THE STATE ELECTRICITY AUTHORITY

HESTVATN HYDRO-ELECTRIC PROJECT

POWER STUDIES

by

JAKOB BJÖRNSSON

Reykjavik, July 1961

THE STATE ELECTRICITY AUTHORITY

HESTVATN HYDRO-ELECTRIC PROJECT

POWER STUDIES

by

JAKOB BJÖRNSSON

Reykjavik, July 1961

CONTENTS

POWER STUDIES

1. Introduction

In the following, a forecast of the power consumption in South-Western Iceland for the period 1960-1970 will first be outlined. After that, the results of a study made last winter, of the operation of the proposed Hestvatn Development, interconnected with the existing power plants in the area, to supply the estimated load will be described. This study, which was performed on an electronic computer, was based on the hydrological condition prevailing in the water year 1950/51, which is the driest year of record in the area. The available records (10 - 12 years, with exception of the Sog, where 18 years of record were at hand) are too short to allow any reliable predictions to be made as to how often such a year may be expected, although there are some indications that 95% of years are equal to or better than 1950/51. Since the South-West Iceland Power System is essentially a hydro system, with insufficient thermal capacity to supply a hydro deficit of any size, it was felt warranted to select 1950/51 as a base year for the power study and to treat as secondary any surplus energy available in wetter years. No studies have as yet been performed of the operation of the System under more favourable hydro conditions.

2. Load Growth in South-Western Iceland in the Period 1960-1970

2.1 Load Area

The area included in this forecast is shown on the accompanying map (fig. 4-1). It is planned to extend a transmission network over this area in a few years.

The backbone of this future System will be the existing Sog System (from 5 to 24 on the map, shown in full lines).

The total population of the area was ab. 121,000 on Dec. 1 1959, or 70% of the whole population of Iceland. In the area served by the Sog System there lived 112,000 people on the same date, or 93.5% of the whole population of South-Western Iceland.

2.2 Power Generation, Plant Capacity and Maximum Demand in the Load Area in the Last 6 Years

Table 4-1 shows the gross generation in the area for the years 1954-59, incl.

Table 4-2 shows the generator nameplate rating of power stations in the area.

Table 4-3 shows the maximum demand, MD, for individual power stations and for the Sog System as it was until 1958 (with 5 and 6 excluded from the present network, since information is not available on the coincident MD for the present Sog System).

Table 4-1

Gross power generation in South-West Iceland
1954-59, GWh

Power Plant	Type	1954	1955	1956	1957	1958	1959
Ljósafoss	Hydro	85,9	90,9	102,3	104,5	105,0	110,7
Írafoss	"	166,5	207,2	211,9	213,6	221,5	234,5
Steingrímsstöð	"	-	-	-	-	-	0,2
Elliðaár, hydro	"	5,4	5,0	9,2	9,9	5,9	11,7
Elliðaár, steam	Steam	0,6	0,3	0,2	0,4	1,0	2,8
Andakíll	Hydro	19,7	18.5	19,1	19,2	22,7	25,9
Total, existing Sog System		278,1	321,9	342,7	347,6	356,1	385,8
Annual increase %		.	15.8	6.5	1.4	2.5	8.3
Rjúkandi	Hydro	×1.0	1.2	1.9	2.4	3.3	3.3
Stykkishólmur	Diesel	×0.5	×0.5	×0.5	×0.5	×0.5	0.8
Vestmannaeyjar	"	3.7	4.0	4.2	4.3	4.7	5.2
Vík í Mýrdal	Hydro	×0.4	×0.4	×0.4	×0.4	×0.4	×0.3
Total, S.W. Iceland		283.7	328.0	349.7	355.2	365.0	395.4
Annual increase %		.	15.6	6.6	1.6	2.8	8.3

Subdivision of load:

	1954	1955	1956	1957	1958	1959
General load	191.2	204.7	217.7	228.9	247.4	268.6
Annual increase %	.	7.1	6.3	5.2	8.1	8.6
Fertilizer Plant	92.5	123.3	132.0	126.3	111.3	113.3
Cement Plant	-	-	-	-	6.3	13.5

Average annual increase, 1954-1959 (5 years):

Existing Sog System	6,7%
Whole S. W. Iceland	6.8%
S. W. Iceland, General load	7.0%

× Estimated figure

Table 4-2

Generator nameplate ratings, in MW, of power plants in S. W. Iceland

Power plant	1954	1955	1956	1957	1958	1959
Ljósafoss	14.60	14.60	14.60	14.60	14.60	14.60
Írafoss	31.00	31.00	31.00	31.00	31.00	31.00
Steingrímsstöð	-	-	-	-	-	26.40
Elliðaár, hydro	3.16	3.16	3.16	3.16	3.16	3.16
Elliðaár, steam	7.50	7.50	7.50	7.50	7.50	7.50
Total, Sog System as it was until 1958	56.26	56.26	56.26	56.26	56.26	82.66
Andakíll	3.52	3.52	3.52	3.52	3.52	3.52
Total, present Sog System	59.78	59.78	59.78	59.78	59.78	86.18
Rjúkandi	0.84	0.84	0.84	0.84	0.84	0.84
Stykkishólmur	0.24	0.24	0.24	0.24	0.44	0.44
Vestmannaeyjar	1.74	1.74	2.56	2.56	2.56	2.56
Vík í Mýrdal	0.10	0.10	0.10	0.10	0.10	0.10
Total, S.W. Iceland	62.70	62.70	63.52	63.52	63.72	90.12
Total, Hydro	53.22	53.22	53.22	53.22	53.22	79.62
Total, Steam	7.50	7.50	7.50	7.50	7.50	7.50
Total, Diesel	1.98	1.98	2.80	2.80	3.00	3.00

Table 4-3

MD, in MW, of power plants in S. W. Iceland, 1954-1959

Power plant	1954	1955	1956	1957	1958	1959
Ljósafoss	16.4	16.1	16.3	16.4	16.1	16.2
Írafoss	33.5	33.7	32.7	32.4	32.2	32.4
Steingrímsstöð	-	-	-	-	-	10.2
Elliðaár, hydro	3.1	2.8	3.0	2.9	3.1	3.0
Elliðaár, steam	6.9	3.0	7.7	7.9	8.3	8.2
Total, non-coincident MD of present 1958 Sog System	59.9	55.6	59.7	59.6	59.7	70.0
Coincident MD of pre-1958 Sog System	49.7	51.3	50.4	53.4	65.5	60.3
Diversity Factor of pre-1958 Sog System	1.20	1.08	1.18	1.12	1.06	1.16
Andakíll	3.4	3.6	3.8	3.8	3.9	4.0
Total, non-coincident MD of present Sog System	63.3	59.2	63.5	63.4	63.6	74.0
Rjúkandi	0.3	0.4	0.7	0.9	1.0	0.9
Stykkishólmur	x 0.2	x 0.2	x 0.2	x 0.2	x 0.3	x 0.3
Vestmannaeyjar	1.4	1.5	1.5	1.7	1.7	1.9
Vík í Mýrdal	x 0.1	x 0.1	x 0.1	x 0.1	x 0.1	x 0.1
Total, non-coincident MD of S. W. Iceland	65.3	61.4	66.0	66.3	66.7	77.2

x Estimated figure

2.3 Estimated Load Growth 1960-1970

For the purpose of analysis, the total load is subdivided as follows:

a) General load, i.e. the total load minus the load under b), c) and d)

b) Fertilizer Plant load

c) Cement Plant load

d) Keflavík Airport load

The future trend in each category has been estimated separately.

Table 4-4 shows the estimated annual energy requirements, in GWh, for each year 1960-1970. The estimate is based on the following:

a) An average annual increase of 8% in the General load.

b) A constant Fertilizer Plant load of 135 GWh/year for the whole period.

c) An estimate of the cement requirements in Iceland in the next future, made by the Director of the Cement Plant, for the Cement Plant load.

d) Information from the Technical Dept. of the NATO Air Base at Keflavik Airport about the present load requirements of the Airport and the expected increase during the next few years. (The Airport was connected to the Sog-System early in 1960).

Table 4-5 shows the annual utilization time (annual load factor x 8760 h) for the pre-1958 Sog System.

Table 4-4

Estimated energy requirements of S.W. Iceland 1960-1970, in GWh/year

(All losses included)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
General load	290	313	338	365	395	426	460	497	537	580	626
Fertilizer Plant	135	135	135	135	135	135	135	135	135	135	135
Cement Plant	14.2	14.9	15.5	16.2	16.9	17.7	18.5	19.3	20.4	21.4	22.5
Keflavik Airport	33.0	39.6	42.3	44.0	45.6	47.3	48.9	50.6	52.2	53.9	55.5
Total	472	503	531	560	593	626	662	702	745	790	839

Table 4-5

Annual utilization time of the pre-1958 Sog System hours

Year	1954	1955	1956	1957	1958	1959
UT, hours	5200	5915	6420	6150	5900	5950

The somewhat high UT in 1956 and 1957 is presumably due to a rather high energy consumption by the Fertilizer Plant in these years (cf. Table 4-1). From the estimated energy figures of Table 4-4, it is apparent that the relative magnitude of the Fertilizer Plant and the Cement Plant load is expected to decrease, which would result in a lower UT. Further, the connection to the system of areas still outside it, as the Westman Islands will also tend to lower system UT. On the other hand, due to increased diversity, the load factor of the General load will probably tend to increase somewhat in the future. With all this in mind, the annual UT for the whole S.W. System has been estimated in the range 5500 - 6000 h for the period 1960 - 1970.

Table 4-6 shows estimated MD´s of the S.W. System, based on the energy figures of Table 4-4 and the above UT´s.

The table also shows the MD´s used in the power study. They are based on the application of an annual variation factor (α_a) and a daily variation factor (α_d) to the estimated annual energy requirements, as described later. These last figures show the load factor to diminish with time, consistent with the smaller part played by the Fertilizer Plant in the total load as time goes on, as assumed in the energy forecast.

Table 4-6

Estimated maximum demand on the S.W. Power System 1960 - 1970, MW

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Annual UT 6000 h	79	84	89	93	98	104	110	117	124	132	140
Annual UT 5500 h	86	92	97	102	108	114	120	128	136	144	152
Assumed in power study		84	90	96	103	110	118	127	136	146	156

2.4 Possible Additions to the System

At the moment, the following capacity additions to the System are contemplated or considered possible.

	Type	For base operation	For peaking
1. Additional unit at Irafoss; Sog	Hydro		15.5 MW
2. Additional unit at Ljósafoss; Sog	Hydro		8.5 MW
3. Geothermal plant	Geothermal	15.0 MW	
4. Hestvatn	Hydro	38.4 MW	
5. Dynjandi	Hydro	5.0 MW	
6. Årbæjarfoss	Hydro	4.4 MW	
7. Tungufoss	Hydro	5.8 MW	
8. Additional unit at Elliðaár Steam Station 1)	Steam		10.0 MW

1) The existing boiler capacity at the Station is sufficient for this addition.

In a water year like 50/51, the reference year, the additions to the existing stations on the Sog would give only a negligible increase in energy, and, thus, would be a pure peaking capacity. The geothermal plant is inherently a base load plant, since there are no practical means of storing geothermal steam. Hestvatn is here listed as a base load capacity, although, by installing a third unit, it may also be operated on the intermediate part of the load curve without reducing its energy output in a reference year. The three small hydro stations are all best fitted for base load operation, whereas the Elliðaár steam station would, of course, be used for peaking only.

The above list is not intended to show any contemplated or assumed sequence of capacity additions to the System.

3. System Operation Study

3.01 General

The study, described below, in fact only constitutes the first phase of more elaborate studies, that will be necessary to carry out in connection with the planning of new power plants in South-West Iceland. Its primary aim was to establish, for several of the capacity additions to the System mentioned above, the amount of energy a new plant could supply to the System, in a reference year, when operated interconnected with the existing generating facilities. The computer program was so constructed as to secure maximum utilization of the stream flow and the storage facilities available. In a practical operation, of course, part of the storage space would be used to render the installed capacity of the hydro stations firm, while the remaining space would be used to secure maximum energy output. The program, therefore, may need some modifications for studies where capacity rather than energy is the prime factor. It is not believed, however, that the possible energy output of each station would be materially affected by such a modification of the program.

3.02 Assumed Load

The assumed load data are taken from the forecast described above, with the energy figures modified to apply to a water year (Sept 1 - Aug 31) instead of a calender year. The energy requirements of a water year were then divided into two parts, viz

a) General load + Cement Plant load + Keflavik Airport load.

b) Fertilizer plant load.

To the annual load figure for a) was then applied an annual variation factor (αa), expressed as the portion of the annual energy that was generated on a particular day. This resulted in an energy figure for each day of the year, which figure, in turn, was multiplied by a daily variation factor (αd) indicating how great a part of the daily energy is generated in each hour of the day.

For the Fertilizer Plant a constant daily load of 370,000 kWh was assumed, corresponding to an annual consumption of 135 GWh/year. A daily load curve for the Fertilizer Plant was then applied.

In this manner, for each hour of the year, a figure for the load under a) and another for the load under b) the Fertilizer Plant are obtained. Addition of these figures then gives the total load or average demand on the System for each hour of the year.

The annual variation and daily variation factors for the general load + Cement Plant load + Keflavik Airport load, which are shown graphically in fig. V4-1; 2 and V4-1; 3, respectively, were derived from a study of the load pattern of the Sog System during the last 4 years. The daily load curve for the Fertilizer Plant (Fig. V4-1; 4) was based on a similar analysis of the load of that plant during the same period. (In figs. V4-1; 2 and V4-1;3 the term "general load" is used to indicate the load under a), i.e. it comprises the Cement Plant load and the Keflavik Airport load. In these figures, the term has a different meaning from that ascribed to it in the load forecast above).

3.03 Existing Power Plants Included in the Study

The following existing hydro plants in South-West Iceland were included in the system operation study:

Steingrímsstöð	26.40	MW
Ljósafoss	14.60	"
Írafoss	31.00	"
Andakíll	3.52	"
Elliðaár hydro	3.16	"
Total	78.68	MW

or 98.8% of the total hydro capacity of the System.

For convenience, the remaining two small hydro stations were excluded from the study.

Since, as stated above, the primary aim of the study was to assess the amount of hydro energy available to meet the requirements of the System in a reference year, the fuel-fired stations were taken into account in the following ways only:

1) System demands in excess of the total installed capacity of the hydro stations were allocated to the fuel-fired stations, without regard to their installed capacity. By comparing the maximum hourly load thus placed on these stations with their capacity, however, a deficit in total System capacity is readily ascertained.

2) When the flow at the hydro stations as modified by storage is insufficient to meet system demand the deficit is again allocated to the fuel-fired stations.

The two categories of fuel-fired station loading were kept separated and each summed throughout the year. In that way, both the annual peaking generation of the fuel-fired station and the yearly amount of water deficit at the hydro stations are obtained.

3.04 New Generating Facilities Studied

The program was run for three additions to the existing plants, viz a third unit in the Irafoss, the geothermal plant and Hestvatn. In each case, the study was made for several years, each time with a new annual load figure.

The geothermal plant was treated as a hydro station without any pondage and with a constant flow corresponding to its installed capacity of 15 MW, except for two summer months when maintenance was scheduled, with one of the two units of the plant taken from service at a time. During that time, the flow was assumed only one half of that during the remainder of the year.

For Hestvatn, the following values for the basic data were used:

1. Discharge of Hvítá River: The records of the water year 1950/51. (For the other hydro stations the flow records of the respective rivers for the same water year were applied. In the case of the Ljósafoss & Írafoss, the inflow for the hour under consideration was taken as the output of the upstream Steingrímsstöð plant during the preceding hour).
2. Head. Since the principal aim of the study was the annual energy output, an average figure (16.0 m) was used for the

net head, of the plant. According to Thoroddsen's report, however, the average net head of the plant will be about 15.6 m. This figure was obtained as follows (see also Thoroddsen's report).

Average Gross head	49.5 - 33.0 =	16.5 m
÷ 25% of max. reservoir drawdown, 1.9 m	0.5 m	
÷ head loss in the headrace canal at 25% drawdown	0.4 m	0.9
Average net head		15.6 m

Since the difference between this head and that assumed in the system operation study is small the results may be adjusted by multiplying them by the ratio $\frac{15.6}{16.0}$

3. Pondage. A pondage space in Lake Hestvatn of 12 Gl corresponding to a drawdown of the Lake of some 1.9 m, was assumed, but no other storage in Hvítá River or its upstream tributaries. The effect of storage in Lake Apavatn and/or Lake Hvítárvatn will require additional studies.

4. Installed capacity. An installed capacity of 33.0 MW was assumed. After the study was completed, however, the rating of the plant was increased to 38.4 MW, the figure stated in Thoroddsen's report. The study therefore has to be repeated with the latter figure for installed capacity. However, in a dry year like 1950/51 and with Lake Hestvatn as the only storage, the energy output will be very little affected by this change in the figure for installed capacity. In table 4-8, below, column 9 will be affected by this discrepancy, but since those figures are small it is not important. In col. 14 this difference has been taken into account, so that this column shows the correct figures.

3.05 Data for Existing Plants

For the existing hydro plants in the area, average figures, similar to those selected for Hestvatn were employed. Their values, together with those of Hestvatn and the geothermal plant, discussed above, are listed in the following table.

Table 4-7

Data for hydro plants included in the System operation study

Plant	Average net head m	Average overall efficiency %	Energy content of water		Inst. capac. MW	Size of pond	
			MWh/Gl	MW/kl/s		Gl	MWh
Steingrímsstöð	20.5	88	49.1	0.177	26.4	124.0	6100
Ljósafoss	16.6	79	35.7	0.129	14.6	} 1.36	160
Írafoss	36.8	84	82.0	0.303	31.0		
Elliðaár hydro	...	...	80.6	0.300	3.16	2.3	187
Andakíll	...	...	115.8	0.417	3.52	10.2	1180
Hestvatn	16.0	81	35.3	0.127	33.0	12.0	424
Geothermal plant	.	.	.	.	15.0	0	0

3.06 Loading Sequence

In running the program, the individual stations were loaded in the following way:

1. The stations were considered in the following order:
   Steingrímsstöð
   Geothermal plant (when included)
   Andakíll
   Elliðaár hydro
   Hestvatn (when included)
   Ljósafoss + Írafoss

2. For each station, it was first ascertained whether or not its pond would be filled during the hour under consideration if no load was placed on that station. If so, for that hour, the station was loaded, either to full capacity, or until total System demand was met or until its pond was empty, depending on which of the three was the limiting factor. If not, the station was not loaded until the same question had been answered for all the stations. The purpose of this was to prevent water from spilling over at some stations while reservoirs were being tapped at others. After this, if the requirements of the System for the hour had not been met, the stations where there would be no spillover were then loaded, in the sequence shown, again up to the limits posed by the deciding one of the above three factors.

   By this procedure, when there would be a spillover at some of the hydro stations, it tends to occur at those last in the loading sequence. The loading sequence, therefore, at times of excess flow at the hydro stations considered as a whole, will affect the distribution of generation between the hydro plants, but only during such periods. It will not affect the total hydro generation, and is therefore unimportant for our present purposes.

For further information, the flow chart of the program (Fig. V4-1; 5) should be consulted.

3.07 Results

The results of the study is shown in table 4 - 8.

The first column shows the years (water years) for which runs were made. For the two first years, only the existing power plants were considered to be in operation, but from 1962 - 63 onward a third unit in the Írafoss plant was assumed.

The next three columns show the generation of the Sog stations. In the study, the Ljósafoss and Írafoss were treated as a single plant, since the pondage between them is negligible.

Columns 5 - 8 show the energy generated by the other hydro stations and by the geothermal plant. Col. 9 shows the peaking generation of the fuel-fired plants, while col. 10 shows the fuel generation due to water deficit at the hydro plants. Col. 11 shows total fuel generation (col. 9 + col. 10) and col. 12 shows total generation, hydro geothermal and fuel, which, of course, is equal to the estimated system requirements.

The last two columns show maximum demand, Col. 13 shows maximum System demand, while col. 14 shows the maximum peaking demand on the fuel-fired stations. This last column was found by subtracting the total capacity of the hydro and geothermal stations from System peak.

Two runs were made with the existing power plants alone, for the water years 60/61 and 61/62. Then, two more runs were carried out with the third unit in the Írafoss plant, 62/63 and 63/64.

After that, two alternative capacity additions were considered, and, finally, both these two alternatives in a different time sequence, as shown in the table. In each case, col. 11 shows how the deficit at the hydro stations increases with time.

Since, as previously stated, Ljósafoss + Írafoss were the last plants in the loading sequence, spillover at some of the hydro stations will mainly occur there when running the program. That is the reason for the relatively more fuctuating generation figures in col. 3 than in the other columns. However, this will not affect the figure for the total hydro generation on the System.

The table shows that when, for a given hydro capacity, the program is run for successive years, the figures in cols. 2 - 7 tend to increase, indicating a greater part of the energy of the flowing water that is utilized on load. However, as was to be expected, the corresponding growth in the necessary fuel generation (col. 11) quickly sets a practical limit to this improvement in water utilization.

3.08 When Must New Hydro Capacity be Added to the System?

The figures in table 4-8, col. 11, show that 56.6 GWh of fuel generation will be required in 1963/64 to make good the water deficit at the hydro stations, assuming the hydrological conditions of the base water year. Although not shown in the table, this energy will have to be generated in the winter months. With the existing thermal capacity of the System, ab. 10.6 MW, this would correspond to a running time of ab. 5200 h at full capacity. That energy, therefore, cannot be generated in the existing thermal stations. By installing a new 10 MW unit in the Elliðaár Steam Station, however, as mentioned earlier, this might be accomplished. The boiler capacity of this Station will also be used to meet the demand of the Hot Water Supply during cold periods, when it will be unavailable for power generation. Taking this into account, the amount of power that the steam station could generate after installation of the 10 MW unit has been estimated at ab. 44 GWh. The remaining 12.6 GWh could possibly be generated by the other ghermal stations.

Considering the inevitable uncertainty in an energy forecast of the type described earlier, therefore, it appears that provisions should be made to have a new hydro or geothermal power plant in the area ready for operation not later than by the fall of 1964.

3.09 Energy Output of the Hestvatn Plant

Since only a daily pondage is available in Lake Hestvatn, the maximum amount of energy the Hestvatn power plant could generate in a base water year, assuming no upstream storage and no load limitations, may be computed from the flow-duration curve for that water year. The result is ab. 205 GWh/year, based on an installed capacity of 38.4 MW. The figures in table 4-8 range between 201-206.4 GWh, based on an average net head of 16.0 m and an installed capacity of 33.0 instead of 38.4 MW. This corresponds to 196-201 GWh at a net head of 15.6 m, as assumed here. Without going into details unwarranted in this connection, therefore, a figure of 200 GWh/base water year of power, firm to the assumed load, may be given as the possible output of the Hestvatn plant when operated intergrated with the existing hydro plants.

3.10 Capacity of the Hestvatn Plant

As stated above, an installed capacity of 38.4 MW has been assumed for the Hestvatn power plant. The cost estimates in Thoroddsen's Report are also based on this figure. Another cost estimate was made for a 50% more capacity or 57.6 MW, to access the incremental cost of this increase.

Assuming an energy output of 200 GWh, the 38.4 MW correspond to an annual plant factor of ab. 60% or an annual UT of 5200 hours.

In a base water year, and with an installed capacity of some 30 MW or more, the size of capacity will essentially affect the plant factor only and not the energy output.

Undoubtedly, in the final design, the figure for installed capacity will need some more consideration and will possibly be somewhat modified from what has been assumed here.

4. Acknowledgement

The writer wishes to express his thanks to Mr. Helgi Sigvaldason, M. Sc. M. E., of the State Electricity Authority, for his important constribution to this study. Mr. Sigvaldason wrote the computer program, prepared much of the data and supervised the actual computations.

Sincere thanks are also due to Mr. N.I. Bech, director of the Danish Computation Centre in Copenhagen, who generously made their DASK electronic computer available for this job free of change.

Table 4 - 8

South-West Iceland Power System Operation Study

(Note: Based on water years, Sept 1st - Aug 31st)

1. Existing plants + additional unit at Írafoss from 62-63 onward

Year	Power generation GWh											Max. demand, MW	
	SOG							Fuel-fired plants					
	Stein-grímsstöð	Írafoss + Ljósafoss	Sog total	Anda-kíll	Elliða-ár	Hest-vatn	Geo-thermal	Peaking	Hydro deficit	Total, fuel	Total generation	System	Fuel-fired plants
1	2	3	4	5	6	7	8	9	10	11	12	13	14
60-61	142.8	311.4	454.2	19.2	8.5	.	.	-	13.1	13.1	495.0	83.5	-
61-62	143.1	323.9	467.0	19.4	8.4	.	.	1.0	26.2	27.2	522.0	89.5	4.1
62-63	144.9	342.2	487.1	20.5	8.6	.	.	-	34.8	34.8	551.0	95.9	-
63-64	147.0	349.0	496.0	20.7	8.7	.	.	0.2	56.4	56.6	582.0	102.7	1.8

2. Hestvatn Power Plant completed before Sept 1st 1964

64-65	142.8	244.3	387.1	18.5	8.4	201.0	.	-	-	-	615.0	110.0	-
65-66	142.8	271.3	414.1	19.0	8.4	203.2	.	-	6.3	6.3	615.0	117.9	-
66-67	142.8	290.6	433.4	19.4	8.4	204.5	.	-	24.3	24.3	690.0	126.6	-
67-68	142.9	309.8	452.7	19.6	8.5	205.4	.	0.1	44.7	44.8	731.0	135.6	1.9
68-69	143.3	324.1	467.4	19.8	8.5	206.4	.	0.9	73.0	73.9	776.0	145.5	11.6

3. Geothermal power plant completed before Sept 1st 1964

64-65	142.8	316.5	459.3	19.3	8.6	.	120.4	-	7.4	7.4	615.0	110.0	-
65-66	143.3	334.2	477.5	19.9	8.4	.	120.4	0.1	24.7	24.8	651.0	117.9	2.0

4. Hestvatn completed before Sept 1st 1964 and the geothermal plant before Sept 1st 1967

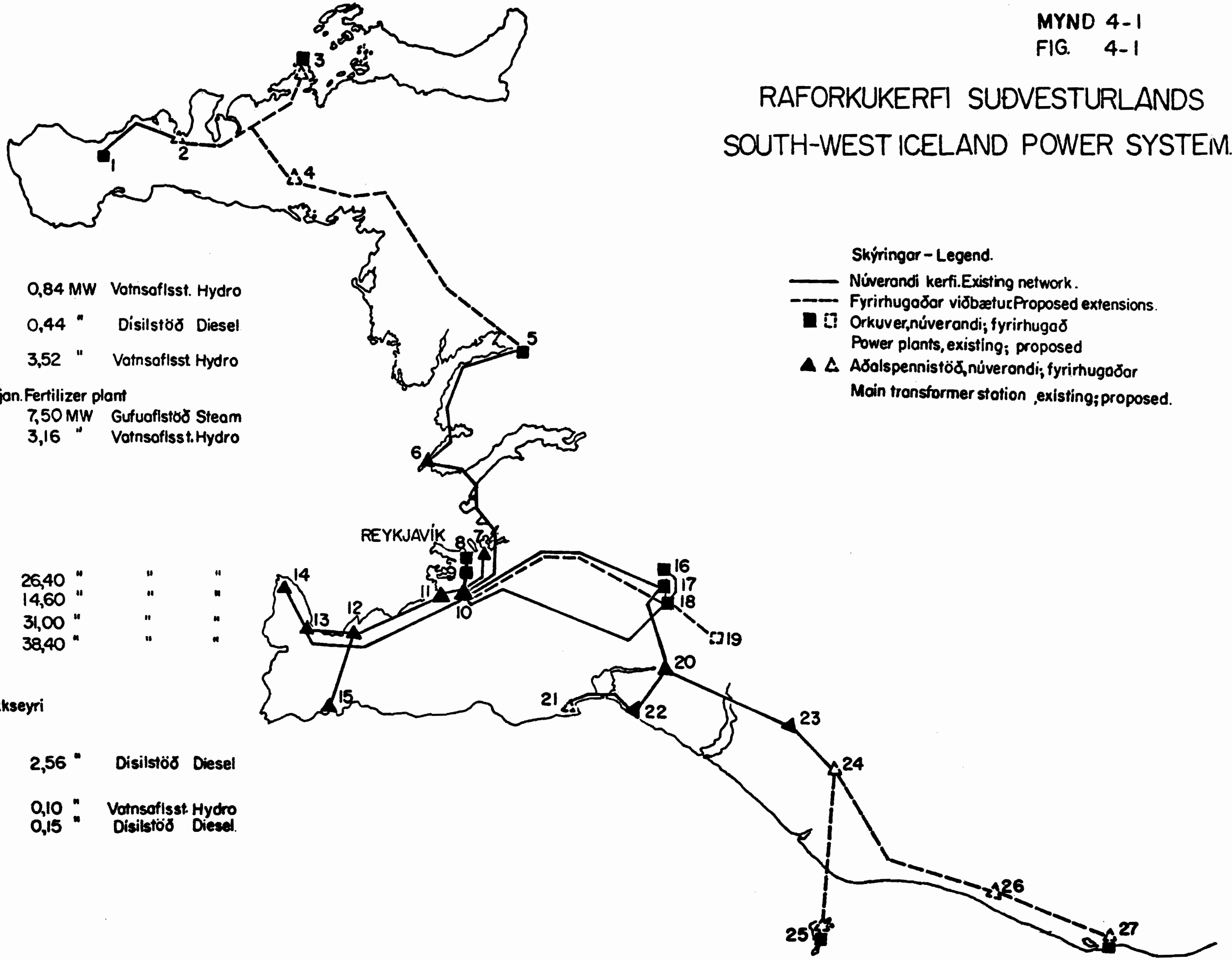
64-65	142.8	244.3	387.1	18.5	8.4	201.0	.	-	-	-	615.0	110.0	-
65-66	142.8	271.3	414.1	19.0	8.4	203.2	.	-	6.3	6.3	651.0	117.9	-
66-67	142.8	290.6	433.4	19.4	8.4	204.5	.	-	24.3	24.3	690.0	126.6	-
67-68	142.7	243.7	386.4	18.4	8.3	197.5	120.4	-	-	-	731.0	135.6	-
68-69	142.8	271.6	414.4	19.2	8.4	201.6	120.4	0	12.0	12.0	776.0	145.5	-
69-70	142.8	294.3	437.1	19.4	8.4	204.1	120.4	0.2	34.4	34.6	824.0	156.1	7.2

5. Geothermal plant completed before Sept 1st 1964 and Hestvatn before Sept 1st 1966

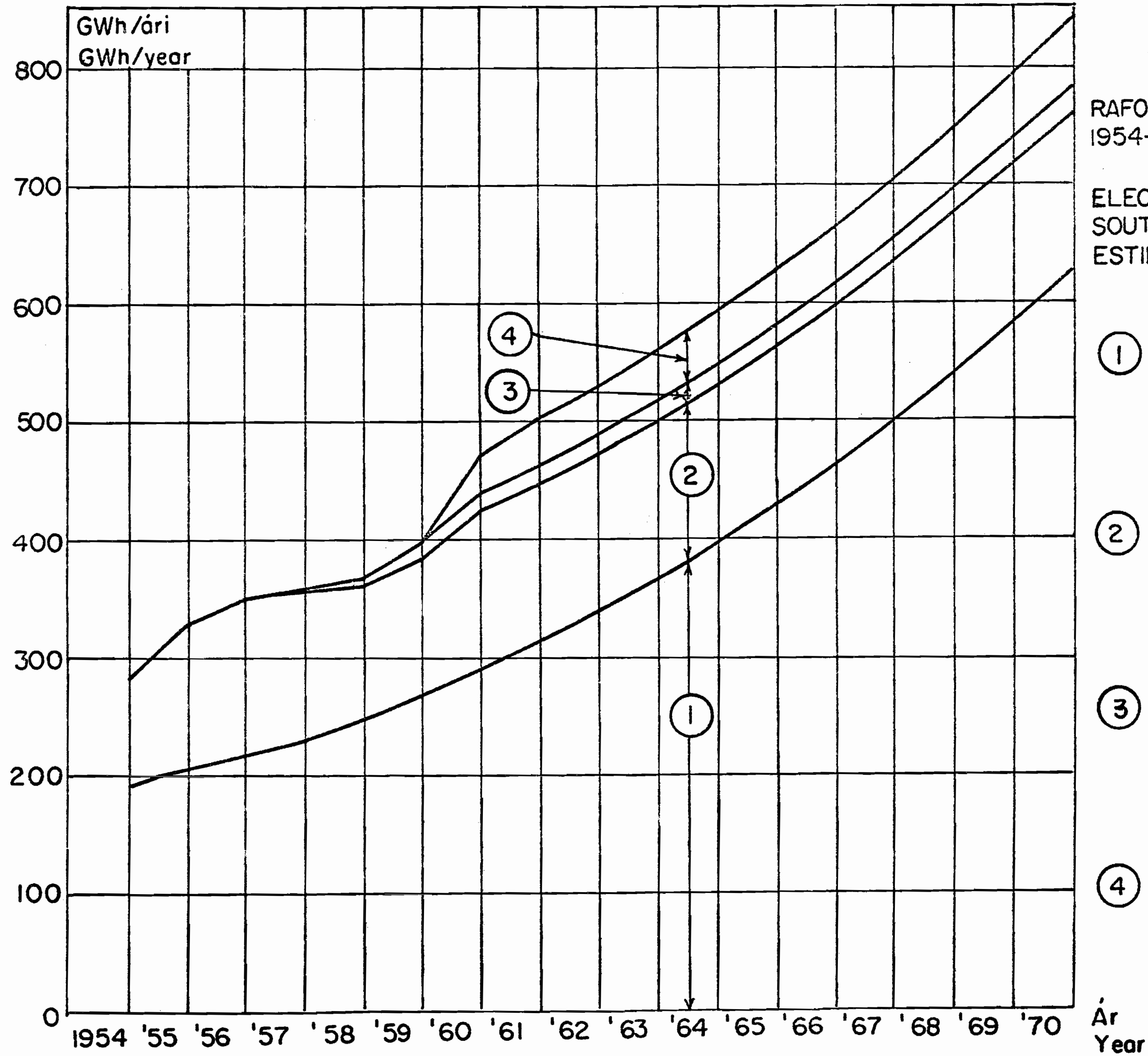
64-65	142.8	316.5	459.3	19.3	8.6	.	120.4	-	7.4	7.4	615.0	110.0	-
65-66	143.3	334.2	477.5	19.9	8.4	.	120.4	0.1	24.7	24.8	615.0	117.9	2.0
66-67	142.8	206.8	349.6	18.4	8.3	193.3	120.4	-	-	-	690.0	126.6	-
67-68	142.7	243.7	386.4	18.4	8.3	197.5	120.4	-	-	-	731.0	135.6	-
68-69	142.8	271.6	414.4	19.2	8.4	201.6	120.4	0	12.0	12.0	776.0	145.5	-
69-70	142.8	294.3	437.1	19.4	8.4	204.1	120.4	0.2	34.4	34.6	824.0	156.1	7.2

MYND 4-1
FIG. 4-1

RAFORKUKERFI SUÐVESTURLANDS
SOUTH-WEST ICELAND POWER SYSTEM.



1. Rjúkandi,	0,84 MW	Vatnsaflsst.	Hydro
2. Grafarnes			
3. Stykkishólmur,	0,44 "	Dísilstöð	Diesel
4. Vegamót			
5. Andakíll	3,52 "	Vatnsaflsst	Hydro
6. Akranes			
7. Áburðarverksmiðjan. Fertilizer plant			
8. Varastöð	7,50 MW	Gufuaflstöð	Steam
9. Elliðaár	3,16 "	Vatnsaflsst.	Hydro
10. Elliðaár			
11. Hafnarfjörður			
12. Vogar			
13. Keflavík			
14. Gerðar			
15. Grindavík			
16. Steingrímsstöð	26,40 "	"	"
17. Ljósafoss	14,60 "	"	"
18. Írafoss	31,00 "	"	"
19. Hestvatn	38,40 "	"	"
20. Selfoss			
21. Þorlákshöfn			
22. Eyrarbakki-Stokkseyri			
23. Hella			
24. Hvolsvöllur			
25. Vestmannaeyjar	2,56 "	Dísilstöð	Diesel
26. Skógar			
27. Vík í Mýrdal	0,10 "	Vatnsaflsst.	Hydro
	0,15 "	Dísilstöð	Diesel



MYND 4-2
FIG 4-2

RAFORKUÞÖRF Á SUÐVESTURLANDI 1954-'59 OG ÁÆTLUÐ ÞÖRF 1960-1970.
(Öll töp meðtalin)

ELECTRIC ENERGY REQUIREMENTS IN SOUTH-WEST ICELAND 1954-'59 and ESTIMATED REQUIREMENTS 1960-1970
(All losses included)

(1) Almenn notkun
General Load

(2) Áburðarverksmiðjan
Fertilizer Plant

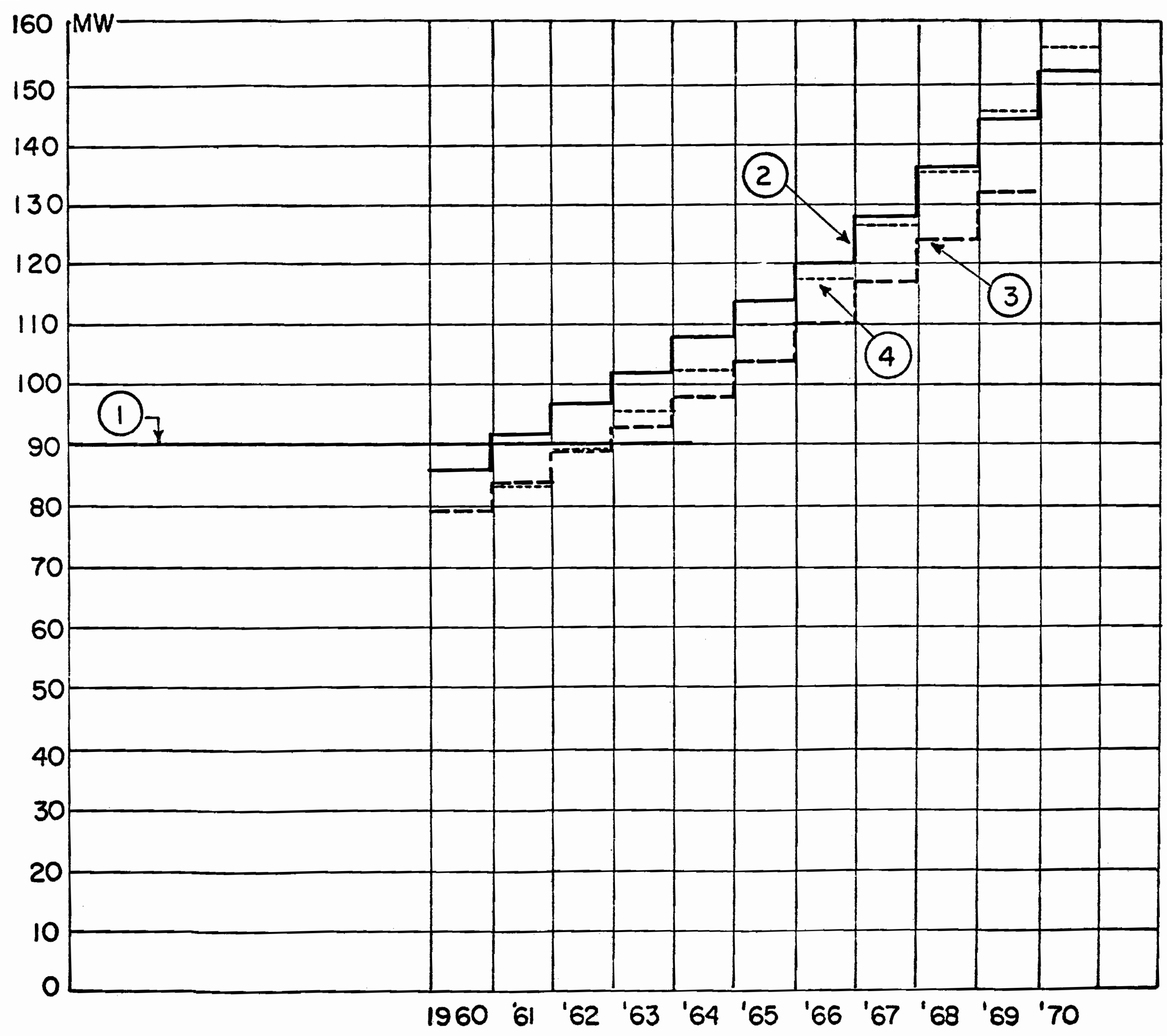
(3) Sementsverksmiðjan
Cement Plant

(4) Keflavíkurflugvöllur
Keflavík Airport

MYND 4-3
FIG. 4-3

ÁÆTLAÐ MESTA ÁLAG Á RAFORKUKERFI SUÐVESTURLANDS 1960-1970.

ESTIMATED MAXIM.DEMAND IN THE SOUTH-WEST ICELAND POWER SYSTEM 1960-1970.



(1) Núverandi upps.afl í kerfinu, 90,12 MW
Present System Capacity 90,12 MW

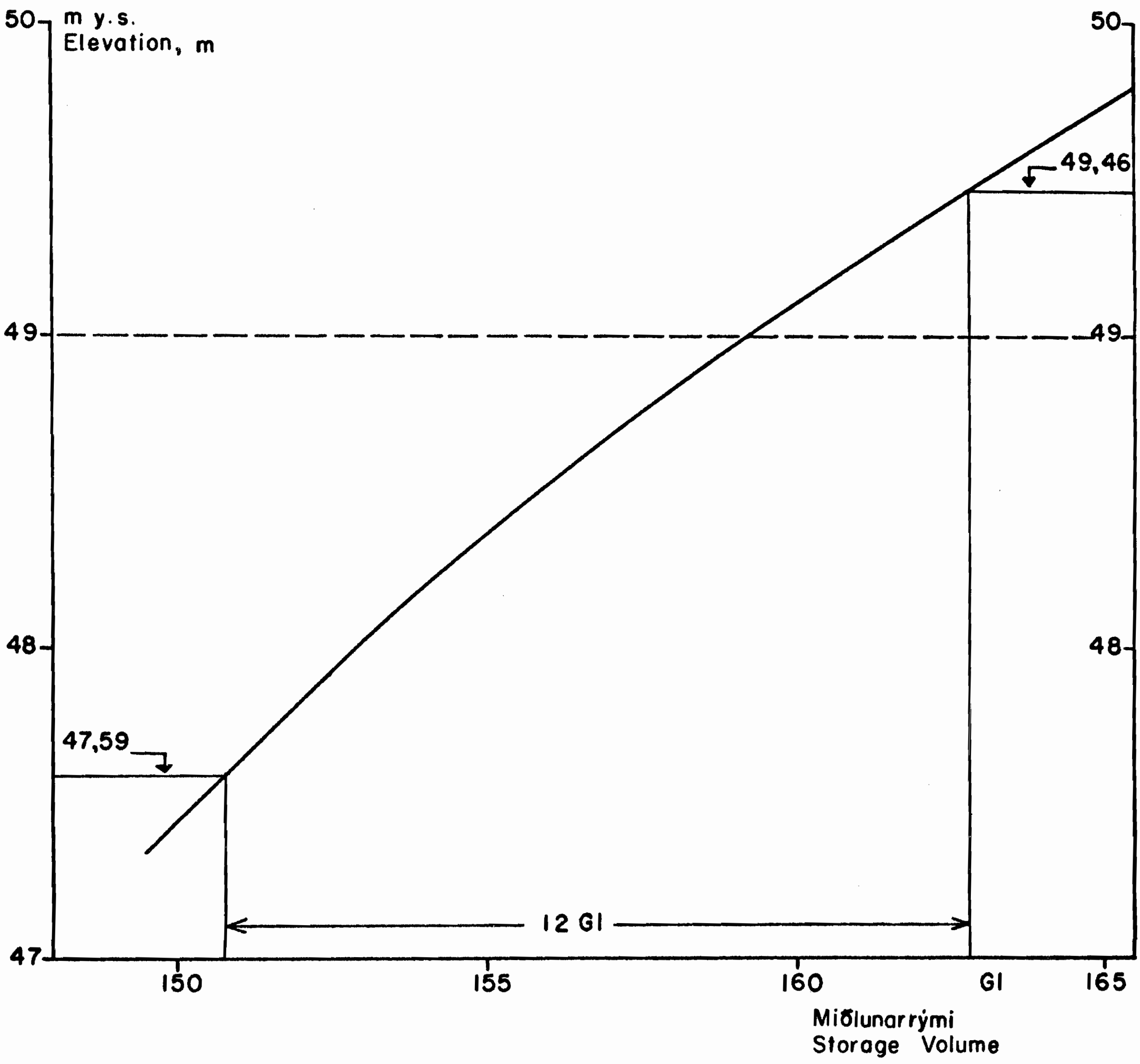
(2) Árlegur nýtingartími 5500h
Annual utilization time 5500h (Load Factor 63%)

(3) Árlegur nýtingartími 6000 h
Annual utilization time 6000h (Load Factor 68,5%)

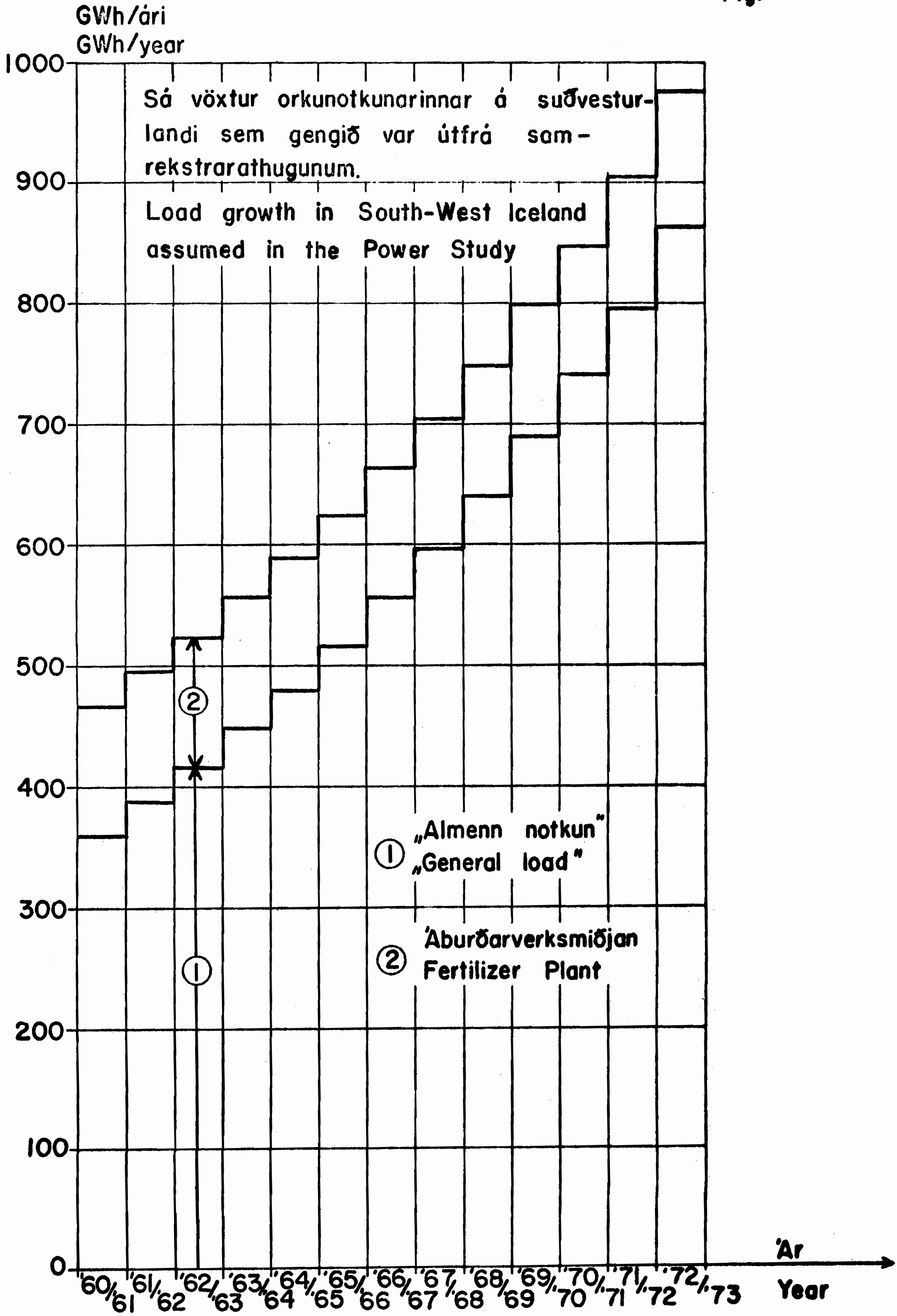
(4) Reiknað með þessu í samrekstrarathugun
Assumed in Power Study

Miðlunarrými í Hestvatni og Hvítá
þegar tillit er tekið til aurburðar

Storage Volume in Lake Hestvatn
and Hvítá River, after Reduction
by Sedimentation



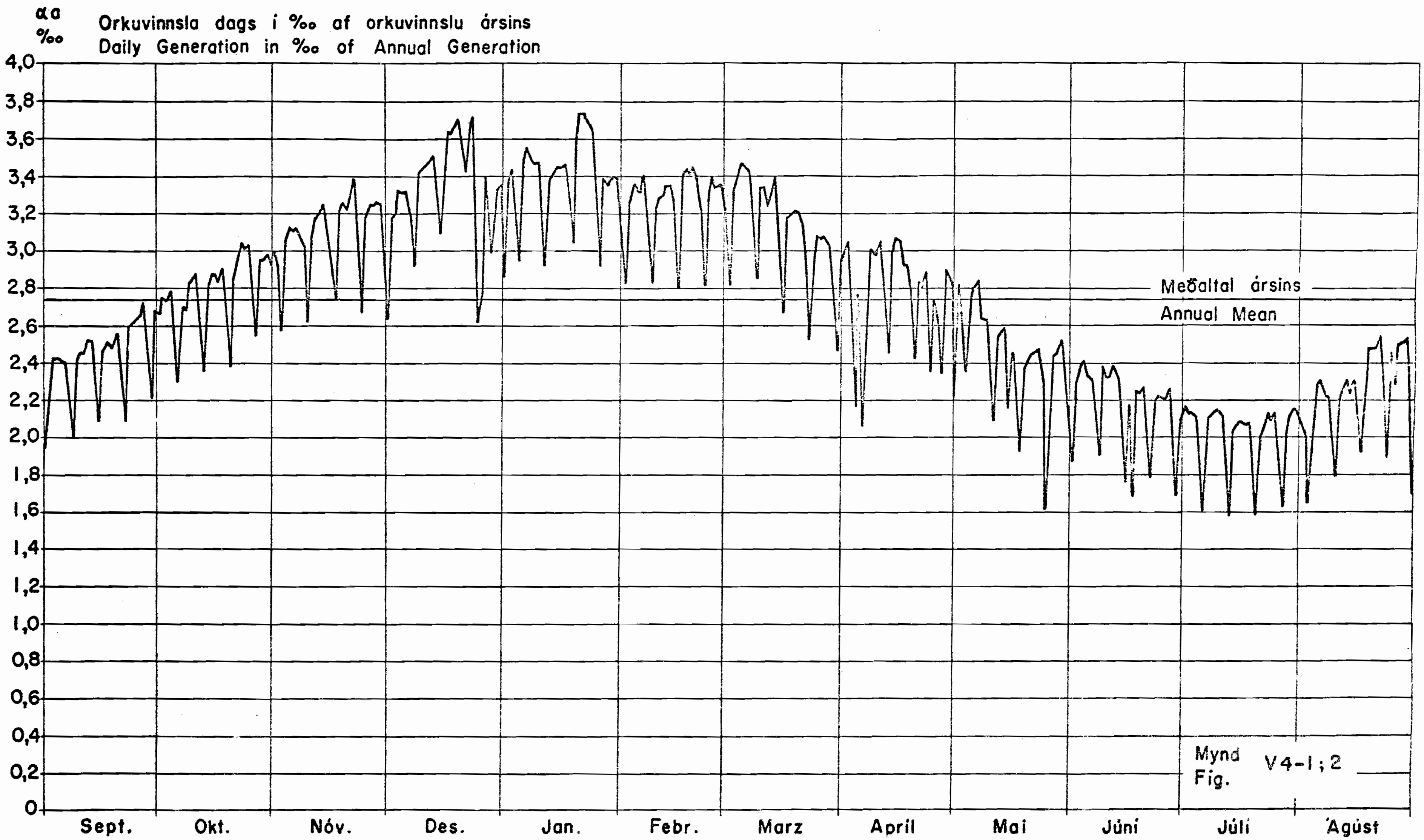
Mynd
Fig. V4-I ; I



13.2.'61 H.S./O.H. B-O Tnr.215 Fnr.5336

Sveiflur almennrar notkunar frá degi til dags, α_a

Annual Variations in General Load, α_a



Mynd / Fig. V4-1;2

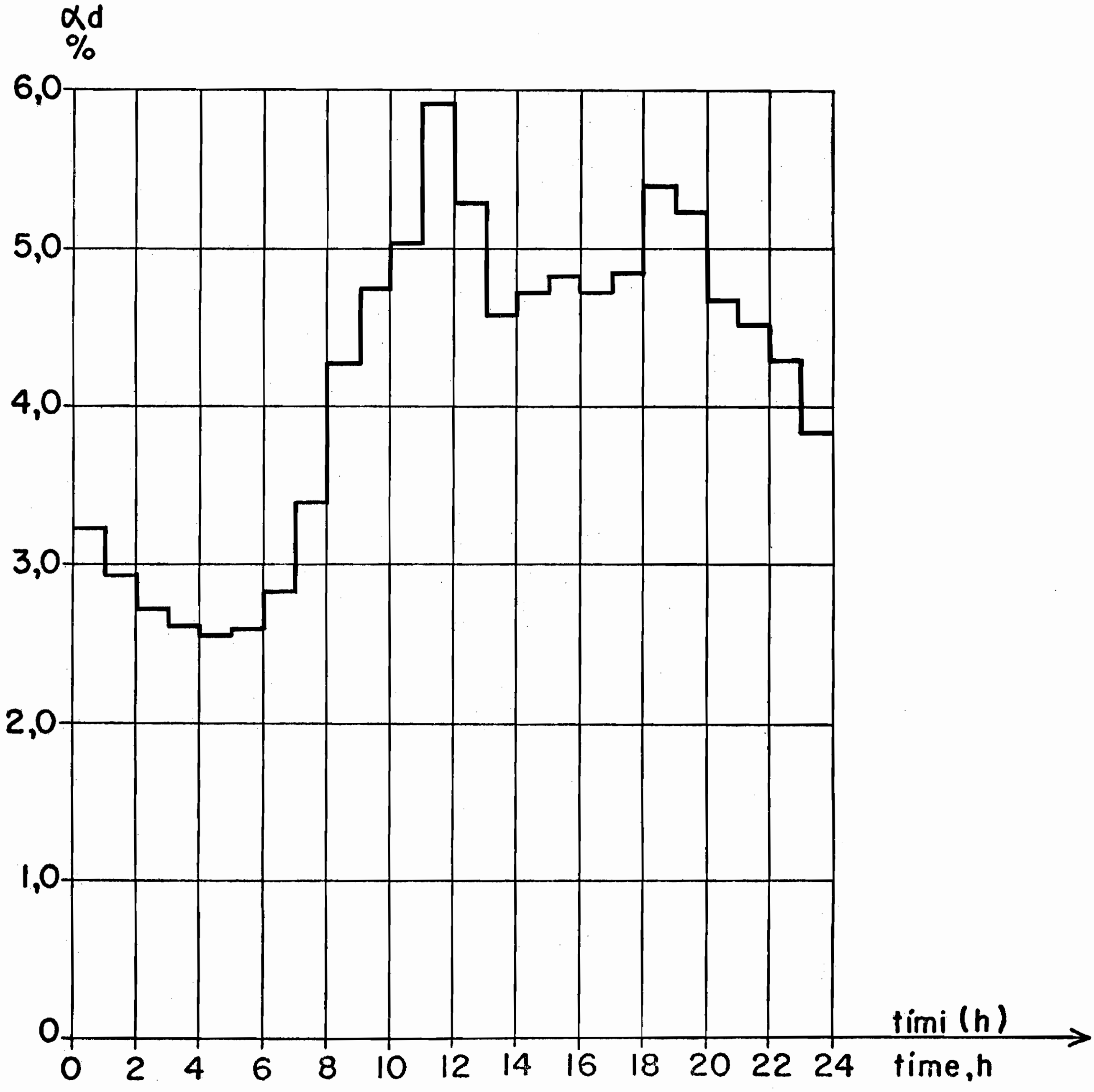
13.2.'61 H.S./O.H. B-O Tnr. 216 Fnr. 5337

Mynd
Fig. V4-1;3

Dægurálagslína almennrar notkunar, α_d
Daily Load Curve, General Load, α_d

Orkuvinnsla klukkustundar í %
af orkuvinnslu dagsins.

Hourly Generation in %
of Daily Generation.

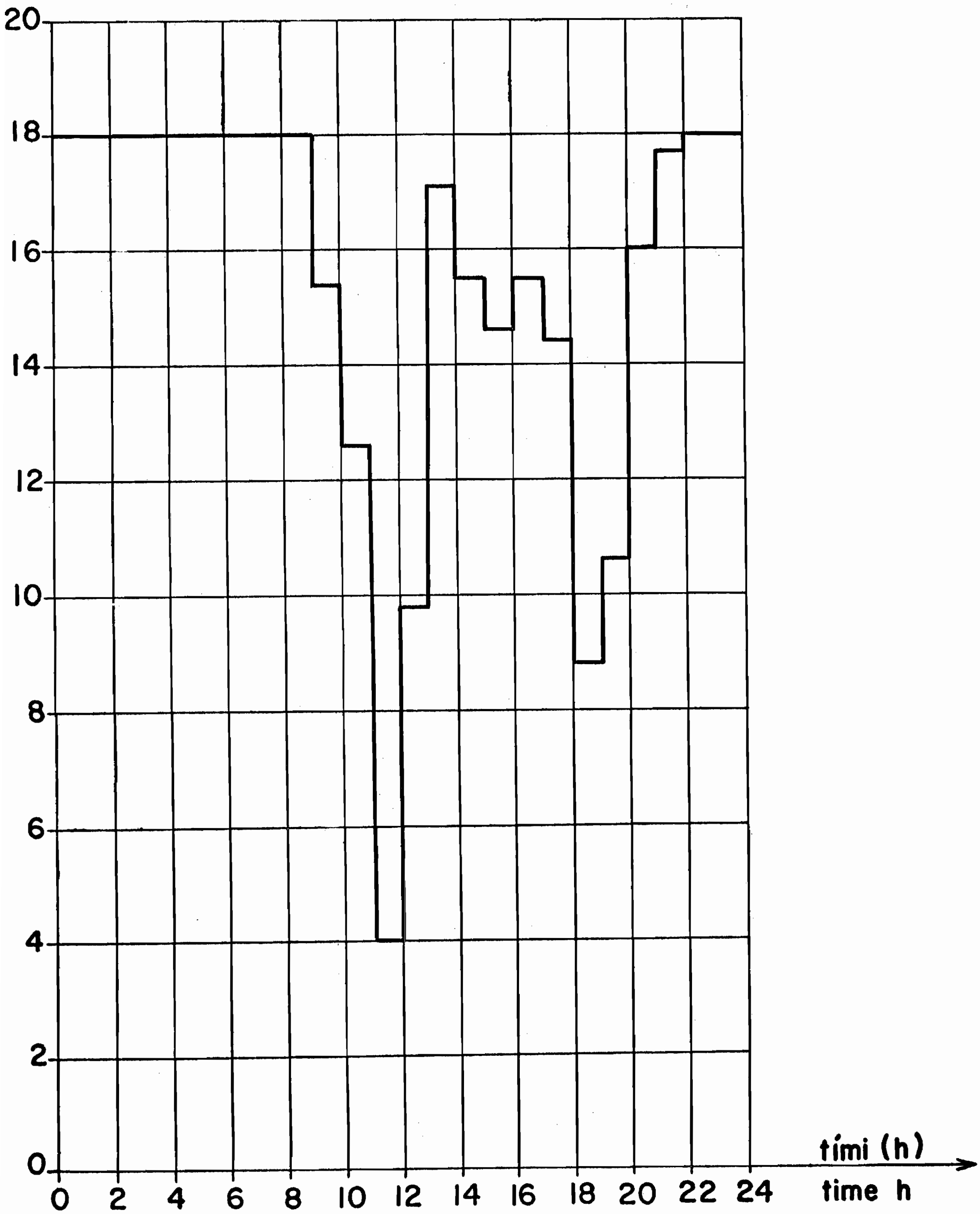


13.2.'61 H.S./O.H. B-O Tnr. 217 Fnr. 5338

Dægurálagslina fyrir Áburðarverksmiðju, MW
Daily Load Curve; Fertilizer Plant, MW

Ath: Konstant dagsnotkun 370 MWh = 135 GWh/ári
Note: Constant Daily Load 370 MWh = 135 GWh/year

Álag
Demand MW

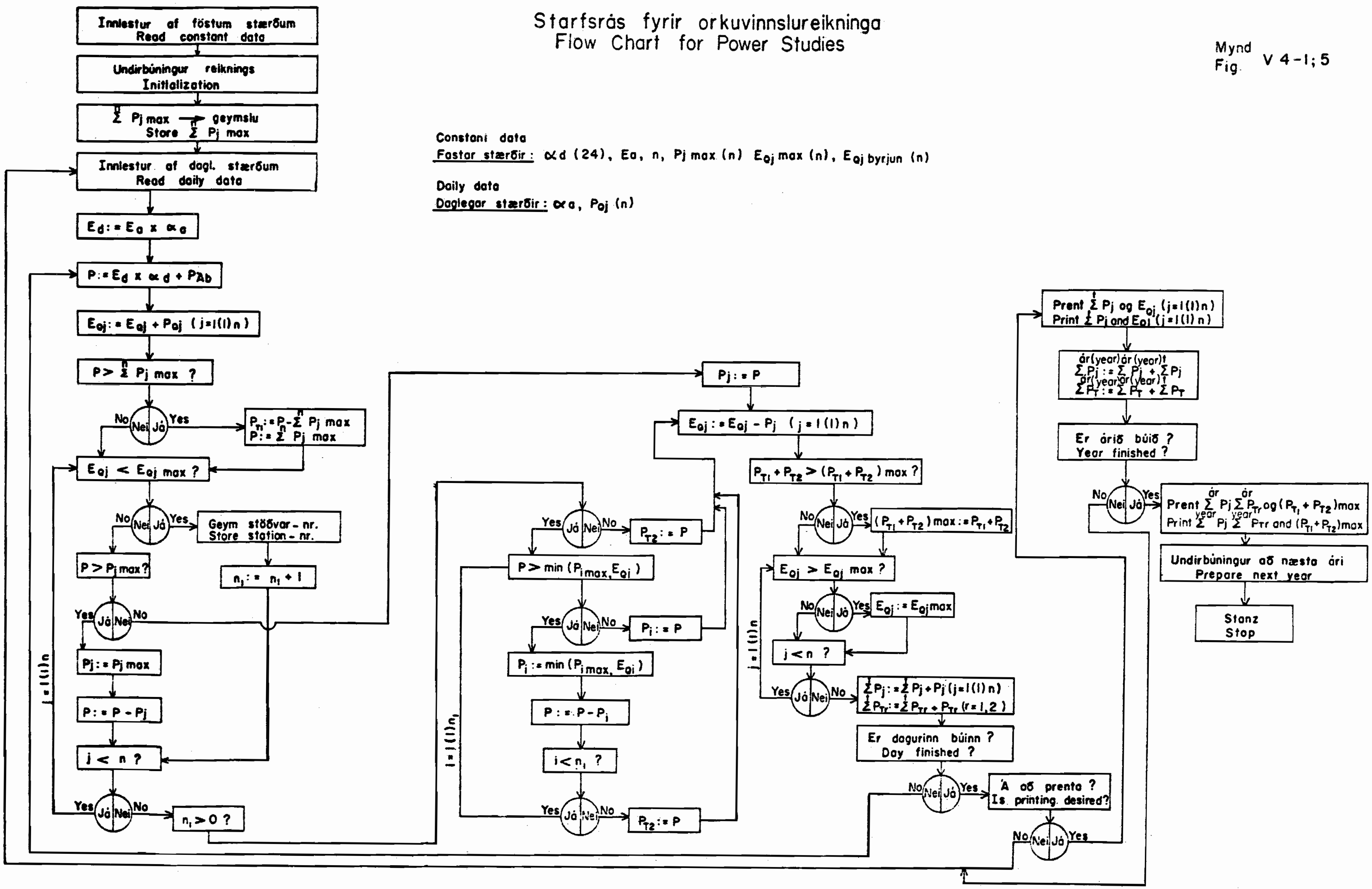


Starfsrás fyrir orkuvinnslureikninga
Flow Chart for Power Studies

Mynd
Fig. V 4-1;5

Constant data
Fastar stærðir: αd (24), E_a, n, $P_j max (n)$, $E_{oj} max (n)$, $E_{oj} byrjun (n)$

Daily data
Daglegar stærðir: αa, $P_{oj} (n)$



27.2.1961 H.S/O.H.

8-0 Tnr. 224 Fnr. 5368