0.9
Voltage	13.8 kv
Cycles per second	50
Main Transformers	
Type	Outdoor - Three phase OA/FA/FOA
Rating	22/29.4/36.7 mva
Voltage	13.8/138 kv
Main Transmission Line	
Length	103 km
Voltage	138 kv
Number of circuits	one
Size of conduits	477 MCM
Construction	Woodpole

TABLE OF CONTENTS

APPRAISAL REPORT

ON

THE BURFELL PROJECT

60 MW PLANT

GENERAL FEATURES

This Appraisal Report presents a layout and a cost estimate for an initial 60 megawatt power plant on the Thjorsa at Burfell. The project location and the gross head developed will be essentially the same as for the Upper Alternative presented in our Appraisal Report, dated March 30, 1962. The project will develop about 118 meters of gross head by a diversion north of the mountain, Burfell, into the Fossa River about two kilometers upstream of its confluence with the Thjorsa. The general location is shown on the Key Plan of Exhibit 1.

The 60 MW installation will develop only a small portion of the total potential of the site. The project plan includes, therefore, minimum provisions that are required in order to permit future extensions. The present plan is a run-of-river development which permits the future construction of a storage dam and reservoir if considered desirable. The water supply will be no problem with this initial project because the minimum flow of the river is estimated to be greater than the maximum turbine flow capacity. The average flow is about six times the station capacity.

The project estimate presented herein is for a two-unit installation, each unit rated at 30,000 kilowatts. Also included is an estimate of the cost with only one unit provided initially.

DESCRIPTION OF PROPOSED FACILITIES

The general layout of the Burfell 60 megawatt plant is shown on Exhibit 1. It will consist of: (1) A diversion canal leading from the river at a point about 4.5 kilometers upstream of the low waterfall, Trollkonuhlaup, to (2) a headrace pond formed by a dike across the stream, Bjarnalaekur; (3) an intake canal connecting the pond with (4) the power intake and sluice structure located at the divide between the Thjorsa and Fossa Basins about 300 meters north of the saddle between Skalarfell and Samstadamuli, two smaller mountains north of Burfell; (5) one vertical pressure shaft (penstock) leading from the intake to (6) an underground powerstation; (7) a tailtunnel and a short canal terminating in the Fossa River; (8) a switchyard; (9) access facilities and an operators village;and (10) the main station equipment.

The location of the powerstation is now well defined on the basis of the relatively extensive subsurface explorations that have been carried out during the past summer. Minor adjustments that may occur during detailed planning, are not expected to have a significant bearing on overall costs. The location of the diversion canal was selected on the basis of economic studies in connection with the planning of a larger development at Burfell.

Diversion Canal

The general plan and section of the diversion canal is shown on Exhibit 2. The canal will extend from the right bank of the river westward for about 1.3 kilometers into a depression drained by the Bjarnalaekur.

The flow will enter the canal through a wide and shallow trench excavated in the river bed and extending out to the deepest channel. This excavation can be accomplished under water without the need of a cofferdam.

A weir across the river to divert the flow into the canal is considered not necessary because the station flow will normally be only a fraction of the river discharge. A concrete shear wall will be constructed across the canal in line with the right bank of the river in order to reduce the amount of ice entering the canal. The water will flow underneath the wall at low velocities.

The excavation in the river will slope down to elevation 237 at the canal entrance near the right bank. From this point on the 20 meter wide canal will be constructed with a gentle slope towards the depression. The water level in the canal will be slightly below the natural river level, which is approximately at elevation 243.0 for normal discharges of 200 to 400 cubic meters per second. At normal operating conditions the velocity will be about 0.5 meters per second. Most of the excavation, including that in the river, will be in Thjorsa lava. The intake for future developments will begin downstream of the canal entrance, to permit continuous operation of the initial plant.

<u>Bjarnalaekur Dike</u>

A rockfill dike with a vertical impervious core will be constructed across the Bjarnalaekur. The right abutment will be on the northeast slopes of Skalarfell. The left abutment will tie into a rock outcrop rising to elevation 245 on the left bank of Bjarnalaekur. The dike will have a crest at elevation 245.5 and will be designed for future raising to elevation 251.0.

The rockfill dike will extend northeasterly for about one kilometer from the rock outcrop and terminate at somewhat higher ground about 400 meters southwest of the diversion canal entrance. This dike extension will be under very low water pressure and is planned without an impervious core inasmuch as some leakage will be permissible. However, the leakage may be reduced by the placing of impervious material on the upstream slope of the rockfill, if necessary. The rockfill will be placed on rock and will serve as a cofferdam and upstream toe of the higher dike required for the future development.

Intake Canal

The intake canal will connect the Bjarnalaekur Pond with the power intake. It will be about 500 meters long and of the same cross section as the diversion canal. The bottom will be at about elevation 235 with a slight grade toward the intake. The canal will be widened and deepened to assure low approach velocities under all operating conditions whenever additional power capacity is added.

Power Intake and Sluice Structure

The general plan and sections of the power intake and the sluice structure are shown on Exhibit 3. The intake will be one bay only located at the top of the pressure shaft. The sluice structure is located in a channel that leads from the south end of the forebay to the outlet on the west slopes of Skalarfell. Future extensions of the intake will be to the north and away from the sluice structure.

The intake will form the entrance to the vertical pressure shaft, and will be provided with a removable trashrack and an emergency gate. Concrete construction will be utilized except for the deck which will be made of steel to facilitate future raising. The sill will be at elevation 231 or about two meters above the bottom of the forebay. The trashrack will be submerged about two meters below minimum operating level and will be made removable. Stoplogs may be inserted in the trash-rack slots when required. Heating of the trashrack will be provided to minimize the possibility of clogging by ice. A movable hoist will be positioned on the intake deck at elevation 245.5 for handling of the trash rack and stoplogs. The emergency gate will be of the radial type, 5 meters wide by 6 meters high and will be operated by a hoist placed on the intake deck. The transition from the trashrack openings to the pressure shafts will be designed to minimize hydraulic losses.

The sluice structure will be designed to permit passing debris and ice over a weir at elevation 240.5 and sediment through an undersluice with the sill at elevation 229, two/meters lower than the intake sill. Both openings will be six meters wide. A movable hoist will operate both gates. The hydraulic capacity of the two openings will total about 150 cubic meters per second.

The water from the sluiceway will be discharged through an excavated channel and released down the west slopes of Skalarfell into the Fossa. The channel will be 8 meters wide at the bottom and constructed with a grade towards the outlet. The channel excavation will be almost entirely in basalt and most of the rock excavated from this channel as well as the headrace canals will be used in the construction of dikes.

The saddle between Skalarfell and Samstadamuli will be closed by a dike with the crest at elevation 245.5. The dike will be designed for future raising to an ultimate height of elevation 251 approximately.

Pressure Shaft

The vertical pressure shaft (penstock) will connect the intake with the two turbines in the powerstation located underground. A profile of the shaft is shown on Exhibit 3. The shaft will be steel lined throughout and of constant diameter 3.8 meters from the intake and down to the bifurcation at the powerstation level. A nearly 90 degree bend at the bottom of the shaft connects with a short, near horizontal section, which bifurcates into two smaller pipes, one leading to each turbine. Each of the two pipes will be provided with a short removable section (spool) located inside the powerstation and accessible from the machine hall crane. Emergency repairs of one of the two units will involve draining of the entire penstock and will result in outage of both units. The unit not being repaired can, however, be restored to operation in a short time by removing the spool and installing a bulkhead on the upstream flange of the pipe to the unit which is to be repaired. When the repair and maintenance is completed the penstock would again be drained and the repairdd unit connected. The spools may be replaced at any time by Butterfly valves if desired. The total length of the penstock including the bifurcation and horizontal portion will be about 135 meters.

Powerstation

The location of the powerstation was chosen on the basis of the results of extensive core drilling in the general area. All of the excavation will be in basalt except the upper portion including the roof arch which will be in basalt breccia. Beds of basalt, breccia and tuff form the 100 meter thick rock mass above the powerstation.

The general arrangement of the powerstation is shown on Exhibit 3. As presently planned, the machine hall will house two units of a vertical setting. It will be 14 meters wide and 37 meters long not including the additional excavation required at the north end to permit future extension. The main access will be by a 900 meter tunnel which will be sloping towards the powerstation at a grade of about four percent. The 5.5 meter wide access tunnel floor will be concrete paved. The walls and roof will be lined only where necessary, estimated at 50 percent of the length. The tunnel will enter the machine hall at the south end where an erection bay will be provided. Access to the powerstation will also be provided by a vertical shaft that will be connected to the erection bay by a short tunnel and will daylight in the control building which is located on the surface near the switchyard and the intake. The shaft will, in addition to a stairway and an elevator, also house the low tension cables and a ventilation duct. Fresh air will be drawn in through the main access tunnel by fans located in the erection bay below the main floor and be distributed by a system of ducts to the various floors of the powerstation. The exhaust air will be blown out through the access and cable shaft.

The roof in the machine hall will be concrete lined throughout. The lining will be constructed in sections of six meters with a space of 0.6 meters provided between each to permit relief of water pressure. Metal trays to collect seepage water will be provided across the entire arch under the openings. The water will be collected by open roof drains supported along the roof abutments. No drip ceiling is considered necessary with this arrangement.

An overhead bridge crane will be supported by concrete columns and beams along the entire length of the machine hall. The turbine will be set at elevation 119 or four meters below the estimated minimum tailwater in order to permit high speed units. The draft tubes will converge into a surge chamber excavated downstream of the machine hall. A draft tube gate structure will be provided within the surge chamber. The gates will be handled by a gantry crane positioned on the draft tube deck at elevation 136.5. Access to the deck will be by a short high level tunnel connection with the access and cable shaft. Venting of the surge chamber will also be through this tunnel. The draft tube gate will be brought in through the tailtunnel.

Future extension of the powerstation will require a temporary construction access for excavation and concreting operations. Such access could be provided by a 300 meter tunnel branching out from the main access tunnel and curving around and upstream of the pressure shafts to enter the future extension at the north end. Installation of the equipment would, however, be from the initial erection bay at the south end.

Tailrace

The tailrace will be located as shown on Exhibit 3. It will be in tunnel from the surge chamber to the portal, a distance of about 1750 meters. The tunnel will be flowing full under low pressures and is planned to be concrete lined throughout except for the upstream 100 meters which will be unlined and enlarged to serve as a surge gallery under load rejection operations. The tunnel will be of horseshoe shape with 17.6 square meters nominal cross-sectional area. A concrete portal structure with stoplog slots will be provided at the downstream end of the tunnel. The tunnel will discharge into a 200 meter long open canal which will be excavated between the portal and the Fossa.

Switchyard

The switchyard will be located directly above the powerstation and adjacent to the intake as shown on Exhibit 3. The cables from the powerstation will enter at the north end of the switchyard area. Offices and control room will be provided in a building at the top of the access and cable shaft. The main power transformers will be located in the yard.

Access and Operators Village

A narrow trail which connects with the main road system in Southwest Iceland exists to the west of the Fossa. This road and portions of the connecting road net will be improved to serve as main access to the project. A bridge across the Fossa will be constructed at a point about 300 meters upstream of the tailrace outlet. Project roads will be developed from the bridge to the access tunnel entrance, the intake and switchyard area, and to the Bjarnalaekur dike.

The project will be operated essentially by remote control. An operators village is therefore not required initially. Two attendants will be present at all times. They will be housed in the office building near the switchyard.

Main Station Equipment

The present plans provide for an installation of two units. The generators will be of the vertical-shaft type, rated 33,333 kilovoltampere, 0.9 power factor, 13.8 kilovolt, three phase, 50 cycles.

The two turbines will each be of the Francis type sized for a maximum output of 49,000 metric horsepower at 115 meters net head. The speed has been selected at 333 r.p.m. The low tension leads from the generators will be non draining cables. Each unit will be protected by a 13.8 kilovolt draw-out type circuit breaker, located in the powerstation.

TRANSMISSION PLANT

A single circuit 138 kilovolt line of woodpole construction will transmit the power from Burfell to the Ellidaar Substation at Reykjavik. The line will be provided with a tie-in with the existing Sog System at the Irafoss Substation. The total length of the transmission line is estimated at 103 kilometers, of which 45 kilometers is the length from Irafoss to Reykjavik.

A one-line diagram of the Burfell substation is shown on Exhibit 4. The two main transformers will be the OA/FA/FOA three-phase type, rated 13.8/138 kilovolt, 22/29.4/36.7 megavolt ampere. Provisions will be made for a 69 kilovolt line for a tie-in with the local system. Air blast circuit breakers will be provided on the outgoing high tension lines.

Two main transformers will be provided also at the Ellidaar Sub-station in Reykjavik in addition to the necessary busses, structures, switches, and breakers. The transformers will have the same rating as those at Burfell.

The transmission voltage for an enlarged development at Burfell will probably be 230 kilovolt. It is, therefore, possible that the line should be designed for this voltage although initial operation would be at 138 kilovolt. The initial 138 kilovolt equipment which in that case would be replaced by 230 kilovolt equipment, could probably be used elsewhere in Iceland. The tie-in with the 138 kilovolt system at Irafoss could either be abolished or made permanent through a 230/138 kilovolt auto-transformer.

POWER AND ENERGY

The 60 megawatt development at Burfell as presented herein will utilize a flow of 58 cubic meters per second, with the turbines operating at best efficiency. This flow will be available for all practical purposes 100 percent of the time as determined on the basis of past discharge records. The average flow of the river is estimated at 338 cubic meters per second. About 66 cubic meters per second could be utilized by operating the turbines at full gate.

PRIMARY ENERGY

The primary energy of the 60 megawatt plant has been considered as that produced from a flow of 58 cubic meters per second. The overall efficiency, not including hydraulic losses in the water conduits but including transmission losses and station service, was taken at 83 percent.

The water utilization was assumed 98 percent. The annual primary energy delivered at the low tension side in Reykjavik is estimated at 470 million kilowatt-hours on this basis. Some secondary energy will be available by turbine operation between best gate and full gate, but this has not been evaluated.

PEAKING CAPABILITY

It is estimated that the plant can deliver to the load center peaking power up to 62,000 kilowatts. This might be slightly reduced during periods of floods in the Fossa and to a lesser degree, in the Thjorsa.

PROJECT COST

A cost estimate was prepared for the 60 megawatt Burfell development as described above. The estimate is presented in Exhibit 5 which includes a summary tabulation as well as details. The estimate represents our best judgement of unit prices and lump sums for the various items of work. All costs are expressed in U. S. Dollars. The rate of exchange used for converting Icelandic Kronur to U. S. Dollars was 43 Kronur to one Dollar.

The estimate was prepared as the result of detailed quantity surveys based on the drawings referred to above and supplemented by sketch drawings of structures as considered necessary. The unit prices used were estimated on the basis of labor rates and costs of material and equipment as of October 1962.

Import duties and taxes have been included where applicable on imported materials and equipment, including construction equipment. The estimate in this respect is comparable with the cost estimate for the

Hestvatn and the Upper Bruaru projects. An allowance was made in the unit prices for a reasonable profit to the general contractor or contractors.

The estimated costs for permanent equipment was based on recent quotations from well-known Western European manufacturers. All costs are for the equipment fully installed. Again import duties and taxes have been included.

The cost of land was not included in the costs. The cost of the water rights has been included as an annual charge as discussed below.

A contingency item of 15 percent was added to the subtotal of direct cost as an allowance for omissions and possible increases in quantities and prices. This allowance is considered reasonable in view of the information available on equipment cost and the generally conservative approach adopted in establishing the cost of the civil structures.

An allowance for price escalation of five percent was added to the estimated subtotal including contingencies. This allowance is considered appropriate and reasonable in view of recent price trends in Iceland and Western Europe.

The addition of the escalation allowance established the total direct cost but without import duties and taxes was then applied to allow for such indirect costs as design engineering, supervision of construction and owner's overhead.

A further allowance of $510,000 was made to cover the estimated cost for preliminary planning basic to design and for field investigations. This allowance includes the total cost of the extensive site explorations already carried out which will also benefit future developments at Burfell. This relationship should be kept in mind when comparing the 60 megawatt project with alternative sources of power. The above additions resulted in an estimated total construction cost of $17,980,000.

Financing terms are, at present, not established. The cost of interest during construction can therefore not be accurately determined. However, the cost normally amounts to about three or four percent of the construction cost for each year of construction. An allowance of ten percent of total construction cost was, therefore, made to cover interest during the estimated three year construction period. This addition resulted in an estimated total investment of $19,800,000.

The cost of establishing working capital and interest reserves was not included, and may not be necessary.

Our estimates show that the foreign currency requirement will be the equivalent of about $10,800,000. The expenditure of local currency is estimated at $9,000,000 or 387,000,000 Icelandic Kronur, of which import duties and taxes amount to about 148,000,000 Kronur and local labor and materials to about 239,000,000 Kronur.

The construction cost for an initial installation of one unit only is estimated at $16,330,000. The total investment, including interest during construction, would be $18,000,000 or $1,800,000 less than for the two-unit installation estimated above. The savings are primarily in the cost of the main equipment: turbine, generator, transformers, and circuit breakers.

We have estimated the additional cost of constructing the transmission for 230 kilovolt initially. The additional investment required for the entire line from Burfell to Reykjavik is estimated at $800,000 including interest during construction. The portion of the line from Burfell to Irafoss is estimated at $450,000 additional.

ANNUAL COSTS

The annual charges against a power system include interest on invested capital, depreciation of the installation or amortization of investment, operation, and maintenance expenses, and taxes.

We have estimated the annual operation and maintenance expenses of the Burfell 60 MW Project including the transmission plant to be $190,000. This is based on the assumption that normal operation of the plant will be semi-automatic. This means that voltage and load regulation will be by remote control, whereas the starting of the units will be at the plant. We assumed that two attendants will be stationed at the plant at all times. Maintenance other than daily routine work will be by a separate crew.

Insurance and taxes were not included in our estimates of annual charges.

Interest and amortization charges (debt service) will represent the major portion of annual costs. This cost will, however, not be known until such time as the financing terms are established.

Compensation for the use of the water rights was included as an annual cost. This annual cost is considered to be the fair return on the value of such rights, which are not known definitely. We have also included reserve funds as an annual charge taken at about one percent of the estimated total construction cost. These funds are required to cover expenses of an extraordinary nature not otherwise covered by insurance or normal maintenance.

The estimated annual costs other than debt service will then be as follows:

Operation and Maintenance		$190,000
Water Rights and Reserves		240,000
	Total	$430,000

PRIMARY ENERGY COSTS

No consideration was given to the income from the sale of secondary energy in the evaluation of unit energy cost. The annual primary energy was taken at 470 million kilowatt hours delivered at Reykjavik as estimated above.

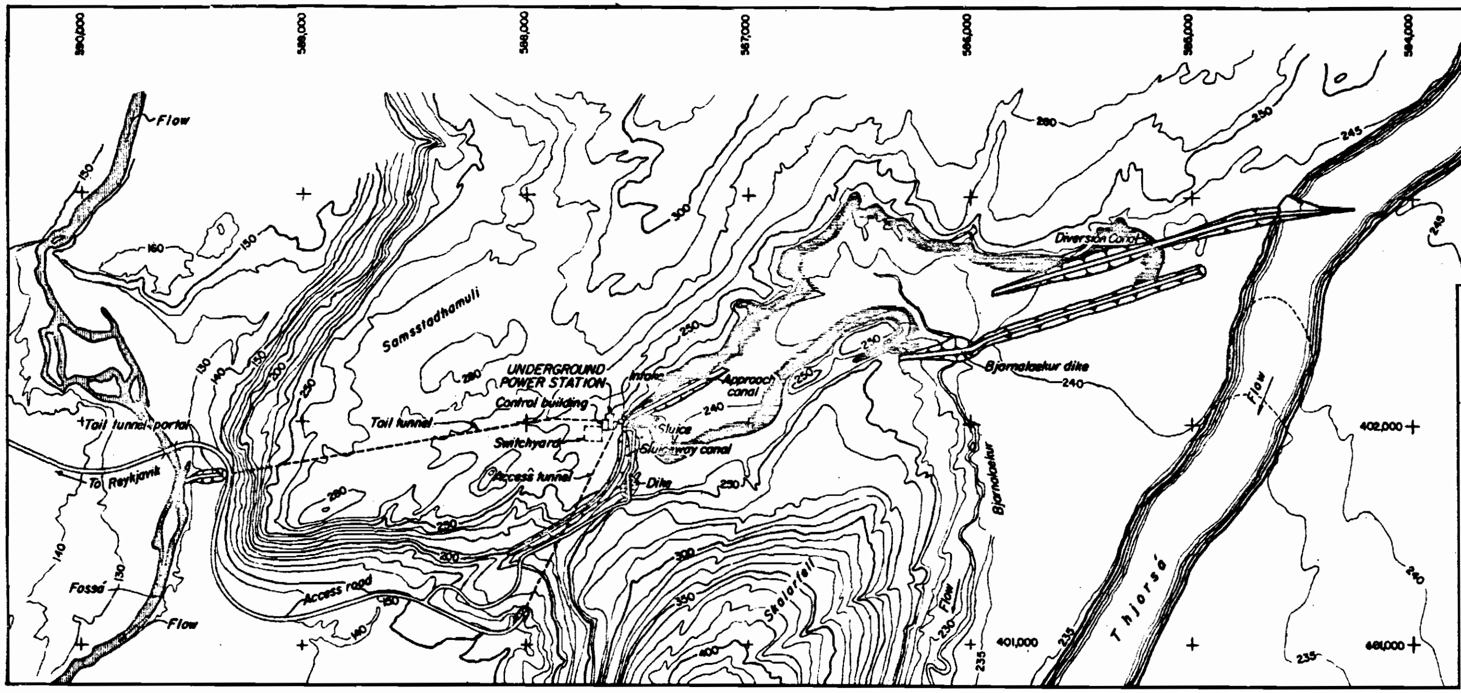
Inasmuch as the financing terms have not yet been established we chose to present the estimate of unit cost of energy as a graph for a range of annual debt service expressed as a percentage of the total project investment of $19,800,000 over a range of five to nine percent. This graph is shown on Exhibit 6. It includes, of course, the other estimated annual costs amounting to $430,000 as a fixed amount not varying with the debt service. The estimated unit cost is as delivered at the low tension side in Reykjavik, but does not include any allowance for profit. Import duties and taxes are included in the estimate of capital costs on imported materials and equipment as appropriate. It should be noted that the estimate also includes the entire cost of the transmission line to Reykjavik.

The graph shows that the cost of primary would be in the order of 3.0 to 4.5 U.S. mills per kilowatthour for the most common financing conditions. An interest rate of five percent and a 40-year amortization period will give a unit energy cost of 3.3 mills. A 25-year amortization period and six percent interest rate will give a cost of 4.2 mills per kilowatthour of primary energy.

290-G
12/10/62
ARE/dbs

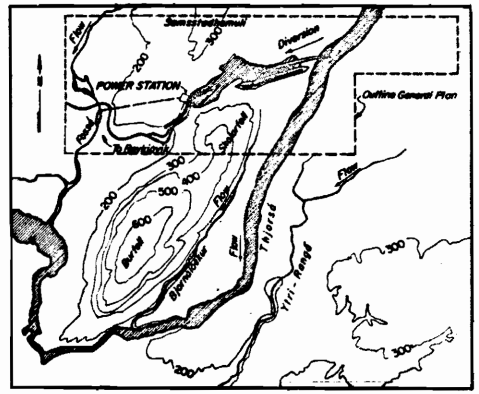
LIST OF EXHIBITS

EXHIBIT I



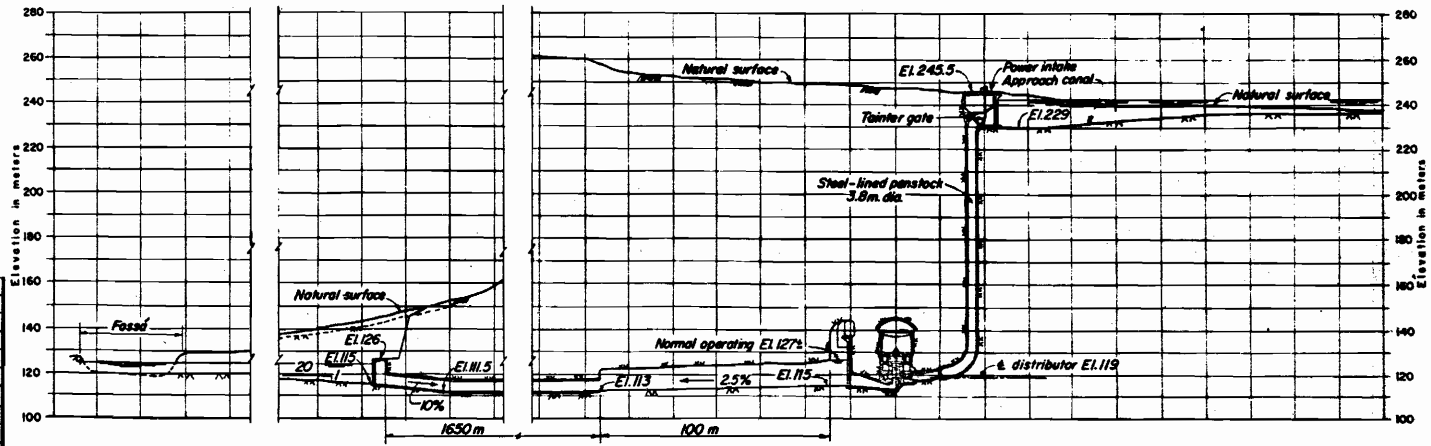
GENERAL PLAN

Scale 0 200 Meters



KEY PLAN

Scale 0 1000 Meters



PROFILE

Scale 0 20 Meters

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PRINTS		

	BY	DATE	CHKD	DATE
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DRN.	V.E.T.			
DEPT.	GROUP LEADER	SECT. HEAD	DEPT. HEAD	
CIVIL				
MECH.				
ELECT.				
PLAN.	ACE			
STAFF			CHIEF ENG.	

PREPARED FOR HARZA ENGINEERING COMPANY INTERNATIONAL

THE STATE ELECTRICITY AUTHORITY
ICELAND

BURFELL PROJECT 60 MW PLANT

GENERAL PLAN AND PROFILE

HARZA ENGINEERING COMPANY
APPROVED

CHICAGO, ILLINOIS | DATE DEC. 1962 | DWG. NO. 290 P 1

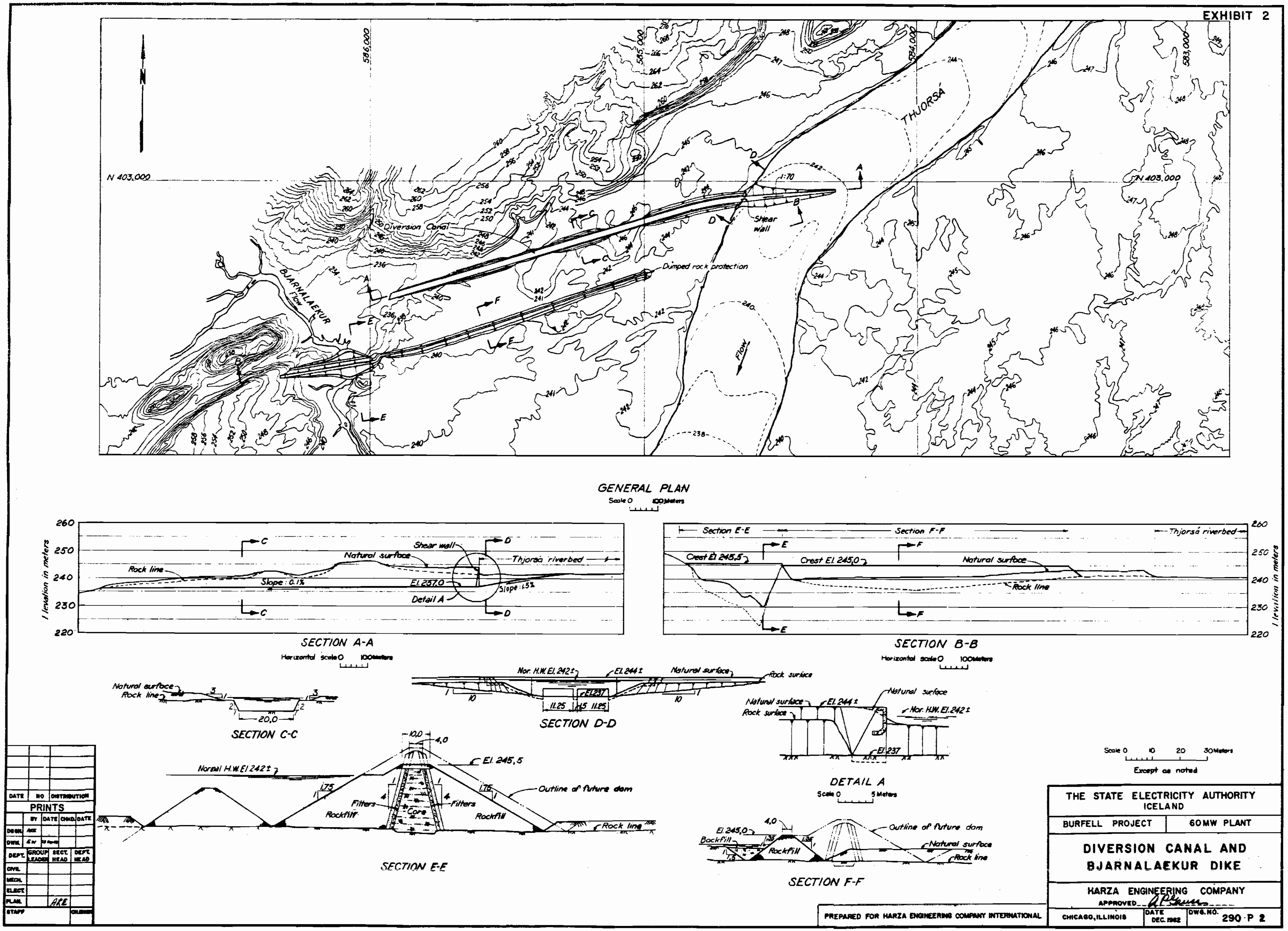

EXHIBIT 2
586,000
585,000
584,000
583,000
N 403,000
THJORSÁ
BJARNALAEKUR
Flow
Diversion Canal
Shear wall
Dumped rock protection
GENERAL PLAN
Scale 0 100 Meters
Section A-A
Rock line
Natural surface
Shear wall
Thjorsá riverbed
Slope: 0.1%
El. 237.0
Slope: 1.5%
Detail A
Elevation in meters
SECTION A-A
Horizontal scale 0 100 Meters
Section E-E
Section F-F
Thjorsá riverbed
Crest El. 245,5
Crest El. 245,0
Natural surface
Rock line
SECTION B-B
Horizontal scale 0 100 Meters
Natural surface
Rock line
20,0
SECTION C-C
Nor. H.W. El. 242 ±
El. 244 ±
Natural surface
Rock surface
El. 237
11.25
1.5
11.25
SECTION D-D
Natural surface
El. 244 ±
Rock surface
Nor. H.W. El. 242 ±
El. 237
DETAIL A
Scale 0 5 Meters
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Normal H.W. El. 242 ±
El. 245,5
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Filters
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El. 245,0
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Backfill
Rockfill
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Rock line
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DATE
DSGN.
DWN.
DEPT.
GROUP LEADER
SECT. HEAD
DEPT. HEAD
CIVIL
MECH.
ELECT.
PLAN.
ARE
STAFF
THE STATE ELECTRICITY AUTHORITY
ICELAND
BURFELL PROJECT
60 MW PLANT
DIVERSION CANAL AND
BJARNALAEKUR DIKE
HARZA ENGINEERING COMPANY
APPROVED
CHICAGO, ILLINOIS
DATE DEC. 1982
DWG. NO. 290 · P 2
PREPARED FOR HARZA ENGINEERING COMPANY INTERNATIONAL

EXHIBIT 3

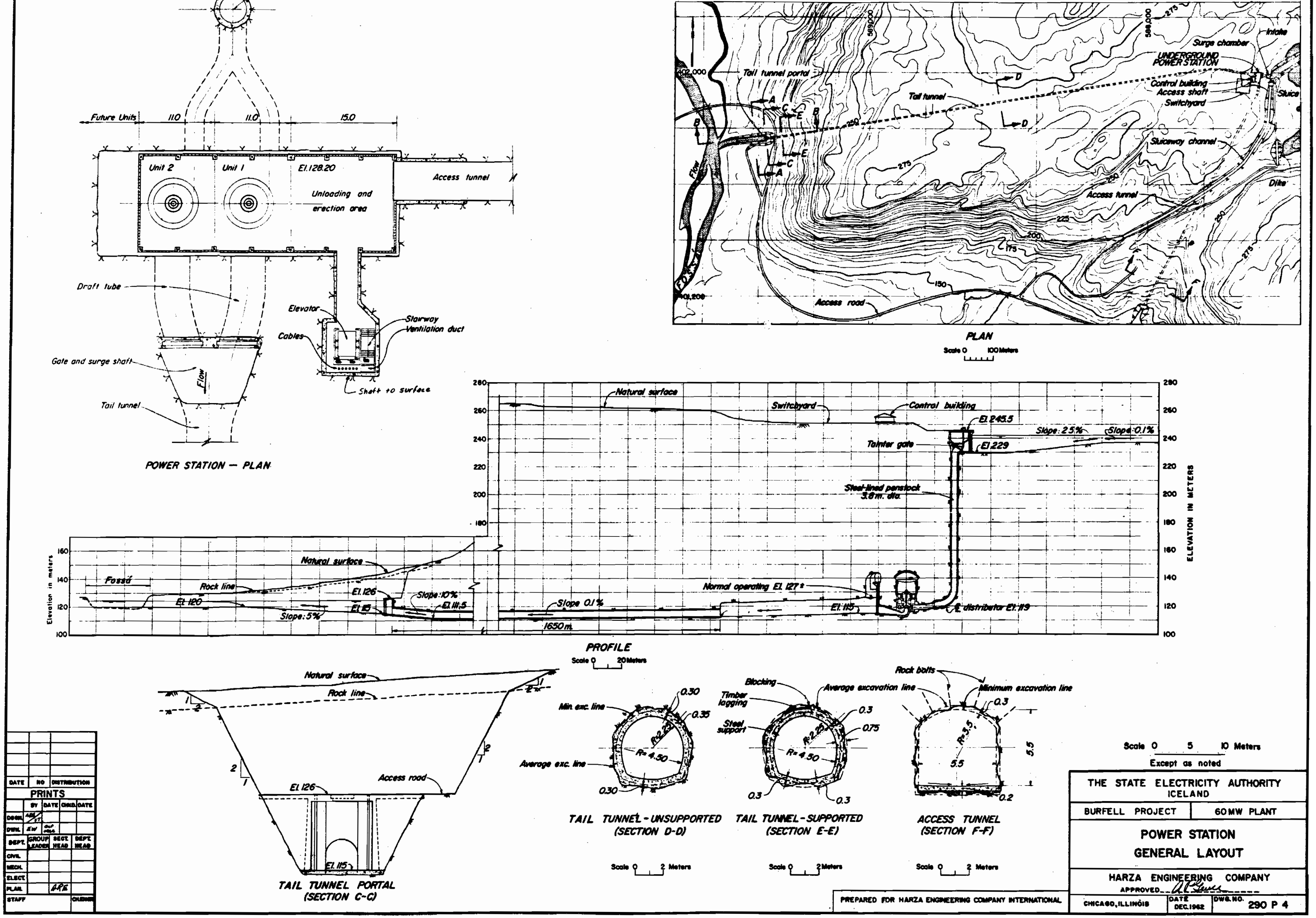
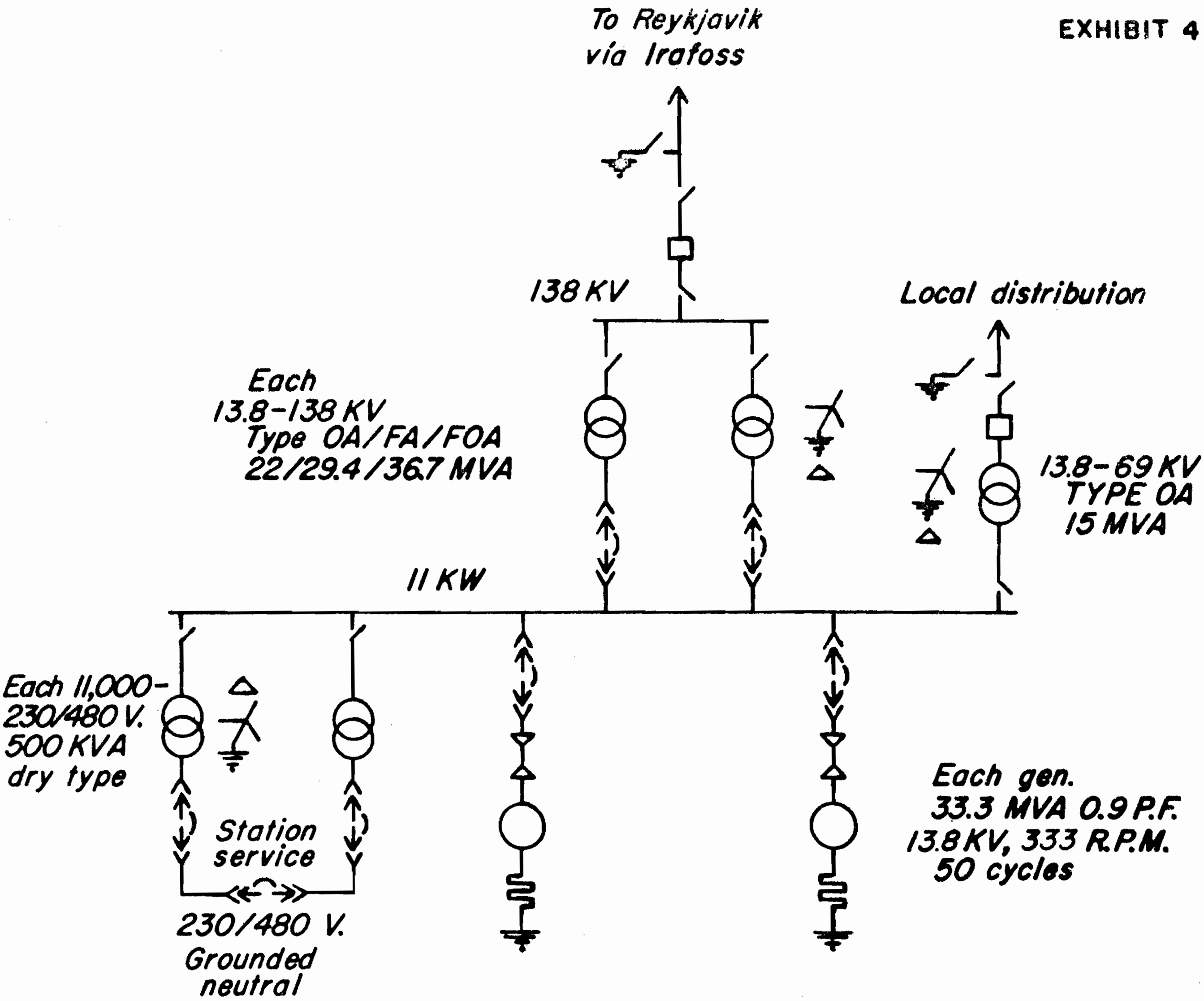
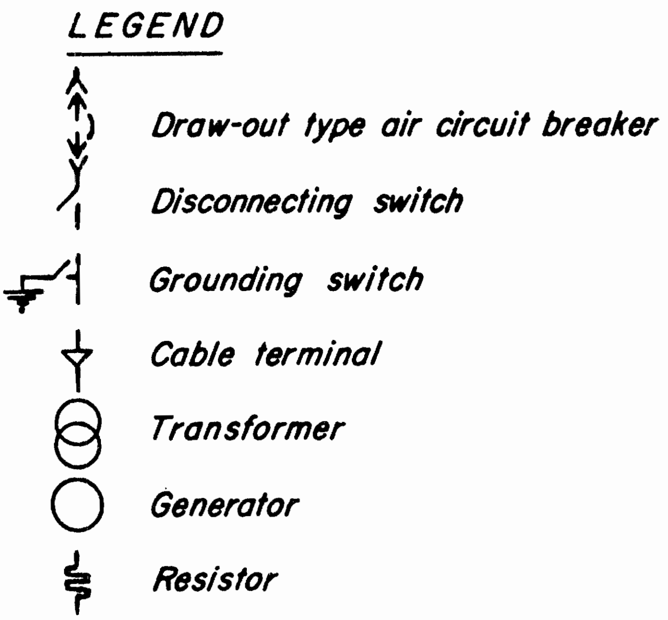

Penstock, I.D. 3.8m
Future Units
11.0
11.0
15.0
Unit 2
Unit 1
El. 128.20
Unloading and erection area
Access tunnel
Draft tube
Elevator
Cables
Stairway
Ventilation duct
Shaft to surface
Gate and surge shaft
Flow
Tail tunnel
POWER STATION — PLAN
Tail tunnel portal
Tail tunnel
UNDERGROUND POWER STATION
Surge chamber
Intake
Control building
Access shaft
Switchyard
Sluice
Sluiceway channel
Access tunnel
Dike
Access road
Flow
Fossá
PLAN
Scale 0 100 Meters
Natural surface
Switchyard
Control building
El. 245.5
Slope: 2.5%
Slope: 0.1%
Tainter gate
El. 229
Steel-lined penstock 3.8m. dia.
Fossá
Rock line
El. 126
El. 120
El. 115
Slope: 10%
El. 111.5
Slope: 5%
Slope 0.1%
1650 m.
Normal operating El. 127±
El. 115
℄ distributor El. 119
Elevation in meters
ELEVATION IN METERS
PROFILE
Scale 0 20 Meters
Natural surface
Rock line
Access road
El. 126
El. 115
TAIL TUNNEL PORTAL (SECTION C-C)
Min. exc. line
Average exc. line
R=2.25
R=4.50
0.30
0.35
TAIL TUNNEL - UNSUPPORTED (SECTION D-D)
Blocking
Timber lagging
Steel support
Average excavation line
0.3
0.75
TAIL TUNNEL - SUPPORTED (SECTION E-E)
Rock bolts
Minimum excavation line
R=3.5
5.5
0.2
ACCESS TUNNEL (SECTION F-F)
Scale 0 2 Meters
Scale 0 5 10 Meters
Except as noted
THE STATE ELECTRICITY AUTHORITY ICELAND
BURFELL PROJECT
60 MW PLANT
POWER STATION GENERAL LAYOUT
HARZA ENGINEERING COMPANY
APPROVED
CHICAGO, ILLINOIS
DATE DEC. 1962
DWG. NO. 290 P 4
PREPARED FOR HARZA ENGINEERING COMPANY INTERNATIONAL
DATE
NO
DISTRIBUTION
PRINTS
BY
DATE
CHKD.
DSGN.
DWN.
DEPT.
GROUP LEADER
SECT. HEAD
DEPT. HEAD
CIVIL
MECH.
ELECT.
PLAN.
STAFF
CHIEF

EXHIBIT 4





THE STATE ELECTRICITY AUTHORITY
ICELAND

BURFELL PROJECT | 60 MW PLANT

ONE LINE DIAGRAM

HARZA ENGINEERING CO., CHICAGO
APPROVED A. P. Fuss

DATE DEC. 1962 | DWG. NO. 290 P 6

K+E PHOENIX N166 TRACING CLOTH

COST ESTIMATE-SUMMARY
BURFELL PROJECT - 60 MW

Item	Total w/o Duties and Taxes U.S. $	Import Duties and Taxes U.S. $	Total with Duties and Taxes U.S. $
PRODUCTION PLANT			
Power Plant Structures	1,268,705	247,755	1,516,460
Reservoirs, Dams, and Waterways	4,991,430	943,900	5,935,330
Turbines and Generators	1,195,000	410,000	1,605,000
Accessory Electrical Equipment	300,000	100,000	400,000
Miscellaneous Power Plant Equipment	415,000	142,800	557,800
Access Roads and Bridges	340,000	45,000	385,000
Access Tunnel	889,550	169,570	1,059,120
Control Building	25,000	2,250	27,250
Operators Village	35,000	3,000	38,000
Subtotal Production Plant	9,459,685	2,064,275	11,523,960
TRANSMISSION PLANT			
Burfell Step-Up Substation	246,000	84,000	330,000
Transmission Line Burfell-Ellidaar Via Irafoss	978,500	312,000	1,290,500
Irafoss Substation Additions	84,000	28,000	112,000
Ellidaar Substation Additions	249,000	85,000	334,000
Subtotal Transmission Plant	1,557,500	509,000	2,066,500
SUBTOTAL DIRECT COST	11,017,185	2,573,275	13,590,460
Contingencies, 15% ±	1,652,815	386,725	2,039,540
Subtotal	12,670,000	2,960,000	15,630,000
Cost Escalation, 5% ±	630,000	150,000	780,000
TOTAL DIRECT COST	13,300,000	3,110,000	16,410,000
Engineering and Supervision, 8% ± of Total Direct Cost without Duties and Taxes	1,060,000	0	1,060,000
Preliminary Investigation Costs	490,000	20,000	510,000
TOTAL CONSTRUCTION COST	14,850,000	3,130,000	17,980,000
Interest During Construction, 10% ±	1,500,000	320,000*	1,820,000
TOTAL PROJECT INVESTMENT	16,350,000	3,450,000	19,800,000

*Interest on the cost component from duties and taxes

COST ESTIMATES
BURFELL PROJECT

Item	Quantity	Unit Price* U.S. $	Amount U.S. $	Import Duties and Taxes U.S. $
PRODUCTION PLANT				
POWER PLANT STRUCTURES				
Excavation				
Main hall	17,600 m^3	8.50	149,600	26,400
Draft tubes	860 m^3	13.50	11,610	1,935
Cable and access shaft	10,000 m^3	13.50	135,000	22,500
Access tunnel to cable shaft	400 m^3	14.00	5,600	924
Access tunnel to surge chamber	330 m^3	15.00	4,950	792
Drainage tunnels	1,100 m^3	15.00	16,500	2,640
Aeration shaft from surge chamber	50 m^3	20.00	1,000	165
Air exhaust tunnel	400 m^3	15.00	6,000	960
Steel Supports	91,000 kg	0.35	31,850	9,464
Timber	150 m^3	80.00	12,000	2,700
Rockbolting		L.S.	115,000	20,700
Grouting		L.S.	13,000	2,340
Pumping		L.S.	25,000	4,500
Concrete				
Substructure	1,800 m^3	40.00	72,000	11,880
Superstructure	1,100 m^3	85.00	93,500	15,510
Roof arch	1,070 m^3	65.00	69,550	11,555
Draft tubes	380 m^3	65.00	24,700	4,104

*Without Import Duties and Taxes

COST ESTIMATE
BURFELL PROJECT

Item	Quantity	Unit Price* U.S. $	Amount U.S. $	Import Duties and Taxes U.S. $
PRODUCTION PLANT (continued)				
Cable and access shaft	3,100 m^3	65.00	201,500	33,480
Access tunnel to cable shaft	190 m^3	65.00	12,350	2,052
Access tunnel to surge chamber	53 m^3	65.00	3,445	572
Air exhaust tunnel	70 m^3	65.00	4,550	756
Concrete block walls	165 m^3	50.00	8,250	1,386
Reinforcing steel	363,000 kg	0.25	90,750	29,040
Miscellaneous metals	30,000 kg	1.20	36,000	11,400
Architectural treatment		L.S.	125,000	30,000
SUBTOTAL POWER PLANT STRUCTURES			1,268,705	247,755
RESERVOIRS, DAMS, AND WATERWAYS				
DIVERSION CANAL				
Excavation, common, dry	37,000 m^3	0.90	33,300	5,550
Excavation, common, wet	4,000 m^3	2.00	8,000	1,320
Excavation, rock, dry	142,000 m^3	3.00	426,000	72,420
Excavation, rock, wet	35,000 m^3	5.00	175,000	28,875
Concrete	650 m^3	60.00	39,000	8,415
Reinforcing steel	10,000 kg	0.25	2,500	800
SUBTOTAL DIVERSION CANAL			683,800	117,380

*w/o Import Duties and Taxes

COST ESTIMATE
BURFELL PROJECT

Item	Quantity	Unit Price* U.S. $	Amount U.S. $	Import Duties and Taxes U.S. $
PRODUCTION PLANT (continued)				
ROCKFILL DIKE				
Excavation, common	97,000 m^3	0.80	77,600	13,100
Rockfill	125,000 m^3	0.25	31,250	5,625
Backfill	17,000 m^3	1.00	17,000	2,805
SUBTOTAL ROCKFILL DIKE			125,850	21,530
BJARNALAEKUR DIKE				
Excavation, common	85,000 m^3	0.80	68,000	11,475
Excavation, rock	7,000 m^3	5.00	35,000	5,775
Foundation preparation and treatment		L.S.	50,000	9,000
Impervious core	38,000 m^3	2.00	76,000	12,540
Filters	17,000 m^3	1.90	32,300	5,100
Rockfill	137,000 m^3	0.70	95,900	16,440
Backfill	12,000 m^3	1.00	12,000	1,980
Diversion and pumping		L.S.	50,000	9,000
SUBTOTAL BJARNALAEKUR DIKE			419,200	71,310
APPROACH CANAL				
Excavation, common	40,000 m^3	0.90	36,000	6,000
Excavation, rock	12,000 m^3	4.00	48,000	7,920
SUBTOTAL APPROACH CANAL			84,000	13,920

*Without Import Duties and Taxes

COST ESTIMATE
BURFELL PROJECT

Item	Quantity	Unit Price* U.S. $	Amount U.S. $	Import Duties and Taxes U.S. $
PRODUCTION PLANT (continued)				
SLUICEWAY				
Excavation, common	400 m^3	1.50	600	100
Excavation, rock	157,000 m^3	3.00	471,000	80,070
Foundation preparation and treatment		L.S.	10,000	2,000
Concrete	4,000 m^3	60.00	240,000	39,600
Reinforcing steel	170,000 kg	0.25	42,500	13,600
Sluice gates and frame and guides	17,700 kg	1.00	17,700	5,310
Ice gate and frame and guides	5,900 kg	1.00	5,900	1,770
Gate hoist, movable, capacity 75 tons		L.S.	65,000	20,000
Backfill	3,100 m^3	1.00	3,100	510
Miscellaneous		L.S.	15,000	3,600
SUBTOTAL SLUICEWAY			870,800	166,560
DIKE				
Excavation, common	22,500 m^3	1.25	28,125	4,725
Excavation, rock	1,200 m^3	5.00	6,000	990
Foundation preparation and treatment		L.S.	15,000	3,000
Impervious core	5,200 m^3	2.00	10,400	1,715
Filters	4,700 m^3	1.90	8,930	1,410
Rockfill	13,000 m^3	0.50	6,500	1,090
Backfill	3,300 m^3	1.00	3,300	545
SUBTOTAL DIKE			78,255	13,475

*Without Import Duties and Taxes

COST ESTIMATE
BURFELL PROJECT

Item	Quantity	Unit Price* U.S. $	Amount U.S. $	Import Duties and Taxes U.S. $
PRODUCTION PLANT (continued)				
INTAKE				
Excavation, common	2,000 m^3	1.50	3,000	510
Excavation, rock	2,000 m^3	6.00	12,000	1,980
Foundation preparation and treatment		L.S.	3,500	1,000
Concrete	1,300 m^3	50.00	65,000	10,725
Reinforcing steel	16,000 kg	0.25	4,000	1,280
Intake gate and embedded parts	16,000 kg	1.20	19,200	6,080
Intake gate hoist		L.S.	16,500	5,000
Trashracks and guides	18,000 kg	0.75	13,500	3,960
Bulkhead gates and frames and guides	35,500 kg	0.90	31,950	7,100
Gantry crane, capacity 10 tons		L.S.	26,000	7,800
Miscellaneous		L.S.	10,000	2,400
SUBTOTAL INTAKE			204,650	47,835
PENSTOCKS				
Excavation shaft and tunnels	3,000 m^3	13.00	39,000	6,480
Steel supports	47,000 kg	0.35	16,450	4,890
Timber	70 m^3	80.00	5,600	1,260
Grouting		L.S.	30,000	5,000
Concrete	1,500 m^3	32.00	48,000	8,100

*Without Import Duties and Taxes

COST ESTIMATE
BURFELL PROJECT

Item	Quantity	Unit Price* U.S. $	Amount U.S. $	Import Duties and Taxes U.S. $
PRODUCTION PLANT (continued)				
Steel plate	167,000 kg	0.65	108,550	33,400
Reinforcing steel	17,500 kg	0.25	4,375	1,400
SUBTOTAL PENSTOCK			251,975	60,530
TAILRACE SURGE CHAMBER				
Excavation, shaft	5,600 m^3	8.50	47,600	7,980
Excavation, gallery	7,000 m^3	10.00	70,000	11,550
Rockbolting		L.S.	38,500	7,000
Grouting		L.S.	7,000	1,000
Concrete	410 m^3	75.00	30,750	5,160
Reinforcing steel	31,000 kg	0.25	7,750	2,480
Draft tube gate and frames and guides	13,000 kg	1.00	13,000	3,900
Miscellaneous		L.S.	6,000	1,800
SUBTOTAL TAILRACE SURGE CHAMBER			220,600	40,870
TAILRACE TUNNEL				
Excavation	47,000 m^3	8.50	399,500	66,975
Steel supports	293,000 kg	0.35	102,550	30,475
Timber	600 m^3	80.00	48,000	10,800
Rock bolting		L.S.	35,000	6,300
Grouting		L.S.	107,000	19,000

*Without Import Duties and Taxes

COST ESTIMATE
BURFELL PROJECT

Item	Quantity	Unit Price* U.S. $	Amount U.S. $	Import Duties and Taxes U.S. $
PRODUCTION PLANT (continued)				
Concrete, tunnel lining	19,000 m^3	45.00	855,000	142,500
Concrete, tunnel portal	300 m^3	60.00	18,000	2,970
Reinforcing steel	685,000 kg	0.25	171,250	54,800
Stoplogs and guides		L.S.	8,000	2,400
Pumping and ventilation		L.S.	25,000	7,500
SUBTOTAL TAILRACE TUNNEL			1,769,300	343,720
TAILRACE CANAL				
Excavation, common	10,000 m^3	1.50	15,000	2,550
Excavation, rock	67,000 m^3	4.00	268,000	44,220
SUBTOTAL TAILRACE CANAL			283,000	46,770
SUBTOTAL RESERVOIRS, DAMS, AND WATERWAYS			4,991,430	943,900
TURBINES AND GENERATORS				
Turbines and governors	2	222,500	445,000	150,000
Generators and exciters	2	375,000	750,000	260,000
SUBTOTAL TURBINES AND GENERATORS			1,195,000	410,000
ACCESSORY ELECTRICAL EQUIPMENT		L.S.	300,000	100,000
MISCELLANEOUS POWER PLANT EQUIPMENT				
Bridge crane		L.S.	135,000	48,000
Draft tube crane		L.S.	15,000	4,800

*Without Import Duties and Taxes

COST ESTIMATE
BURFELL PROJECT

Item	Quantity	Unit Price* U.S. $	Amount U.S. $	Import Duties and Taxes U.S. $
PRODUCTION PLANT (continued)				
Heating and ventilation		L.S.	60,000	20,000
Miscellaneous mechanical equipment including plumbing, piping, unwatering, and station drainage		L.S.	205,000	70,000
SUBTOTAL MISCELLANEOUS POWER PLANT EQUIPMENT			415,000	142,800
ACCESS ROADS AND BRIDGES		L.S.	340,000	45,000
ACCESS TUNNEL				
Excavation, open cut, common	600 m^3	1.50	900	155
Excavation, open cut, rock	2,700 m^3	3.00	8,100	1,375
Excavation, tunnel	34,000 m^3	10.00	340,000	56,100
Steel supports	200,000 kg	0.35	70,000	20,800
Timber	310 m^3	80.00	24,800	5,580
Grouting		L.S.	100,000	18,000
Concrete, tunnel lining and portal	4,800 m^3	50.00	240,000	40,320
Concrete, floor slab	1,200 m^3	35.00	42,000	6,840
Reinforcing steel	255,000 kg	0.25	63,750	20,400
SUBTOTAL ACCESS TUNNEL			889,550	169,570
CONTROL BUILDING		L.S.	25,000	2,250
OPERATORS VILLAGE		L.S.	35,000	3,000
SUBTOTAL PRODUCTION PLANT			9,459,685	2,064,275

*Without Import Duties and Taxes

COST ESTIMATE
BURFELL PROJECT

Item	Quantity	Unit Price* U.S. $	Amount U.S. $	Import Duties and Taxes U.S. $
TRANSMISSION PLANT				
BURFELL STEP-UP SUBSTATION				
Grading, surfacing, foundations, and fencing		L.S.	7,000	1,000
Structures, busses, and switches		L.S.	18,000	6,000
Transformers, 138 kv, OA/FA/FOA, 22/29.4 /36.7 mva	2	75,000	150,000	53,000
Transformer, 69 kv, OA, 15 mva	1	40,000	40,000	14,000
Circuit breakers		L.S.	31,000	10,000
SUBTOTAL BURFELL STEP-UP SUBSTATION			246,000	84,000
TRANSMISSION LINE-BURFELL-ELLIDAAR VIA IRAFOSS	103 km	9,500	978,500	312,000
IRAFOSS SUBSTATION ADDITIONS				
Circuit breaker positions, 138 kv	2	27,000	54,000	18,000
Miscellaneous switchyard equipment		L.S.	9,000	3,000
Miscellaneous control room equipment		L.S.	21,000	7,000
SUBTOTAL IRAFOSS SUBSTATION ADDITIONS			84,000	28,000
ELLIDAAR SUBSTATION ADDITIONS				
Circuit breaker positions, 138 kv	3	27,000	81,000	26,000
Transformers, 138 kv OA/FA/FOA, 18/24/30 mva	2	69,000	138,000	49,000

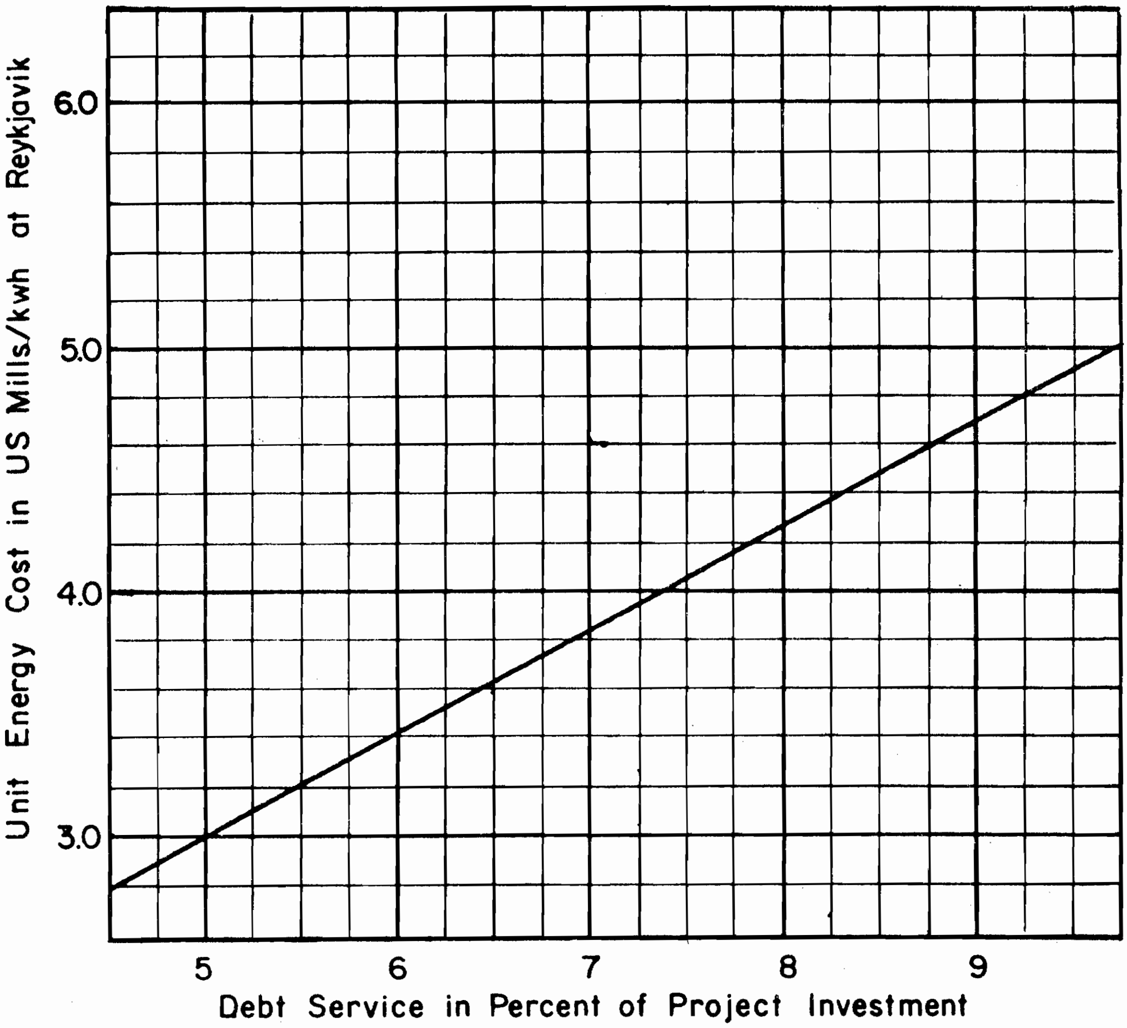
* Without Import Duties and Taxes

COST ESTIMATE
BURFELL PROJECT

Item	Quantity	Unit Price* U.S. $	Amount U.S. $	Import Duties and Taxes U.S. $
TRANSMISSION PLANT (continued)				
Miscellaneous structures and equipment		L.S.	30,000	10,000
SUBTOTAL ELLIDAAR SUBSTATION ADDITIONS			249,000	85,000
SUBTOTAL TRANSMISSION PLANT			1,557,500	509,000

*Without Import Duties and Taxes

EXHIBIT 6



1. *Total project investment $ 19,800,000.*
2. *Annual cost other than debt service $ 430,000.*
3. *No allowance made for income from sales of secondary energy.*
4. *Import duties and taxes included*

THE STATE ELECTRICITY AUTHORITY ICELAND	
BURFELL PROJECT	60 MW PLANT
ESTIMATED COST OF PRIMARY ENERGY	
HARZA ENGINEERING CO., CHICAGO APPROVED A.P. Juss	
DATE DEC. 1962	DWG. NO. 290P 8

K+E PHOENIX N106 TRACING CLOTH