LETTER REPORT
SUPPLEMENT TO
PROJECT PLANNING REPORT

BURFELL PROJECT

BY THE
HARZA ENGINEERING COMPANY INTERNATIONAL

PREPARED FOR
THE STATE ELECTRICITY AUTHORITY
GOVERNMENT OF ICELAND
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BURFELL HYDROELECTRIC PROJECT
LETTER REPORT SUPPLEMENT TO
PROJECT PLANNING REPORT

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

Gentlemen:

Introduction

In compliance with your request, we have appraised the Burfell Hydroelectric Project on the basis of development by Stages. Three Stages of two generating units each were assumed. The cumulative total rated installed capacity will be 60, 120 and 180 MW for the Stages designated I to III, respectively. The appraisal was based on the general designs presented in the January, 1963, Planning Report, but with certain modifications. These design modifications included: (a) those considered required because of staged development, and (b) those considered as design advances. The modifications are discussed below.

The principal modifications were as follows:

1. Initial construction of the Tailrace Tunnel and Canal to full size for a 180 MW plant. (a)
2. Rearrangement of Powerstation and Tailrace Surge Chamber. (a)
3. Realignment of Access Tunnel to fit (2), above. (a)
4. Rearrangement of Intake to fit (2), above. (a)
5. Reduction of Sluiceway to ice sluicing only. (b)
6. Addition of Bjarnalækur Canal at low level from right end of Thjorsá Diversion Weir to the Bjarnalækur. (b)

7. Addition of Bjarnalækur Sluice Structure at right end of Thjorsá Diversion Weir to control Bjarnalækur Canal. (b)
8. Elimination of Silt Excluder from Thjorsá Diversion Inlet. (b)
9. Redesign of Thjorsá Diversion Inlet to fit staged development (a) and (6), (7) and (8), above. (b)
10. Redesign of Diversion Canal to fit staged development (a) and (9), above. (b)
11. Redesign of Burfell Step-Up Substation to fit staged development. (a)
12. Redesign of Burfell-Reykjavik Transmission Line to fit staged development. (a)
13. Elimination of Ellidaár Substation Additions and associated Transmission Line. (b)

The remaining elements of the Burfell Project will remain unchanged, essentially, from the designs presented in the Planning Report. The Stage during which each will be constructed was assumed as follows:

Stage	Item
I	Burfell Reservoir
I	Approach Canal
I	Dike at Sluiceway
I & III	Bjarnalækur Dike
I, II & III	Penstocks (one each per Stage)
II	Thjorsa Diversion Dike, Right Bank
III	- - - Left -
III	- - Weir

The Powerstation Equipment, the Substations and Equipment and the General Plant will be installed as required for each Stage of development. The same will be true for the Access Roads and Bridges and the Operators Village.

Each of the above features of the Burfell Hydroelectric Project is discussed with respect to staged development and design changes in greater detail below.

Tailrace Tunnel and Canal

A Study was made in order to compare the relative economy, based on estimated investment costs, between several alternatives of tailtunnel construction to fit staged development. Alternatives studied included the following plans:

A. One initial tunnel to serve all six generating units.
B. One initial tunnel to serve four units followed by one smaller tunnel to serve two units.

C. One initial tunnel to serve two units followed by one larger tunnel to serve four units.

D. One initial tunnel to serve three units followed by a second of equal size.

E. Three successive tunnels sized each to serve two units.

The study was based on the general designs and assumptions presented in the Planning Report. Quantities were computed on that basis in order to assure comparability. Unit costs were varied to reflect the various tunnel sizes and associated construction conditions. Thus the cost estimates do not agree exactly with those presented either in the Planning Report or the December, 1962 60 MW Appraisal Report. The study required estimates for tunnels sized for two, three, four, and six units. No allowance was made with respect to construction of multiple tunnels, each at a different time, which could expect ordinarily to increase costs because of price excalation and multiple construction plant assembly and overheads.

The Tailtunnel investment costs are presented in bar graph form on Exhibit S-1, attached. This graph shows that an initial tunnel sized for six units (A) bears the following approximate investment cost relationship to multiple tunnels:

Plan	Additional Cost	Additional Cost in percent
B	$ 2,000,000	45
C	2,000,000	45
D	2,100,000	47
E	3,600,000	80

Consideration of cost differentials inherent with staged construction would enhance further the relative economy of initial provisions for six units. There would also be relatively small increases in the investments for Tailrace Canals with multiple tunnels over that required for a single large tunnel. These were not evaluated.

In view of the inherent ultimate economy indicated by the study, we recommend that serious consideration be given to sizing the initial Tailrace Tunnel and Canal for the six unit development. The Project cost analyses which follow are based on that assumption.

Powerstation and Related Features

The general layout of the Powerstation was rearranged from the plan shown on Exhibit 18 of the Planning Report to the plan shown on Exhibit S-2, attached. The control room and access and cable shaft were moved to the left end of the powerstation. The erection bay was repositioned between the left and intermediate pairs of units. The overall length, thus, was not changed.

The repositioning of the generating units produced some relatively minor changes in associated features. The right two penstocks were each set to the right about 16 meters. This change lengthened the Intake facewall and house a corresponding distance. In other respects the Intake and Penstocks were not changed. The draft tube extensions were modified to fit with the relocation of generating units. The basic cross-section of the Surge Chamber was not changed. However, the chamber was divided into two sections as shown on Exhibit S-2. The two sections will be connected at low level for equalizing purposes and at high level for draft tube gate handling. The lower portion of the Access Tunnel was rerouted and lengthened to pass upstream of the left penstock and enter the right end of the erection bay. A personnel access drainage and ventilation tunnel will connect to the control room.

It will also be necessary to provide for ventilation and escape from the right end of the powerstation with a shaft connecting either to the surface or to the elevation 152 drainage gallery. The latter route was assumed for this study.

The excavation for the powerstation and associated features will be accomplished in Stages I and II, except for the right penstock which will be accomplished in Stage III. The Access Tunnel and the Shaft will be completed in Stage I together with required concrete lining. The machine hall excavation will be accomplished to a few meters beyond the erection bay in Stage I, then completed in Stage II together with the placing of the concrete roof arch. The left and right sections of the Surge Chamber will be completed in Stages I and II, respectively. The draft tube gate handling and equalizing galleries will be excavated for a few meters in Stage I, with a bulkhead placed in the latter. Except for a bulkhead-equipped short section of the collecting tunnel, only the left two draft tube extensions will be accomplished in Stage I. The remainder of the draft tube extensions, including bulkhead removal and concreteing, will be accomplished in Stage II. This second Stage will also see the completion of the right two draft tubes downstream from the downstream face of the machine hall. Bulkhead gates will be required to close the openings until the completion of Stage III.

The concrete in the machine hall will be placed as required. Stage I will include all concrete as far as the right edge of the erection bay. Stage II concrete will include only the additional amount required for the two units, plus completion of the roof arch. The remainder of the concrete, representing only that required for the last two units, will be placed in Stage III.

The Intake Approach Canal will be excavated fully in Stage I, but the Intake itself will be constructed only to the extent required for the left bay. Provision will be made for installing a cofferdam with Stage II for completing nearly all of the remainder of the Intake. Inasmuch as the third penstock will not be installed until Stage III, it will be necessary to defer until Stage III a small portion of the intake concrete overlying the shaft. The only cofferdam required for this last Stage will be insertion of a bulkhead in the emergency gate slot provided by the Stage II construction.

Sluiceway

The low velocities in the Bjarnalækur Pond led to the decision to provide a Sluiceway for surface ice only beyond the left end of the Intake. This reduced greatly the quantities in the sluiceway canal and control structure. The canal grade will be raised to about six and one-half meters above the earlier plan, to begin at elevation 237. The sluicegate will be eliminated and the vertical lift ice gate replaced by one of the flap type. This gate will be operated from within the Intake house by either a hoist or hydraulic cylinder. A house over the control structure is no longer required.

Suitable excavation from the Intake Approach and Sluiceway Canals will be used to construct the shells for the adjacent Sluiceway Dike, which will be completed in Stage I. The remaining suitable rock will be placed in the shells of the Bjarnalækur Dike.

Bjarnalækur Sluice Structure and Canal

The general engineering experience in ice control at river intakes or inlets has indicated the great desirability of placing the entrance ports as far below the normal winter water surface as is feasible. The earlier studies indicated that a level of the Diversion Inlet ports below that shown in the Planning

Report was not feasible by utilizing a sluiceway canal downstream along the right side of the Thjorsa. More recent studies have indicated that a sluiceway canal, extending from the right end of the Thjorsa Diversion Weir south-westerly to the Bjarnalækur, is feasible. The length will be about one and one-half kilometers to attain a level in the Bjarnalækur of about 223 meters with the diverted flow. This level is about 18 meters below the natural level in the Thjorsa at the upper end of the proposed canal. This differential permits adequate height both for a canal grade providing relatively high velocities and for lowering the inlet ports to eight meters or more below the Thjorsa surface. Revised designs incorporating these features were included with the study presented herein.

The canal grade was set at elevation 232 at the Thjorsa end. This permits an adequate thickness (3 to 4 meters) of the base of the uppermost Thjorsa lava flow as the foundation for the concrete structures in that vicinity. The canal was set at a grade of 0.0045 with a base width of six meters in order to maintain the moderately high velocities over the required flow range to transport the ice. The resulting velocities will range between about 2.4 and 3.5 meters per second over a flow range of 25 to 100 cubic meters per second, respectively.

The discharge to the canal will be controlled by a Sluice Structure representing the right bay of the Thjorsa Diversion Weir. This concrete structure will contain two sluices set at the elevation 230 grade, with control provided by two 2.5 meter square wheeled gates. Each gate will be controlled by a hoist or hydraulic cylinder positioned in a gallery within the concrete mass above. These undersluices will permit desilting from in front of the Diversion Inlet Structure, and also provide water, if required, for aiding in ice transport within the canal.

The overflow section of the control structure was established with a crest width of 12 meters and a modified ogee downstream face. A two meter high bascule gate will provide crest control with Stage III. For the two earlier Stages the crest will be leveled off at elevation 239.2 and operate uncontrolled. Provisions will be made with the Stage I construction to add timber flashboards for use outside the ice season if and when desired. Stoplog slots will be provided on the face of the structure for maintenance closure of each undersluice. Slots will also be provided for stoplogs or a bulkhead to permit future completion of the crest construction.

A V-shaped hollow pier will be provided at the left end of the structure. The right leg will extend as a training wall in the downstream direction. The left leg will extend as a separator wall to elevation 243.0 downstream to exclude all but extreme floods of the main Thjorsa from entering the Bjarnalækur Canal. The hollow center of the pier will provide access to the sluicegate operating gallery. A walkway will connect the left and right piers during Stages I and II. A bridge deck will be added during Stage III.

The canal bottom will be concrete-paved for 15 meters downstream from the sluiceway outlet, and slope slightly upward to terminate in a low sill at elevation 232. The canal walls will be lined below the top of rock for a length of 25 meters downstream of the control structure. The Bjarnalækur Dike will be retained by a wall extending to higher level and supported, in part, by the right canal lining. The right pier of the control structure will contain a gage well, but the stage recorder and transmitter will not be required until Stage III.

In order to aid with the Stage III construction of the Thjorsa Diversion Weir, the part of the Weir that will be gated will be constructed in Stage I to elevation 240.5. The three piers will be constructed to elevation 246, and provided with slots for stoplogs or a bulkhead to permit future completion of these three gated bays. A steel sheetpile interlock section will be built into the last pier for connection to the Stage III main river cofferdam.

<u>Diversion Inlet and Canal</u>

The basic design of the Diversion Inlet structure was not changed from that of the Planning Report. The sill of the ports was lowered to elevation 231 at the left end and graded upward as before towards the right end. The height of the 10 meter wide ports was increased to two meters in order to lower the entrance velocities. The bellmouth entrance was shortened to 1.5 meters in order to lessen possibilities for ice clogging.

The increase in overall height of the structure requires increasing the base width to about 15 meters. Also, the great height of the piers probably means that they will need to be connected by struts. The width of the deck was increased to five meters in order to permit operation of a crane, if required, for silt removal of deposits which might accumulate immediately downstream of the structure.

The Bjarnalækur Canal will be extended upstream with a base width of 12 meters in front of the entire Diversion Inlet Structure. The riverward side slopes will be flattened in order to provide gradual velocity reductions in the diverted power flow. It was considered most practicable to accomplish during Stage I all excavation required in rock for the ultimate Diversion Inlet Structure and the Bjarnalækur Canal extension. All Stage I construction associated with the Thjorsa River Works will be accomplished behind a single fill type cofferdam, tied to the river bank upstream of the Diversion Inlet and downstream of the Bjarnalækur Canal entrance.

The first four bays of the Diversion Inlet will be constructed with Stage I and the remaining six with Stage II. The Stage II construction will require a cofferdam tied to the right pier of the Stage I construction, which will include a steel sheetpile interlock section. It was assumed that some riverbed material, deposited within the Stage I excavation, will need to be removed during the Stage II construction.

The Diversion Canal requires a grade at about elevation 237 near the Inlet Structure and a slope of about 0.001. This grade is six meters above that of the Inlet. Accordingly, it will be necessary that these grades be connected by ramping on about five horizontal to one vertical.

The base width of the Canal will be about 44 meters for Stage I immediately downstream of the Inlet Structure. The base width will be gradually narrowed to 25 meters, beginning about 200 meters downstream from the Inlet. These widths will be doubled to the north during the Stage II construction.
A further short and shallow northward widening immediately downstream from the Inlet is desirable during Stage III construction to improve flow condistions, but not required for low velocity purposes.

The suitable rock excavation from the Canal for Stage I as well as from the Diversion Inlet and Bjarnalækur Canal will be placed in the Bjarnalækur Dike shells. Similarily, the rock excavation from the Stage II canal widening will be placed in the Right Bank Thjorsa Diversion Dike, which will be completed in that Stage. All overburden and rock excavation unsuitable for dike shells will be wasted outside the area of the Bjarnalækur Pond.

Bjarnalækur Dike

The Bjarnalækur Dike was considered to be constructed in Stage I as shown in the 60 MW Appraisal Report, including the Rockfill Dike extension to the east of the stream. In addition a small portion of the eastern terminus will need to be constructed to form an access ramp to the deck of the Diversion Inlet. Inasmuch as the silt sluicing provisions were eliminated in the vicinity of the Power Intake, it may prove desirable to add a small controlled tunnel or culvert at the Bjarnalækur for a somewhat similar purpose. It would also serve for construction diversion.

The remainder of the Bjarnalækur Dike was assumed to be constructed in Stage III. The analyses indicated that there would be some surplus of rock excavation from the Stage I construction. This could either be stock-piled for Stage III or placed directly in the Dike. Also, Stage III excavation indicated a deficiency on the order of 100,000 cubic meters for the shell requirements. This will need to be supplied from a quarry.

The study also showed that short-path leakage from the Bjarnalækur Pond to the Bjarnalækur represented an underseepage danger even with the Stage I construction. Accordingly, the grouting and blanketing shown in the Planning Report was considered to be accomplished with Stage I.

Diversion Weir and Left Bank Dike

The assumption was made that the Diversion Weir would not be required for Stage II power installation. The Left Bank Dike is not required prior to raising of the river level by the Weir. Therefore, both features were considered to be added in Stage III. However, some portion of the Weir may be required in Stage II in order to assure diversion for power up to station hydraulic capacity during extreme low flow periods. This represents a river hydraulics problem which can best be solved by a model study. Analytical studies have not been conclusive at this time. Any Stage II provision of either some portion of the permanent Weir or an interim one would likely require the construction of at least some portion of the Left Bank Dike.

The Diversion Weir was assumed to be identical with that shown in the Planning Report, except for the two right bays. The extreme right bay is now represented by the Bjarnalækur Canal Sluice Structure to be constructed, for the most part, in Stage I. The elimination of the Silt Excluder from the plan also requires a change in the second bay from the right. A twelve meter wide bascule gate was considered as placed in this bay. Thus, Stage III Weir construction will include construction of the Left Dike retaining structure; the free overflow weir; and the completion of the two tainter gate bays, the bascule gate bay, and the Bjarnalækur Canal Sluice structure. The entire construction of the Left Bank Dike will be in Stage III.

In the Planning Report, the normal controlled river level was set at elevation 244.5 to assure, in part, the maximum feasible submergence of the ports in the Diversion Inlet Structure. The substantial lowering of these ports provided by the now proposed Bjarnalækur Canal makes this requirement of much less importance.

This revised consideration requires a nearly complete reevaluation of the economics of the River Diversion Works. Two general alternatives, either of which holds the promise of savings in Project Costs, are currently under study. These are:

1. The lowering of the crest of the Diversion Weir accompanied by lowering the height and reducing the length of the Left and Right Bank Dikes, lowering of the heights of the Bjarnalækur and Intake Sluiceway Dikes, and lowering of the deck levels of the concrete structures such as the Diversion Inlet and the Power Intake. This Diversion Weir crest lowering would eliminate the two tainter gate bays. However, one or more longer, low bascule gate bays may be added, possibly accompanied by flashboard provisions at somewhat higher level for the remainder of the crest length.
2. Repositioning of the Diversion Works up to about 300 meters farther upstream to regain about one meter of head with a corresponding regain in pondage within the Bjarnalækur Pond. The reduction in the height of the structures would be correspondingly less than in (1). The Bjarnalækur Dike would be lengthened approximately the same distance as the move upstream, while the Left Bank Dike may be shortened about the same distance. The same alternatives for crest control as for (1), above, would be available.

Burfell Reservoir

The snow fences along the banks of the Thjorsa upstream from the Diversion Weir, shown in the Planning Report, were considered to be installed in Stage I. The stage recorder and transmitter will be installed in Stage III.

Powerstation Equipment

The main generating equipment consisting of the turbines, governors, generators and exciters were considered to be installed equally on the basis of two complete units per Stage. The cost of the Accessory Electrical Equipment will be somewhat greater for Stage I than for each of the two subsequent Stages, principally because of the requirements for intial control room equipment and conduits as necessary for two units as much as for four or six total units. The cost of this equipment for Stage III will be slightly greater than for Stage II, principally because of the greater length from the generators to the main power transformer in the Substation. Power service to the Thjorsa Diversion Works will be provided almost entirely with Stage I.

More than one-half of the Miscellaneous Power Plant Equipment costs will be involved with Stage I. The remainder will be more or less equally divided between Stages II and III. The machine hall bridge crane, draft tube gate hoist, elevator, diesel generator and some minor items of mechanical equipment will be essential for Stage I and not duplicated for either of the subsequent Stages. A high percentage of such service systems as drainage, raw water, compressed air, heating and ventilating, and fire protection will be required for Stage I, and need only to be expanded in the later Stages.

Access Roads and Bridges

The main access road and required bridges located on the west side of the Thjorsa will be required for the Stage I construction and operation. The same is true for access roads within the Project area. Some additions and improvements will be necessary in Stage II. Access to the east side of the Thjorsa will be required for Stage III construction.

Operators Village and General Plant

One-half of the construction of the Operators Village was assumed required for Stage I. Three-fourths of the remaining cost was considered added with Stage II, with completion scheduled during Stage III. These divisions were somewhat arbitrary inasmuch as the extent of the provisions for maintaining operating personnel has not been established. About two-thirds of the General Plant was considered required for Stage I. The remainder will by added in nearly equal increments with each subsequent Stage.

Burfell Step-Up Substation

The arrangement of the Burfell Step-Up Substation with Stage I was altered from the One-Line Diagram shown in the 60 MW Appraisal Report to provide only one three-phase 13.8 - 138- 230 Kv transformer for the two initial units. No bus structure will be required and the transformer will connect through a 138 Kv circuit breaker directly to the outgoing main transmission line, which will be energized at 138 Kv during Stage I operation. The 69 Kv service will be directly from the generators rather than from a bus.

The main transmission voltage will be increased to 230 Kv beginning with Stage II, with the Burfell Substation modified accordingly. A main and a transfer bus will be installed. A second 230 Kv main power transformer will be added, and the high voltage connection switched to the 230 Kv taps on the first transformer. Four 230 Kv circuit breakers will be installed; one for each main transformer; one for the line; and the fourth for transfer. The 138 Kv breaker and associated equipment will be salvaged. The 69 Kv arrangement will remain unchanged. Station service will be connected over to be served by one unit of each pair.

With Stage III the Burfell Substation will be the same as shown on the One-Line Diagram for one transmission line in the Planning Report. The structures will be extended for the third main power transformer and for serving the 69 Kv line from the 230 Kv buses. Two 230 Kv circuit breakers will be added; one for the third transformer and the second for the 69 Kv service. The 13.8 - 69 Kv transformer and associated equipment will be salvaged.

Burfell - Reykjavik Transmission Line

The Transmission Line will be constructed in Stage I. It will extend from Burfell past Irafoss to terminate at a new Receiving Substation positioned in a location to be selected a short distance to the east of Reykjavik. Woodpole construction will be utilized. The line will be conductored and protected for 230 Kv service adequate for all three Stages. As mentioned above, Stage I energization will be at 138 Kv with the change-over to 230 Kv coming with Stage II. No allowance is provided in the cost estimates for a connection at Irafoss. However, the Sog System will be permitted to make an intertie if it so desires. The Burfell - Reykjavik line will probably be adequate in all three Stages to serve also as a reserve line for the present and definitely planned Sog capability. There will thus be no requirement for transmission line extensions with either Stages II or III. We recognize that initial provision of the transmission line for 230 Kv places a disproportionate burden on Stage I. However, as with the Tailtunnel, the initial provision of capability adequate for all three Stages appears to us to represent sound long range planning.

Reykjavik Receiving Substation

We believe that long range load planning in the Reykjavik metropolitan area and other nearby potential load areas requires the ultimate provision of a major 230 Kv Receiving and Switching Substation at a location somewhat to the east of the present limits of Reykjavik. Further study is required to establish definitely the most favorable location. Local high tension lines would radiate ultimately to serve general loads and such specific loads as aluminium plants and the like. Accordingly, the provision of the Reykjavik Receiving Substation in this study is less specific than shown in the Planning Report.

The initiation of such a Substation will be accomplished in Stage I with 138 Kv provisions. These will include a single 138 Kv breaker position with bus structure, three disconnect switches, and associated structures and equipment. The initial bus could be installed for future 230 Kv operation. The power and energy will be sold at 138 Kv in Stage I and subsequently in the later Stages and beyond, unless the higher voltage of 230 Kv was desired by a specific customer.

When the transmission voltage is raised to 230 Kv in Stage II, the Receiving Substation will be constructed as shown for the Eidi Substation in the Planning Report. Two breaker positions will be provided together with a main and a transfer bus. Any 230 Kv loads, such as an aluminium smelter, will be served from the main bus. A 70 Mva 230 - 138 Kv autotransformer will be installed in order to continue 138 Kv service to the local load. The 138 Kv transmission and associated substation equipment and structures at Ellidaár (or elsewhere) are assumed to be supplied by the power purchaser. The 138 Kv breaker and auxiliaries, installed at the Reykjavik Substation in Stage I, will be salvaged. No further provisions are assumed as required in Stage III over that provided in the Reykjavik Receiving Substation in Stage I.

Construction

Stage I construction can be accomplished in three years, if construction can commence early in the first calendar year. Stage II and III will each require about two years of field construction, although a few months less for Stage III than Stage II. However, the main equipment will need to be ordered with each Stage about one year in advance of the beginning of field construction.

Construction procedures, in general, were assumed to be about the same as considered in the Planning Report. However, Stage III should not require the services of a foreign contractor although the two earlier Stages probably would. The civil construction work in Stage III might be divided between several of the larger local contractors. The staged construction outlined in this study may make it desirable for most major items of construction equipment to be owned by the appropriate entity of the Icelandic Government for use by the contractors of each Stage. Much of the equipment, if properly maintained, would then be available from the first Stage for the next two Stages with a minimum amount of supplemental purchases.

Capital Costs

The estimated capital costs, expressed in United States Dollars for each of the three Stages are summarized on Exhibit S-3. The estimate for each Stage is presented to show the Total Investment. Each total investment was determined by adding to the estimated direct cost allowances for contingencies, engineering, supervision and overhead, and net construction interest. In addition, the estimates for Preliminary Costs presented in the Planning Report was assumed to be repaid from the Stage I financing and might represent a fund for Working Capital which was not otherwise considered. Further, for the general reasons discussed above, the estimates for Stages II and III each include an allowance for extra costs inherent with staged construction as compared with the initial complete construction presented in the Planning Report. The various allowances, except for Construction Interest, are on the same bases as presented in the

Planning Report.

The assumption was made that each Stage would be financed separately. Thus, the period for which Construction Interest would be appropriate would vary between Stages according to the estimate of construction time presented above. The Net Construction Interest was estimated to be 9 percent of the estimated Total Investment for Stage I, and 6.5 percent each for Stages II and III.

Neither of the estimates for the three Stages include any allowances for one year of interest reserve, or for import duties and taxes. The latter would add on the order of 21 percent to each estimate. An exchange rate of 43 Icelandic Kronur to one U.S. Dollar was used where appropriate in the detail back of each summary estimate of Exhibit S-3. The foreign currency requirements were estimated to be about 70 percent of the Total Construction Costs for each Stage. This percentage may, however, vary slightly between Stages, especially if most of the construction equipment is purchased in Stage I and ownership vested with the Iceland Government.

The estimates and procedures of the Planning Report were adopted insofar as feasible for the determination of Direct Costs. Quantities were determined for the redesigned features of the Project discussed above. In general, unit and lump sum prices used in the estimates for all three Stages are the same as presented in the Planning Report.

Capital Costs with Individual Unit Installation

We consider it feasible technically to install individual units separately in each Stage. This procedure would involve with the first unit of each Stage, all of the construction except the equipment and embedment concrete required solely for the second generating unit. In addition, a blind flange would be required for the lower end of the second penstock bifurcation. The estimated Investments required for proceeding with the installation of one unit at a time is shown by the Summary Estimate of Exhibit S-4. We have included an additional allowance of about five percent with the estimate of the second unit for each Stage to provide for the extra costs associated with sub-staging of the construction in that manner. The investment required for the second unit of each stage is about $ 1,000,000. These estimates may be compared by Stage with the estimates presented on Exhibit S-3. No further economic evaluation was made for this procedure. However, it may be assumed that the power and energy produced by each Stage, discussed below, may be divided approximately equally between each of the two units.

Annual Costs

Estimates were prepared for items of annual cost not controlled by financing terms. These items include operation and maintenance costs, compensation for water rights, and reserves to provide for extraordinary replacement costs not included in normal maintenance or covered by insurance. These reserves would be required primarily for equipment rather than more durable features such as the civil engineering structures and the main transmission line. Stages II and III each have a higher percentage of construction cost represented by equipment than does Stage I. Accordingly, the total of reserves and water rights was taken at about 1.00, 1.75 and 1.50 percent of the estimated Total Construction Cost for Stages I to III, respectively. The annual costs other than debt service were estimated to be as follows in thousand United States Dollars:

		Stage	
Item	I	II	III
O & M	200	190	155
Reserves & Water Rights	170	115	115
Total	370	305	270
Cumulative Total	370	675	945

Power and Energy

The peaking power in kilowatts delivered at the Reykjavik Receiving Substation was estimated to be about as follows from the Burfell Project after each successive Stage is completed:

Stage I	62,000
Stage II	114,000
Stage III	175,000

The delivered average annual primary energy in million kilowatthours, computed on the same general bases as in the Planning Report, was estimated to be as follows after each successive Stage is completed:

Stage I	470
Stage II	930
Stage III	1375

The average annual secondary energy production was not determined.

Primary Energy Costs

The unit cost of primary energy for each Stage and for the Burfell Project as each Stage is completed was estimated on the same general basis as utilized in the Planning Report. The unit cost of energy was determined for annual debt service expressed as five, seven and nine percent of estimated Total Investment. These computations are shown on Table 1 and presented graphically on Exhibit S-5.

TABLE I

BURFELL PROJECT

ESTIMATED UNIT COST OF ENERGY

VARIOUS STAGES

		Percent of Debt Service		
		5	7	9
STAGE I				
O & M, Reserves, Etc -	$ 1000	370	370	370
Debt Service -	$ 1000	915	1280	1650
Total - $ 1000		1285	1650	2020
Annual Energy - Million kWh		470	470	470
Cost of Energy - US Mills/kWh		2.73	3.51	4.30
STAGE II				
O & M, Reserves, Etc -	$ 1000	305	305	305
Debt Service -	$ 1000	350	490	630
Total - $ 1000		655	795	935
Annual Energy - Million kWh		460	460	460
Cost of Energy - US Mills/kWh		1.43	1.73	2.04
STAGES I + II				
O & M, Reserves, Etc -	$ 1000	675	675	675
Debt Service -	$ 1000	1265	1770	2275
Total - $ 1000		1940	2445	2950
Annual Energy - Million kWh		930	930	930
Cost of Energy - US Mills/kWh		2.09	2.64	3.17
STAGE III				
O & M, Reserves, Etc -	$ 1000	270	270	270
Debt Service -	$ 1000	410	575	740
Total - $ 1000		680	845	1010
Annual Energy - Million kWh		445	445	445
Cost of Energy - US Mills/kWh		1.53	1.90	2.27
STAGES I + II + III				
O & M, Reserves, Etc -	$ 1000	945	945	945
Debt Service -	$ 1000	1675	2340	3015
Total - $ 1000		2620	3285	3960
Annual Energy - Million kWh		1375	1375	1375
Cost of Energy - US Mills/kWh		1.90	2.39	2.88
STAGE I WITH 21% DUTIES & TAXES				
O & M, Reserves, Etc -	$ 1000	405	405	405
Debt Service -	$ 1000	1110	1550	2000
Total - $ 1000		1515	1955	2405
Annual Energy - Million kWh		470	470	470
Cost of Energy - US Mills/kWh		3.22	4.16	5.13

Summary & Conclusions

The studies summarized in this Letter Report have shown that the construction of the Burfell Project in Stages of two units each is feasible technically and presents no unusual construction problems. Should subsequent studies reveal the requirement for providing a portion of the Thjorsa Diversion Weir with Stage II, the cost increase in that Stage would be offset approximately by savings in Stage III such that each Stage would be about equal in investment cost - or about $ 7,600,000 each.

The design modifications presented in this Study, while apparently not representing any overall cost savings compared to the designs in the Planning Report, appear to have advanced considerably the solution to the ice problems discussed in that Report. More studies with regard to these problems are, of course, required. However, we do not now believe that ice will represent any serious problem with respect to operation of the plants proposed in Stages I and II. The current studies discussed above with respect to redesign of the Thjorsa Diversion Works hold the promise of alleviating ice problems which might be associated with Stage III because of a dam across the river. They may also reduce the estimate of costs for these features to some extent.

Even on the assumption of further design improvements with respect to alleviating any ice problems which may be inherent with a dam crossing the river, it may still be necessary to provide a source of sluicing water during periods of low flow after Stage III is completed. Accordingly, the financing and power marketing for Stage III possibly should include the construction of initial storage at Thorisvatn substantially as proposed in Volume II of the Planning Report.

The Staged construction proposed in this Letter Report is attractive economically. Exhibit S-5 shows that unit energy costs are increased only about one-tenth of a U.S. mill for the complete three Stages as compared with the six-unit initial plant presented in the Planning Report. The estimated unit energy cost for the Project would be only about 2.6 U.S. mills per kilowatthour when Stage III is completed on the assumption of a 25 year amortization period and six percent interest (7.8 percent of Total Investment). This would be increased about one-tenth of a U.S. mill if the initial Thorisvatn Storage Project was added in Stage III. Unit energy costs in this general range well below three U.S. mills must always be considered as extremely low cost energy.

On this same 25-year, six-percent interest basis, the unit energy cost for Stage I is shown by Exhibit S-5 to be about 4.6 and 3.8 U.S. mills with and without import duties and taxes, respectively. The former is about two-tenths of a U.S. mill higher than shown in the Appraisal Report for a plant specifically sized for two units. Much of the addition results from the burden imposed on that Stage by the initial provision of the Tailtunnel and of the Burfell-Reykjavik Transmission Line, both sized for all six units.

The load estimates for the Southwest Iceland System presented in the Planning Report show that, on the assumption that the thermal stations would continue to serve as System reserves, the power from Stage I would be absorbed therein by about 1972 if the fertilizer plant is expanded by 50 percent but continues to operate off-peak primarily. The date would move back about two years to 1970 if that expanded plant started on-peak operation. On the assumption that Stage I is placed in operation in 1967, its capacity will be absorbed fully in three to five years. Thus, further expansions of the Southwest Iceland System might need to be undertaken within about one year after Stage I was completed. Other than the small increase in load for the fertilizer plant, the above analyses assume no new major industrial loads within the next eight years - a situation which in itself appears unlikely.

It may be necessary, on the load basis referred to, to lighten the financial burden during the first few load development years. The following may represent feasible means of accomplishing this reduction:

1. Deferred installation of the second generating unit
2. Deferring the beginning of amortization
3. Capitalization of some portion of the interest for the load development period.
4. Deferring the establishment of reserves.

Careful analyses may reveal other financial means of lightening the financial burden during the development period.

The successive additions involved with Stages II and III, whether considered jointly or separately, will result in remarkably low cost energy. The unit cost shown on Exhibit S-5 would be in the vicinity of two mills per kilowatthour with 25-year, six-percent financing. The inclusion of Thorisvatn Initial Storage with Stage III would, on this same basis, increase the unit energy cost of that Stage by about three-tenths of a U.S. mill.

The addition of Stage II considered jointly with Stage I would, as shown by Exhibit S-5, result in a unit energy cost slightly less than three U.S. Mills on the comparable financing basis. Obviously, this unit cost still includes some burden for the complete Tailrace and Transmission Line. Again, there exists the possibilities referred to above of lowering the unit energy cost slightly during the load development years.

The unit energy costs discussed above and shown graphically on Exhibit S-5 for the proposed staged development of the Burfell Project appear to us to be favorable economically either on an actual or relative basis. This situation is true for each individual Stage or appropriate combination thereof. Even the addition of the proposed Thorisvatn Initial Storage, if required, has no serious adverse cost effect.

The Stage I unit costs are favorable in comparison with that of any other source of hydrelectric power which we have appraised in Southwest Iceland. This relationship applies with respect to either large or small potentials in the area. We are certain that we have not overlooked any site which might be possibly as favorable as Burfell.

The staged development at Burfell has several additional advantages of long-range economic importance. Stage I provides a large enough block of power to satisfy expected normal load growth for about three years after completion. This situation would not be true for one or even more smaller plants. Adequate reserves are available to satisfy the demands of several moderate-sized industries not considered in the normal load. This feature becomes even more important as subsequent Stages are added, assuming no development of a single very large industrial load. The subsequent Stages II and III provide immediate and quick sources for expansion to meet normal loads and small to medium sized industrial loads at incremental energy costs far below that of any other alternative power source. Within the range presented, the larger the Burfell Project becomes the cheaper becomes its average energy cost. Further, Stages II and III each provide blocks of power large enough to attract a single large power consuming industry such as an aluminium reduction plant. While the incremental energy cost as outlined above for each of these two subsequent blocks of power is very low, it must be borne in mind that each Stage should be charged further for its fair share of the common costs provided originally with Stage I.

We conclude on the basis of our studies as summarized in this Report that the Burfell Project represents the next logical development of the hydroelectric power resources of Southwest Iceland to serve the growing loads, both of a normal and of a future industrial nature.

Very truly yours,

HARZA ENGINEERING COMPANY INTERNATIONAL

C.K. Willey

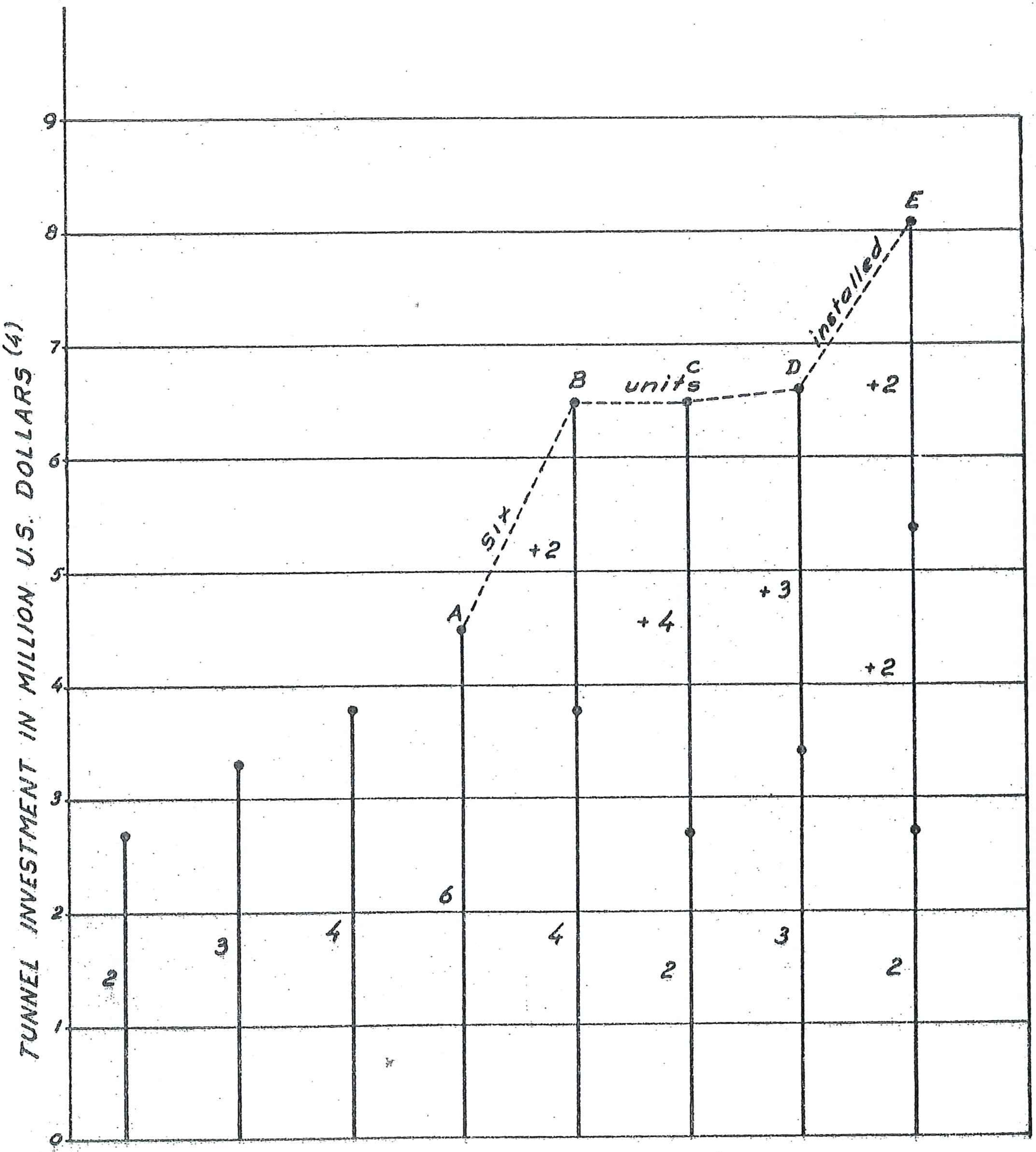
C.K. Willey
Vice-President

BURFELL PROJECT

EXHIBIT S-1

ESTIMATED INVESTMENT

ALTERNATIVE TAIL TUNNEL PLANS



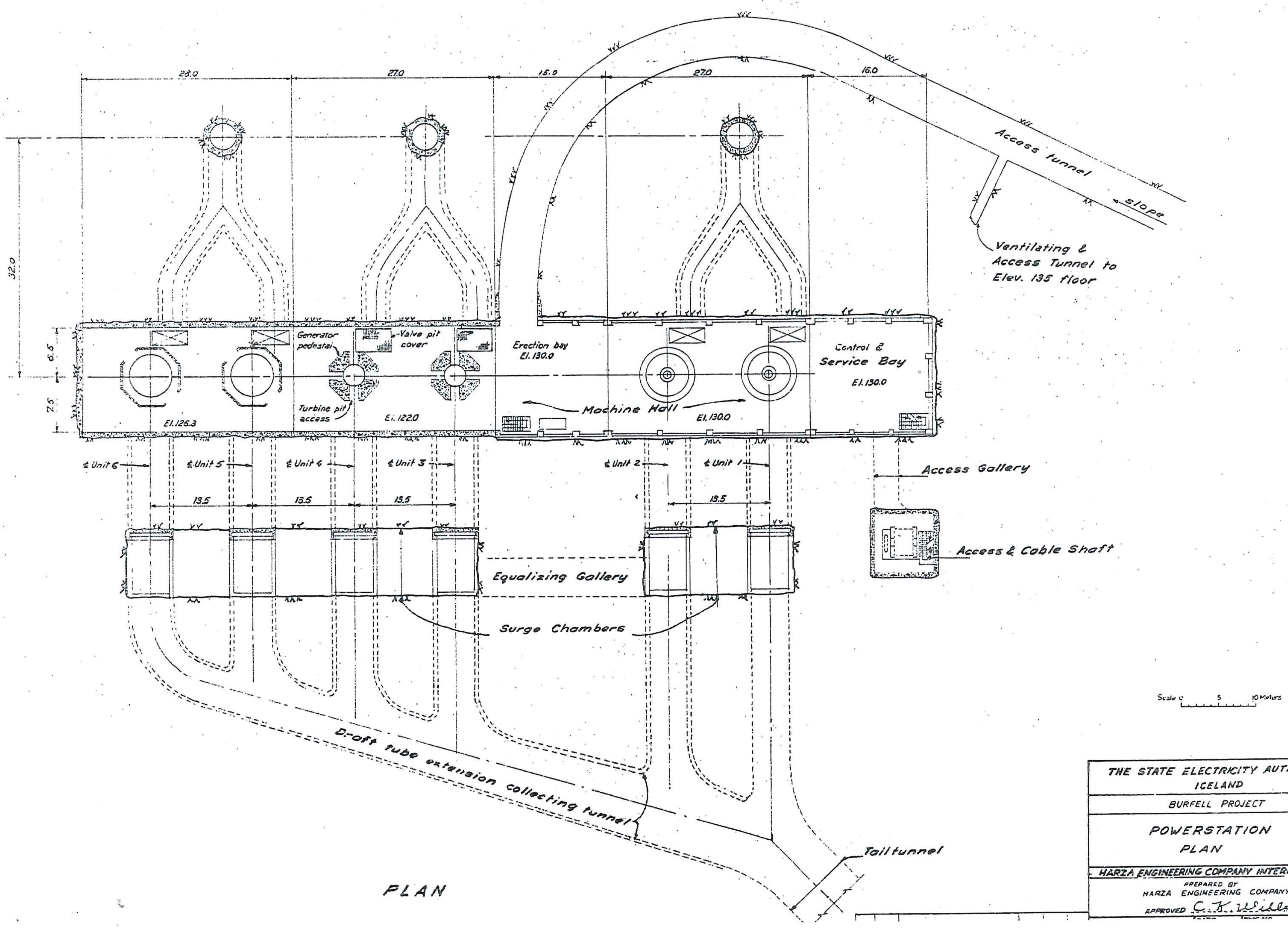
Notes: 1. Numbers indicate number of units per tailtunnel

2. Plus numbers indicate future additions

3. Letters indicate plan designation

4. Investment does not include import duties and taxes

Exhibit S-2



PLAN

THE STATE ELECTRICITY AUTHORITY
ICELAND

BURFELL PROJECT

POWERSTATION
PLAN

HARZA ENGINEERING COMPANY INTERNATIONAL
PREPARED BY
HARZA ENGINEERING COMPANY
APPROVED C. K. Willey

EXHIBIT S-3

BURFELL PROJECT

STAGED DEVELOPMENT

COST ESTIMATES-SUMMARY

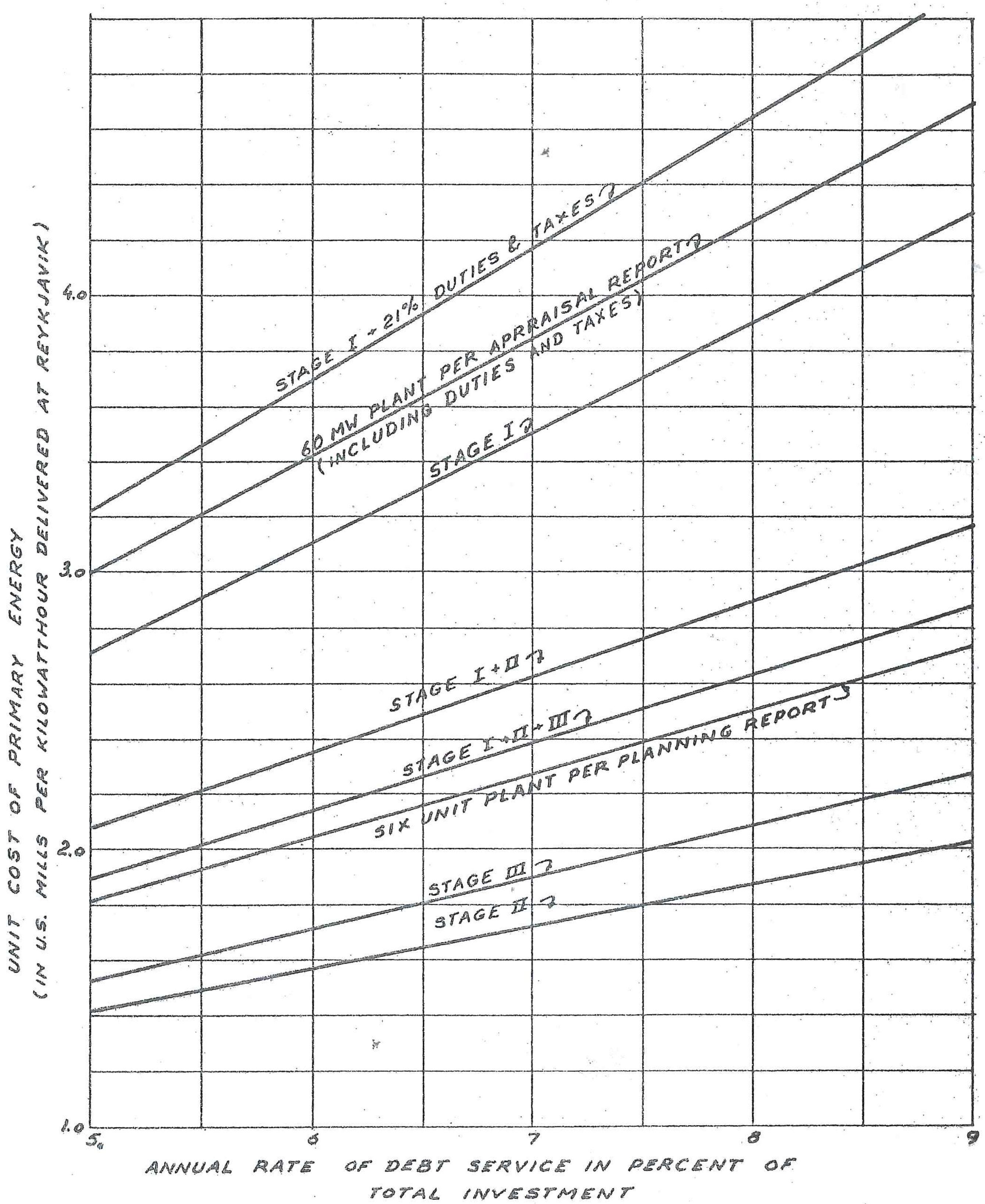
(In United States Dollars)

Item	STAGES I	STAGES II	STAGES III
Production Plant	11,229,600	4,363,750	5,694,400
Transmission Plant			
Burfell Substation	268,000	452,000	313,000
Reykjavik Substation	74,000	300,000	
Transmission Line	1,540,000		
SUBTOTAL DIRECT COST	13,111,600	5,115,750	6,007,400
Contingencies	1,788,400	644,250	742,600
TOTAL DIRECT COST	14,900,000	5,760,000	6,750,000
Engineering and Supervision	1,190,000	460,000	550,000
Preliminary Costs	510,000		
SUBTOTAL	16,600,000	6,220,000	7,300,000
Extra for Incremental	0	320,000	360,000
CONSTRUCTION COST	16,600,000	6,540,000	7,660,000
Interest During Construction	1,650,000	460,000	540,000
STAGE INVESTMENT COST	18,250,000	7,000,000	8,200,000
RATED INSTALLED CAPACITY, kW	60,000	60,000	60,000
Unit Cost-Dollars Per Rated Installed Kilowatt	304	117	137
CUMULATIVE PROJECT INVESTMENT			
Stages I + II		25,250,000	
Stages II + III			15,200,000
Stages I + II + III			33,450,000
CUMULATIVE INSTALLED CAPACITY, kW		120,000	180,000
Cumulative Unit Cost-Dollars Per Rated Installed Kilowatt			
Stages I + II		210	
Stages II + III			127
Stages I + II + III			186

BÚRFELL PROJECT
STAGED DEVELOPMENT EACH SECOND UNIT AS A SUBSTAGE
COST ESTIMATES-SUMMARY (IN UNITED STATES DOLLARS)

STAGE	I		II		III	
SUBSTAGE	A	B	A	B	A	B
Item	First Unit	Increment for Second Unit	First Unit	Increment for Second Unit	First Unit	Increment for Second Unit
Production Plant	10.463.100	766.500	3.583.250	780.500	4.891.900	802.500
Transmission Plant						
Búrfell Substation	268.000	0	452.000	0	313.000	0
Reykjavík Substation	74.000	0	300.000	0	0	0
Transmission Line	1.540.000	0	0	0	0	0
SUBTOTAL DIRECT COST	12.345.100	766.500	4.335.250	780.500	5.204.900	802.500
Contingencies	1.714.900	43.500	584.750	39.500	715.100	42.500
TOTAL DIRECT COST	14.060.000	810.000	4.920.000	820.000	5.920.000	845.000
Engineering and Supervision	1.130.000	80.000	400.000	80.000	480.000	80.000
Preliminary Costs	510.000	0	0	0	0	0
SUBTOTAL	15.700.000	890.000	5.320.000	900.000	6.400.000	925.000
Extra for Incremental	0	40.000	280.000	80.000	320.000	80.000
CONSTRUCTION COST	15.700.000	930.000	5.600.000	980.000	6.720.000	1.005.000
Interest During Construction	1.600.000	70,000	400.000	70.000	480.000	70.000
SUBSTAGE INVESTMENT	17.300.000	1.000.000	6.000.000	1.050.000	7.200.000	1.075.000
TOTAL STAGE DEVELOPMENT		18.300.000		7.050.000		8.275.000
CUMULATIVE INVESTMENT						
Stages I + IIA			24.300.000			
Stages I + II				25.350.000		
Stages I + II + IIIA					32.550.000	
Stages I + II + III						33.625.000

UNIT COST OF ENERGY
STAGED DEVELOPMENT



NOTES:

NO ALLOWANCE MADE FOR INCOME FROM SALES OF SECONDARY ENERGY
IMPORT DUTIES AND TAXES NOT INCLUDED EXCEPT AS NOTED