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ELECTRIC POWER IN THE TRANSCAUCASUS

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FOREWORD

Since the completion of the research for this report, additional information has become available

This information, however, does not materially affect the estimates and conclusions presented in this report.

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ELECTRIC POWER IN THE TRANSCAUCASUS*

Summary

During the past 5 years, an important industrial expansion program has been under way in Azerbaydzhan SSR, the Georgian SSR, and the Armenian SSR, the 3 republics which comprise the Transcaucasus.** To meet the growing demands of industry, the power systems are expanding from a total installed capacity of 858,000 kilowatts (kw) in 1948 to an installed capacity of 2,125,000 kw by the end of 1955. The 1955 capacity of the Transcaucasus (approximately the same as the capacity of the state of New Jersey) will constitute about 7 percent of the total generating capacity of the USSR.

The power system of Azerbaydzhan SSR has shown the most rapid growth of the Transcaucasian power systems. The 1948 installed capacity of 363,000 kw was, by the end of 1953, more than doubled to 775,000 kw and will have tripled by the end of 1955, when the installed capacity will exceed 1 million kw.

* The estimates and conclusions contained in this report represent the best judgment of ORR as of 1 October 1954.
** The economic regions referred to in this report are those defined and numbered on CIA Map 12048.1, 9-51 (First Revision, 7-52), USSR: Economic Regions.

The increase in generating capacity* in the Georgian SSR has been less than in any of the other Transcaucasian power systems. From a total of 288,000 kw in 1948, the system has increased 61 percent to 465,000 kw.

The 1953 generating capacity of the Armenian SSR, 436,000 kw, represents a 75-percent increase over 1948. Power generation in the republic is over 95 percent hydroelectric, with about 79 percent of the installed capacity located on the Zanga River above Yerevan.

Each of the 3 individual power systems has about 90 percent of its generating capacity connected to an adequate transmission network. These systems are expanding at a rate sufficient to allow for the growth of industry as now planned. The limited capacity of connections between these systems, however, is a major handicap in the full utilization of their combined generating capacity.

All three systems have been operating at extremely high plant factors (average load/rated plant capacity) from 1948 to 1953, which means that proper maintenance and repair have been impossible.

In terms of power consumption, the greatest expansion has taken place in the petroleum, chemical, and metallurgical industries. The petroleum industry in Azerbaydzhan SSR requires 63 percent of the available power. The ferrous metal industries in the Georgian SSR consume 44 percent of the power. In the Armenian SSR, industrial consumption of available power is divided between the chemical and nonferrous metallurgical industries, 33 and 40 percent, respectively.

Besides the above weakness, all three electric power systems have strategic vulnerabilities in the geographical location of genera-

* For the purpose of this report, the term "generating capacity" is defined as the rated capacity of the electric generators installed in the electric power stations.

ting facilities or system controls. The Armenian SSR and Azerbaydzhan SSR have the majority of their generating facilities concentrated in a compact area. In the Armenian SSR they are concentrated in the Zanga River valley and in Azerbaydzhan SSR they are concentrated on Apsheronskiy Poluostrov (Apsheron Peninsula). The system of the Georgian SSR has a large group of generating facilities and the dispatching (control) center concentrated around Tiflis. The major load centers are, however, geographically dispersed. Most of the electric power in this area is already allocated to heavy industry, with very little available for consumer or light industry and residential use. Thus any increase in industrial power requirements or decrease in available electric power would necessarily result in the curtailment of some existing heavy industrial production.

A survey of the availability of local fuels reveals little opportunity for an expansion of the capacity of thermal electric stations. Of 2.4 million metric tons* of coal mined, almost half is used for the generation of electric power and the rest is used mainly for the ferrous metal industries. The electric power system of Azerbaydzhan SSR uses 150,000 tons of the 175,000 tons of heating mazut produced in the area.

There is an abundance of water power in all three republics, and from all indications, future additions to the generation capacity will be preponderantly hydroelectric.

Industry will continue to expand in the Transcaucasus. Plans for the expansion of the electric power facilities indicate that this expansion can keep pace with the demands of other industry and that the electric power industry will be able to meet future load requirements.

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* Tonnages throughout this report are given in metric tons.

I. Introduction.

A. General.

In the Transcaucasus, as elsewhere, modern industry must have a sufficient and continuous supply of electric power in order to operate. In assessing the economic capabilities of future development of an area, accurate knowledge of the electric power system is necessary. If the true capabilities of the electric power system are known, an evaluation of the existing industrial situation and its possible future trends can be made. Knowledge of a power system is one of the best means of gaging the economic intentions of a possible adversary. This knowledge must include the past growth of the system, the present generating capacity, the extent and capacity of the transmission network, the present and future needs of the consumers, and the future ability of the power system to expand.

The Transcaucasus is one of the southernmost regions of the USSR, extending over an area of 74,000 square miles south of the Greater Caucasus range. It is bordered by the Black Sea and the Caspian Sea and adjoins Turkey and Iran on the south. It includes three republics, the Georgian SSR in the west, Azerbaydzhan SSR in the east, and the Armenian SSR in the south.

As of 1954 the Transcaucasus has about 4 percent of the total Soviet population and 7 percent of the installed electric generating capacity.

The most important single asset of the Transcaucasus is petroleum, and more than one-third of the Soviet total is produced here. In recent years, however, the creation of new industries supported by the increase of electric power sources has reduced the relative importance of this branch of the economy.

The Transcaucasus is rapidly increasing its industrial capacity and consequently the capacity of the three constituent electric power systems. There has been rapid growth in the major industries, iron and steel, nonferrous metals, chemicals, and petroleum, which are all large users of electric energy. The rate of expansion of the electric generating capacity has averaged about 15 percent per year from 1948 to 1953, and it appears likely that this trend will continue through 1955. The rate of expansion in the US over the same period was approximately 8 percent per year. 1/*

B. Organization.

The power systems of the Georgian SSR, the Armenian SSR, and Azerbaydzhan SSR include electric power stations subordinate to the following four different groups: the Ministry of Electric Power Stations, the Ministry of Agriculture, republic ministries, and industrial ministries. The largest part of the generating capacity is subordinate to the Ministry of Electric Power Stations, although other ministries have built power stations to serve particular installations. In almost all cases these latter stations are connected to the electric network of the entire system to facilitate the exchange of power, although they are under the administration of their own ministries. There are numerous rural generating plants in the area, the majority of which are small. At present, great emphasis is being placed on connecting these plants to the existing transmission system and on building consolidated networks in rural areas. These plants are subordinate to the Ministry of Agriculture. Finally, there are a few older municipal plants which belong to the individual republics and are connected to the electric power system.

Figure 1** is a block diagram depicting the administrative and operational scheme of the electric power industry in the Transcaucasus.

* Footnote references in arabic numerals are to sources listed in Appendix H.
** Following p. 6.

II. Generation.

A. General.

At the end of 1953 the electric power systems of the Transcaucasus had a total estimated generating capacity of 1,675,000 kw, broken down as follows: Azerbaydzhan SSR, 775,000 kw; the Georgian SSR, 465,000 kw; and the Armenian SSR, 435,000 kw.

The electric power systems of the Transcaucasus derive much of their electric power generation from hydroelectric stations. The extent of the water power resources of the Transcaucasus and their potential for providing low-cost power are among the important growth factors of large industries in this region. A Soviet survey 2/ shows the water power reserves at average annual stream flow to be the following: Azerbaydzhan, 4,530,000 kw; Georgia, 9,661,000 kw; and Armenia, 1,232,000 kw. Only the following portion will have been developed by the end of 1955: Azerbaydzhan, 500,000 kw; Georgia, 400,000 kw; and Armenia, 450,000 kw. This development will represent only 8.8 percent of the potential water power reserves.

Production of fuel for the thermoelectric plants in the region allows for little expansion. Of the 2.4 billion tons of coal mined in the region almost 50 percent is used to produce steam power for the Rustavi state regional electric power station (GRES -- that is, gosudarstvenii rayonii elektricheskii stantsii), Tkvarcheli GRES, and the smaller central thermoelectric power (TETs -- that is, teploelektrotsentral') stations. Coal is also consumed by the ferrous metal industries, and very little local fuel is therefore left for electric power development. The stations burning fuel oil use 150,000 tons a month of heating mazut, whereas the area produces only 175,000 tons. Actually some mazut is now imported to the Transcaucasus.

The generating capacity of the three electric power systems has shown significant growth since 1948 (see Table 1*). The Azerbaydzhan electric power system has undergone the greatest expansion.

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* Table 1 follows on p. 7.

Table 1

Growth of the Electric Power Systems in the Transcaucasus a/
1948-55

	Year Ending December 31							
	1948	1949	1950	1951	1952	1953	1954	1955
Azerbaydzhan SSR a/								
System Capacity (Thousand KW)	413	413	463	513	525	775	975	1,125
New Capacity (Thousand KW)	50	0	50	50	12	250	200	150
Yearly Increase (Percent)	13.8	0	12.1	10.8	2.3	47.6	25.8	15.4
Georgian SSR b/								
System Capacity (Thousand KW)	288	346	371	406	433	465	511	542
New Capacity (Thousand KW)	54	58	25	35	27	32	46	31
Yearly Increase (Percent)	23.5	20.5	7.2	9.4	6.6	7.4	10.0	6.0
Armenian SSR c/								
System Capacity (Thousand KW)	157	216	216	221	328	435	435	482
New Capacity (Thousand KW)	0	59	0	5	107	107	0	47
Yearly Increase (Percent)	0	37.6	0	2.3	48.4	32.6	0	10.8

a. The compilation for Azerbaydzhan is made from the information contained in Appendix A.
b. The compilation for Georgia is made from information contained in Appendix B.
c. The compilation for Armenia is made from information contained in Appendix C.

From an installed capacity of 363,000 kw at the beginning of 1948, the system had grown to 775,000 kw by the end of 1953, an increase of more than 110 percent. By the end of 1954 it will have reached nearly 1 million kw. Azerbaydzhan SSR is the only one of the three republics that has had a large percentage of thermal generating capacity.

B. Azerbaydzhan SSR.

At the end of 1953, 76 percent of the generating capacity of the electric power system of Azerbaydzhan SSR was located on the Apsheron Peninsula. The only other large generating plants were being developed on the Kura River in West Central Azerbaydzhan.

Operational statistics available from 1947 to 1950 show that the Azerbaydzhan power system has been critically short of generating capacity. All the steam plants in the system were operating at an average plant factor (100 times the average output in kw divided by the plant capacity) of greater than 85 percent. In the US in 1951, the average plant factor for all electric utility plants was 58 percent. 3/ Operating at an 85-percent plant factor, the necessary time for outages of equipment for repair and maintenance is not available. When the practice is continued over a long period such as this, it will contribute materially to decrease the anticipated useful life of the equipment. Later figures showing decreased use of fuel per kilowatt-hour (kwh) of output indicate that the system load is being more easily met. The latest available operating statistics cover the period through 1952. In the 4-year period, 1948-51, 150,000 kw of new capacity had been added to the system, the entire increase having been at Sumgait thermal electric plant (TETs). By the end of 1953, another 250,000 kw had been added as follows: 50,000 kw at Sumgait, 100,000 kw at Severnaya (GRES), and 100,000 kw at Mingechaur hydroelectric power plant (GES -- that is, Gidroelektrostantsiya). Another 200,000 kw will be added at Mingechaur GES before the end of 1954. These increases should materially improve the operating position of the Azerbaydzhan power system, resulting in a plant factor which can be more easily maintained although providing no surplus of electric power.

ADMINISTRATIVE AND OPERATIONAL SCHEME OF THE POWER SYSTEM IN THE TRANSCAUCASUS

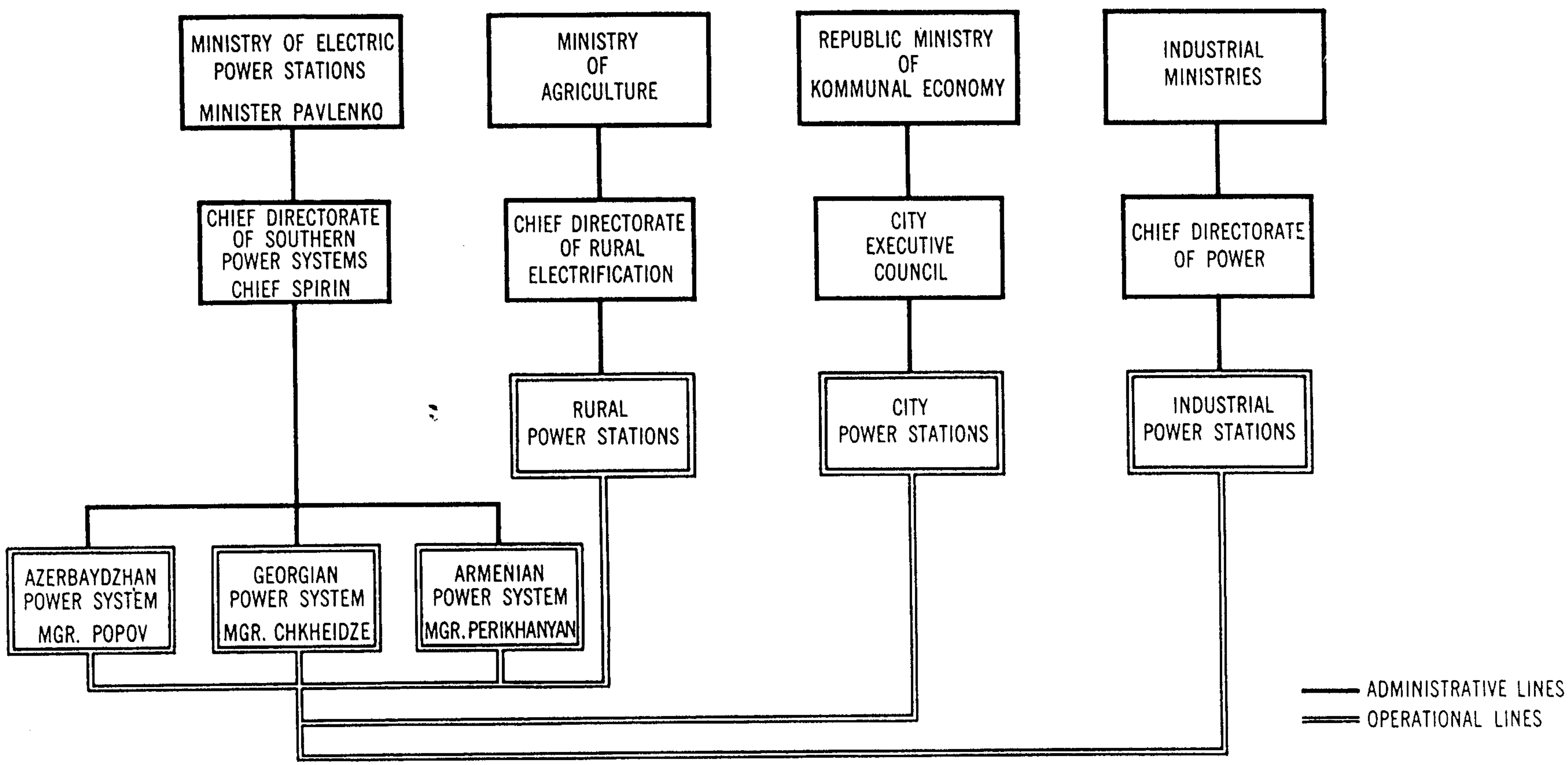

Figure 1

It is estimated from reports during 1952 that at the present time the Azerbaydzhan power system uses an average of 150,000 tons of heating mazut a month. The Baku oil refineries produce approximately 175,000 tons of mazut a month. 4/ Therefore, further electric power development in this area probably will be hydroelectric rather than thermal. This situation is also likely to shift the emphasis of industrial development to the western parts of Azerbaydzhan, since most of the sites for water power development are located there. With considerable amounts of potential hydroelectric power available and a supply of mineral resources in the area, it seems likely that future industrial expansion can be expected in the Dashkesan-Kirovabad area. Deposits which are being worked are copper at Kedabek and Dostafyur; alumite at Zaglik; cement raw materials near Tauz; and iron, sulfur, and cobalt near Dashkesan. At present, construction of a 110-kw network is under way in the area. The cities in this area are all in close proximity to the Tbilisi-Baku Railroad, which can supply good transportation.

New additions in generating capacity will probably be developed on the Terter River. Plans for a series of hydroelectric stations on the river, a tributary of the Kura, have existed since 1936, but at present there is no indication of implementation of this scheme. It is possible that the Karabakh hydroelectric power station now under construction is on the Terter River, since the river's headwaters rise in the Karabakh mountain range. This station's location, however, has not been established.

The electric power production of the Azerbaydzhan system in 1953 was approximately 3.5 billion kwh. This figure is derived from the production chart, Figure 2,* by extrapolation of the curve for 1953 and using the mean of the output.

Shown in Table 2** is a list of main generating stations of Azerbaydzhan SSR showing their type and capacity.

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* Following p. 15.

** Table 2 follows on p. 10.

Table 2

Generating Capacity of Main Electric Power Stations
in Azerbaydzhan SSR
End of 1953

Kilowatts

Station a/*	Type	Known	Probable b/	Under Construction: Probable Date of Completion: End 1954	Under Construction: Probable Date of Completion: End 1955
Andreyev Refinery	Diesel		2,000		
Artema Ostrov	Diesel	2,200			
Baku (old oil refinery)	Diesel		2,200		
BNZ (new Baku oil refinery)	Thermal	12,000			
Chiragidzor	Hydro		1,500		
Dashkesan	Thermal		1,200		
Karabakh	Hydro				50,000
Kirovabad	Thermal		6,000		
Krasin	Thermal	91,000			
Krasnaya Zvezda	Thermal	163,000			
Lt. Schmidt	Diesel		4,000		
Mingechaur	Hydro	100,000		200,000	
Mugan	Diesel	4,200			
Nasosnaya	Diesel		4,500		
Nukha No. 1 and No. 2	Hydro	2,200			
Salyany	Thermal	1,400			
Severnaya	Thermal		100,000		
Siazan'	Thermal		5,000		
Sumgait	Thermal	250,000			
Varvara	Hydro				100,000

* Footnotes for Table 2 follow on p. 11.

Table 2

Generating Capacity of Main Electric Power Stations
in Azerbaydzhan SSR
End of 1953
(Continued)

Kilowatts

Station a/	Type	Known	Probable b/	Under Construction: Probable Date of Completion: End 1954	Under Construction: Probable Date of Completion: End 1955
Zurnabad	Diesel and Hydro	7,000			
Total		633,500 (± 2 per-cent)	126,400	200,000	150,000
Rural Stations		15,000			
Probable		126,400		774,900	974,900
Probable Totals		774,900 (± 4 per-cent)		974,900 (± 6 per-cent)	1,124,900 (± 10 per-cent)
Rounded Totals		775,000		975,000	1,125,000

a. In addition there are 14 stations of unknown capacity, which probably average less than 2,000 kw each.
b. Stations listed as "probable" are so listed for one of two reasons: either the size is not confirmed by more than one source, or the estimate of size is only approximate.

C. Georgian SSR.

Geographically, the generating facilities of the electric power system of the Georgian SSR are rather evenly distributed. In the northwest section are the Sukhumi and Tkvarcheli electric power plants (64,000 kw total); Central Georgia has Rioni, Tkvibuli, and Chitakhevi (about 70,000 kw). The generating capacity of the Batumi area, Southwest Georgia, is the smallest in the republic; less than 30,000 kw are installed in the vicinity of Batumi, which must depend on long lines to supply any additional power needed. The eastern section of Georgia is the largest consuming region and also has the greatest number of plants located in the area, including Khram GES, Zages, Rustavi TETs, Ortachala GES, and several small plants, totaling about 220,000 kilowatts.

Only two thermal electric power plants of any consequence are located in Georgia. They are Tkvarcheli GRES and Rustavi TETs. The coal for the Tkvarcheli plant is mined in the area surrounding the plant, so there is no problem in supplying fuel. Rustavi TETs is dependent on either coal shipped from the Tkvarcheli region or oil from the Baku area, since the plant is capable of using either type of fuel. Although no operating statistics have been located on the Rustavi plant, reports available for Tkvarcheli GRES cover 203 days over the period 1947-52. The station consumed an average of 821 tons of coal per day, operating at an average load of 37,000 kw with a plant factor of 75 percent. The efficiency of the plant in kilograms of standard fuel per kwh over this period is given in Appendix B.

There are indications that the electric power system of Georgia has been short of the electric power to supply the needs of its consumers. Work is proceeding to integrate the rural networks and stations into the main power system. Although these stations are usually small, they will add about 40,000 kw to the capabilities of the system by the end of 1954. Much emphasis has been placed on "automatization" and "telemechanization." The exact meaning of these terms is not understood, but "automatization" seems to include only internal controls at the generating stations, whereas "telemechanization" would include remote control of the station. The only major generating station in the Georgian SSR reported to be operating under remote control is Khram GES, 90,000 kw, whose controls are operated from Tiflis, about 75 kilometers distant.

In 1953 there was reported by Mzhavanadze, Secretary of the Georgian Communist Party, a production of 1,757 billion kwh by the electric power system of the Georgian SSR. 5/ Since normal reports to the Ministry of Electric Power Stations only include stations owned and operated by the Ministry it is believed that the above figure represents the output of these stations. With the addition of nonministry stations operating at approximately the same hours per year the total output would reach almost 2.5 billion kwh.

Table 3* shows the types and capacities of the main generating stations of the Georgian SSR.

D. Armenian SSR.

In the Armenian SSR, 65 percent of the generating capacity is located on the Zanga River above Yerevan. Eventually, a total of 560,000 kw may be installed on the river. 6/ Since Lake Sevan controls the waters of the Zanga, the flow is fairly constant over the entire year. This constant flow eliminates the usual variation of generating capabilities of a hydroelectric station and thus compensates for the lack of support from other types of energy resources for electric power generation. In 1953, 52 percent of the power potential of the Zanga River had been or was being exploited. The other large river left for future development is the Araks; no plans for its use are known. One problem is that the river is the Turkish-Iranian-Soviet border in this area.

From 1948 to 1953, electric power was in extremely short supply in Armenia. reported in-

* Table 3 follows on p. 14.

Table 3

Generating Capacity of Main Electric Power Stations
in the Georgian SSR
End of 1953

Kilowatts

Station a/*	Type	Known	Probable b/	Under Construction: Probable Date of Completion End 1954	End 1955
Adzharis-Tskali GES	Hydro	16,000			
Agara	Thermal	1,500			
Akamara	Thermal	3,000			
Akhalkalaki	Hydro	3,000			
Alazan No. 1 and No. 2	Hydro	8,000		4,800	
Ambrolauri	Thermal	1,500			
Bagnari	Hydro		10,000		
Batumi Refinery No. 429	Thermal		5,000		
Chitakhevi GES	Hydro	24,000			
Gori GES	Hydro		1,500		
Khram GES	Hydro	90,000			
Kutaisi (Automobile)	Thermal		20,000		
Ortachala GES	Hydro			20,000	
Rachka	Hydro	7,000			
Rioni GES	Hydro	48,000			
Rustavi TETs	Thermal	75,000			
Samgori Stations	Hydro	7,000		5,000	17,000
Shaori	Hydro			16,000	
Sukhumi GES	Hydro	20,400			
Sukhumi Municipal	Thermal	3,000			

* Footnotes for Table 3 follow on p. 15.

Table 3

Generating Capacity of Main Electric Power Stations
in the Georgian SSR
End of 1953
(Continued)

Kilowatts

Station a/	Type	Known	Probable b/	Under Construction: Probable Date of Completion: End 1954	Under Construction: Probable Date of Completion: End 1955
Tiflis TETs	Thermal	8,000			
Tkvarcheli GRES	Thermal	49,000			
Tkvibuli GES	Hydro				14,000
Zemo-Avchala (Zages)	Hydro	36,800			
Zugdidi	Thermal	1,500			
Known		402,700 (± 4 per-percent)	36,500	45,800	31,000
Rural Stations		25,500			
Probable		36,500		464,700	510,500
Probable Totals		464,700 (± 7 per-cent)		510,500 (± 8 per-cent)	541,500 (± 8 per-cent)
Rounded Totals		465,000		511,000	542,000

a. There are 12 stations of unknown capacity; 9 of these are small (average 2,000 kw) and 3 may be as large as 25,000 kw each. Five of these are under construction. Completion dates are unknown.
b. Stations listed as "probable" are so listed for one of the two following reasons: either the size is not confirmed by more than one source, or the estimate of size is only approximate.

termittent supply and critical shortages in supply of power to industrial plants, particularly to plants of the Ministry of Nonferrous Metallurgy and the Ministry of the Chemical Industry

The completion of Gyumush GES helped to alleviate the shortage. Even this addition of capacity, however, leaves no surplus for any rapid expansion beyond present plans in the chemical or nonferrous metals industries.

There are very few good output statistics on the Armenian power system. Since both the Armenian SSR and Azerbaydzhan SSR have been short of generating capacity to meet demand, it is assumed that the yearly hours of operation will be the same for both systems. With this assumption, the yearly output of power in 1953 in Armenia was approximately 2.65 billion kwh.

Table 4* shows the types and capacities of the main generating stations in Armenia.

III. Transmission.

A. General.

Each of the power systems in the Transcaucasus has a well-developed transmission network, consisting of 220-, 110-, 35-, 22-, 10-, and 6-kilovolt (kv) transmission lines. The 220- and 110- kv lines are for long distance transmission; the lower voltage lines are industrial feeder lines except for the 35-kv lines, which are used either as tie lines between individual substations or as industrial feeders. The only known 220-kv transmission lines in the Transcaucasus are the 2 transmission lines from Mingechaur to Baku.

* Table 4 follows on p. 17.

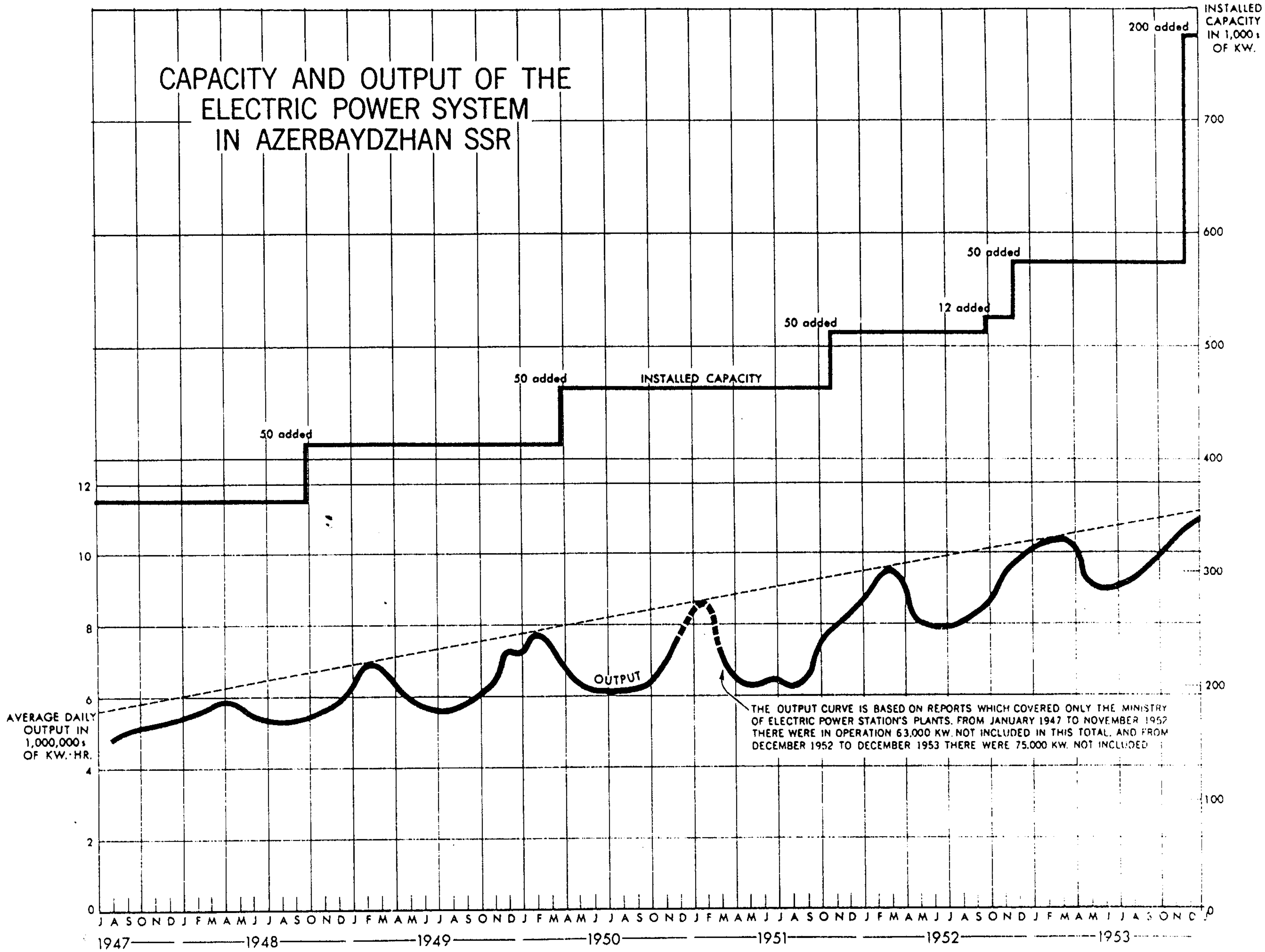
CAPACITY AND OUTPUT OF THE ELECTRIC POWER SYSTEM IN AZERBAYDZHAN SSR
INSTALLED CAPACITY IN 1,000s OF KW.
AVERAGE DAILY OUTPUT IN 1,000,000s OF KW.-HR.
200 added
50 added
12 added
50 added
INSTALLED CAPACITY
50 added
50 added
OUTPUT
THE OUTPUT CURVE IS BASED ON REPORTS WHICH COVERED ONLY THE MINISTRY OF ELECTRIC POWER STATION'S PLANTS. FROM JANUARY 1947 TO NOVEMBER 1952 THERE WERE IN OPERATION 63,000 KW. NOT INCLUDED IN THIS TOTAL, AND FROM DECEMBER 1952 TO DECEMBER 1953 THERE WERE 75,000 KW. NOT INCLUDED
1947
1948
1949
1950
1951
1952
1953

Figure 2

Table 4

Generating Capacity of Main Electric Power Stations
in the Armenian SSR
End of 1953

Kilowatts

Station a/*	Type	Known	Probable b/	Under Construction: Probable Date of Completion End 1954	End 1955
Alaverdi	Hydro		1000/3000		
Arzni GES	Hydro				47,000
Chirkir	Hydro		1,600		
Dzora GES	Hydro	46,500			
Dzhul'ya	Diesel		18,000		
Dzhurkhor	Hydro		4,600		
Gyumush GES	Hydro	214,000			
Kanaker GES	Hydro	88,000			
Leninakan GES	Hydro	5,200			
Sevan GES	Hydro	35,000			
Yerevan GES No. 1 and No. 2	Hydro	4,600) 2,200)			
Total		395,500 (± 3 percent)	25,200		47,000
Rural Stations		15,000			
Probable		25,200			435,700
Probable Totals		435,700 (± 4 percent)			482,700 (± 4 percent)
Rounded Totals		436,000			483,000

* Footnotes for Table 4 follow on p. 18.

Table 4

Generating Capacity of Main Electric Power Stations
in the Armenian SSR
End of 1953
(Continued)

a. There are six stations of unknown capacity. These stations are small, not averaging more than 2,000 kw each. They may add 2 percent to total.
b. Stations listed as "probable" are so listed for one of the two following reasons: either the size is not confirmed by more than one source, or the estimate of size is only approximate.

There is an extensive 110-kv network in the area, which is of great importance, since it gives flexibility to delivery of power to consuming localities.

The Azerbaydzhan and Armenian systems are interconnected by a 110-kv tie line which runs from Mingechaur to Kirovakan. The only other known intersystem ties are a 110-kv line connecting Sukhumi in Georgia with Khosta in the North Caucasus, Georgia, and a 110-kv line from Mingechaur to Navtlug.*

These ties provide for interchange of electric power between the power systems of the Transcaucasus and also with the North Caucasus power system. The actual capacity of these ties is not known, although the Azerbaydzan-Georgian tie is designed to have an ultimate capacity of 18,000 to 20,000 kw.

B. Azerbaydzhan SSR.

Except for the Baku area, the electric power system of Azerbaydzhan SSR is not nearly so extensively developed as that

* See Appendix D.

of Georgia. More than 80 percent of the generating capacity of Azerbaydzhan SSR is derived from oil-fired thermal electric power stations; thus it is located adjacent to the load centers which are concentrated in the Baku area. The only other large generating center in Azerbaydzhan SSR is in the western part of the republic, in the Mingechaur area on the upper Kura River. At present, the majority of this electric power is used in the Baku area; delivery depends on two 220-kv transmission lines and one 110-kv transmission line.

The high-tension transmission system covering the Baku area and the Apsheron Peninsula is extensively developed, consisting of a 110-kv network which has been established to supply the rapidly expanding heavy industrial concentration in the area. There are 12 known major receiving substations in this area. It is believed that of the substations listed in Appendix A covering Azerbaydzhan SSR, the named substations are the major receiving substations, while the number-designated substations are distribution substations, since they are constructed by or are located at industrial plants in many known instances. Khurdalan is the substation at which the 220-kv transmission lines from Mingechaur terminate in Baku, making it of major importance in the supply of power to the local network.

In the western end of the Azerbaydzhan power system there are two exceptionally important lines radiating from Mingechaur, one a 110-kv transmission line supplying the Kirovabad-Dashkesan area and the other a 110-kv line to Kirovakan, Armenia, constituting the interconnection between the Armenian and Azerbaydzhan power systems.

C. <u>Georgian SSR.</u>

As far as can be ascertained, the electric power system of the Georgian SSR has the most extensive 110-kv transmission system in the area under study. This system is especially important for full utilization of available power because 75 percent of the electric power generated in the Georgian SSR is hydroelectric. In most cases, the power is produced at a considerable distance from the load centers, which are thus dependent on a well-developed transmission network. For this reason, a major effort toward construction of the necessary transmission lines has been exerted during the last 5 years. An example of the difficulties involved was the case of the Sukhumi hydroelectric power station, which for 2 years operated at approximately one-fourth of its capacity pending the construction of the Sukhumi-Tkvarcheli transmission line. As of late 1953, the high-tension network in Georgia appears adequate to handle present needs.

Tiflis is the nerve center of the Georgian power system. The city is fed from opposite sides by two major receiving substations. These substations receive the lines from Khram GES, Zages, tie lines from the Armenia power system, and indirectly through these ties from the western part of the network. Tiflis is also thought to be the dispatching center for the Georgia power system. Khram GES, the largest generating plant in Georgia, is reported to be controlled from Tiflis, the telemetering being sent over the 110-kv Khram-Tiflis transmission line.

D. Armenian SSR.

In the electric power system of the Armenian SSR the majority of the generating capacity is concentrated in the Zanga River cascade, and there is a well-developed 110-kv transmission system from Yerevan up the Zanga River Valley to Sevan. The river provides close to 65 percent of all the power generated in Armenia. This abundance of hydroelectric power in the Zanga Valley, especially in the area of Yerevan, has resulted in the creation of a number of industries requiring large amounts of low-cost energy. To supply the industrial consumers there are double-circuited 110-kv lines radiating in both directions out of the Zanga Valley. Kirovakan to the north has the most important major receiving substation on the system, since the interconnecting transmission line from the Azerbaydzhan system terminates here. All the major cities in the Armenian SSR are connected by the 110-kv transmission network.

IV. Consumption.

A. General.

The major industries of the Transcaucasus, from the point of view of power consumption, are petroleum, aluminum, iron and steel, manganese, chemicals, and coal. Major industrial power consumers are estimated to require over two-thirds of the area's electric power production.

The power production in the Georgian SSR has been sufficient to supply requirements, and there appears to be reserve capacity in the system. The power systems of Azerbaydzhan SSR and the Armenian SSR, however, have been severely strained since World War II, and recent additions to generating capacity will only allow for introduction of more normal operating conditions.

B. Azerbaydzhan SSR.

The industries of Azerbaydzhan SSR use more electric power than the total amount used in both of the other Transcaucasian republics. Most of this industrial consumption of electric power is concentrated in the Apsheron Peninsula, where requirements are approximately 3 billion kwh per year.

The most important economic activity in the Transcaucasus, one that dominates the economy of Azerbaydzhan SSR, is the petroleum industry. The industry is highly electrified, and during the period 1947-49 it accounted for more than 75 percent of the total power sales of the Azerbaydzhan power system. 9/ Because methods requiring large amounts of power are widely used by oil extraction enterprises and because of new refining capacity added since 1949, consumption at the end of 1953, even with increasing consumption by other industries, still amounts to about 63 percent of the system's output.

More than half of the total power required in Azerbaydzhan SSR by enterprises of the Ministry of the Petroleum Industry is consumed in the extraction process. In the USSR, this phase of the industry has been electrified to a far greater extent than is true in the US. Although the trend is toward deep well pumps, almost 50 percent of oil extraction in the USSR is accomplished by the compression method, which requires considerably more power than deep well pumps.

In Baku is the largest and most comprehensive single refinery complex in the USSR, accounting for about one-third of the total Soviet petroleum production. It is composed of many different types of equipment, including crude oil distillation units, benzene alkylation units, installations for the production of lubricating oils and greases, and facilities for the manufacture of some of the chemicals used in refining as well as additives used in the final products. 10/

Administratively, many of the oil-machinery-producing plants in Baku are subordinate to the Ministry of the Petroleum Industry, and their power consumption is therefore included in estimates of requirements of the Ministry. These machine-building plants, including Lieutenant Schmidt, Kirov, Montin, Bakinskiy Rabochiy, and others, produce such items as heavy drilling equipment, bits, and machine tools.

Approximately 10 percent of the power production of Azerbaydzhan SSR will be used by the Sumgait Aluminum Plant when it goes into operation some time in 1954. The plant will probably produce 15,000 tons per year during initial years of operation and will require a large amount of power since about 22,000 kwh are needed to produce 1 ton of aluminum.

Although there are 17 plants in Azerbaydzhan SSR which fall into the iron and steel classification, not all of them are subordinate to the Ministry of the Metallurgical Industry. For this reason, and because many are small plants on which information is not available, the over-all power consumption of this segment of industry cannot as yet be estimated. Apart from the Sumgait Metallurgical Plant, the only steel producer in the area is Lieutenant Schmidt, which belongs to the Ministry of the Petroleum Industry. The Sumgait Metallurgical Plant is scheduled to be one of the largest steel plants in the USSR when finally completed. It was in partial operation in 1953, and the 1954 production rate may reach 350,000 tons of finished steel. Assuming a factor of 242.5 kwh per ton of steel made and rolled, power consumption will be about 84 million kwh per year. 11/

Another important industry in Azerbaydzhan SSR is chemical production. The Sumgait Caustic and Chlorine Plant produces an estimated 7,400 tons of sodium hydroxide and 6,600 tons of chlorine per year and requires about 27 million kwh. 12/ Other plants and their estimated annual consumption include the following: Neftechala Iodine Bromide Plant, 7.6 million kwh; Synthetic Alcohol Plant No. 438, 3.0 million kwh; Sumgait Synthetic Rubber Plant, 2.3 million kwh; Baku Iodine Plant, just under 1.0 million kwh. 13/

The construction materials industry is also well developed in Azerbaydzhan SSR. Together, the Baku Asbestos Cement Combine, the Baku explosives industry, the Baku steel foundry, and the Kara Dag Cement Combine probably consume about 35 million kwh per year. 14/ The industry has expanded rapidly since 1949 and production of the Asbestos Cement Combine and Kara Dag Cement Plant is believed to have tripled. 15/

Other industries in Azerbaydzhan SSR include automobile and tractor, fish, food, electrical, and shipbuilding. Figures on their power requirements are not available, but none is a major consumer.

The power supply picture in Azerbaydzhan SSR will improve in the next few years with the completion of the Mingechaur, Varvara, and Karabakh hydroelectric stations. Although new consuming plants will be in operation at about the same time, the additional capacity should satisfy their requirements and allow existing plants to operate more efficiently.

C. Georgian SSR.

The industrial consumers in the Georgian SSR are more dispersed geographically than those in Azerbaydzhan SSR or the Armenian SSR. Although Tiflis is by far the largest city in the Georgian SSR, important industries are located in Batumi, Chiatura, Kutaisi, Rustavi, Tkvarcheli, Tkvibuli, and Zestafoni. This spread also means that the nonindustrial load is comparatively less concentrated.

With respect to heavy power demand, the most important industry in the Georgian SSR is metallurgy. The Rustavi Metals Plant, which in 1953 produced an estimated 430,000 tons of pig iron and 450,000 tons of finished steel, consumes about 130 million kwh a year. 16/ At Zestafoni, a large ferroalloy plant consumes about 219 million kwh per year. 17/ The Chiatura manganese deposits, the second largest in the world, are being intensively exploited. At full-scale operation, when the enriching factory is completed, production will reach 2.4 million tons a year, or one-half of the Soviet total, with a power requirement of over 374 million kwh. These 3 plants consume about 44 percent of the available power. 18/

The Georgian SSR Coal Combine, which has major centers at Tiflis and at Tkvarcheli, supplies coal to the entire Caucasus area. Production in 1952 was over 2 million tons. Since the mines of this combine are among the most highly electrified in the USSR, power consumption is estimated to be over 54 million kwh a year.

Although the petroleum production of Georgia is insignificant in comparison with that of Azerbaydzhan SSR, there are 2 refineries in the republic with a total output of about 1.5 million tons per year. 19/ Annual power consumption of the refineries is estimated to be in the neighborhood of 48 million kwh. 20/

Other important installations in the Georgian SSR and their estimated yearly power requirements include the Kutaisi automobile plant, 24 million kwh; the Kaspi cement works, 18 million kwh; and Tiflis aircraft plant No. 31, 11 million kwh. 21/

Known heavy industry thus consumes about 40 percent of the total available power in the Georgian SSR. This figure includes estimates for all large industrial installations as well as a 42-million-kwh allowance for smaller plants, and is believed to cover present requirements. Although no reliable estimate can be made of the power requirements of nonindustrial consumers, the figure probably does not exceed 450 million kwh -- that is, 20 percent of production. Despite a careful survey of all known industries in the Georgian SSR, approximately 40 percent of 1953 power production cannot be accounted for.

There are, however, numerous indications of restrictions on industrial production because of power shortages which, together with the fact that power is imported into the Georgian system from Azerbaydzhan SSR, show that the power system is operating at capacity. 22/ Therefore, either large quantities of power are exported from the system or large amounts of additional power are consumed by unknown industries within the republic.

With respect to possible sale of power outside the system, the only direction in which power could move is toward the North Caucasus. The transmission line connecting the Azerbaydzhan system with the Georgian system is used for the transfer of power to the Georgian system. As far as can be determined, there are no transmission lines linking the Georgian system with the Armenian system. There is, however, a 110-kv transmission line running from Sukhumi in the Georgian SSR through Adler to Khosta in the

North Caucasus and probably to Sochi. This line probably also connects with the Sochi hydroelectric station at Krasnaya Polyana. 23/ It is interesting to note that the transmission line to the North Caucasus was built between 1948 and 1950, at a time when the Azerbaydzhan systems were critically short of power. Some overriding need must have dictated construction of a line to the north, but until an analysis of the North Caucasus Power System can be made, the nature of this need cannot be determined.

Because the estimates of the power requirements of known industries are generous, additional consumption in the area would have to be attributed to industries whose existence has not yet been established.

The installed capacity in the Georgian system will increase by approximately 17 percent between 1953 and 1955, which will be sufficient to satisfy the known industrial expansion during this period. The Rustavi Nitrogen Plant, which may begin operation in 1955, is the only known major industrial project under construction in Georgia. There are indications of plans for electrolytic production of hydrogen at the plant. 24/ If these indications prove correct, the shop installations will probably be about the same size as the Kirovakan Electrochemical Combine and will require about 400 million kwh per year.

D. Armenian SSR.

Chemical production is one of the most important industries in Armenia and is one of the heaviest power consumers. The largest installation is the Kirovakan Electrochemical Combine, which produces an estimated 35,000 tons of calcium carbide and 50,000 tons of nitric acid a year. 25/ Its annual power consumption for this output is between 106 and 115 million kwh per year. 26/ In addition, equipment for the production of heavy water has been reported at Kirovakan 27/; this activity will require close to 250 million kwh annually.

The Yerevan Carbide Plant requires approximately 203 million kwh for its yearly output of 70,000 tons of calcium carbide. This plant accounts for almost one-fourth of the total Soviet calcium carbide production. 28/

Other Yerevan plants which are subordinate to the Ministry of the Chemical Industry are producers of synthetic rubber, tires, and polyvinyl acetate. The synthetic rubber plant has an output of about 30,000 tons a year and consumes 30 million kwh. For the tire factory,

a power requirement of about 7.5 million kwh. 29/

There is a chemical plant in Alaverdi which produces 14,000 tons of sulfuric acid and 45,000 tons of superphosphates a year. Assuming 15 kwh per ton of sulfuric acid and 25 kwh per ton of superphosphates, annual power consumption is 1.3 million kwh.

The requirements of the chemical industry in 1953 were at least 352 million kwh per year. With the production of heavy water at Kirovakan Chemical Combine, the total annual demand will reach at least 602 million kwh, or about 35 percent of the power output.

Another of the large power-consuming industries of the Armenian SSR is nonferrous metallurgy, whose requirements will approach 800 million kwh a year. The 1953 consumption of Yerevan Aluminum Plant is unknown, but it will, when completed, produce 30,000 tons of aluminum and require 660 million kwh annually. The Alaverdi copper mining and smelting complex produces in the neighborhood of 10,000 tons of copper each year and consumes about 20 million kwh. Consumption of the Zangezuri and Kadzharan Mining Directorates is unknown.

Other industrial plants in the Armenian SSR are small power consumers. An instrument plant, a compressor factory, and a small hydroelectric turbine plant, all of which are in Yerevan, have an estimated annual power requirement of under 2 million kwh a year.

The major consumption statistics of the foregoing discussion are summarized in Table 5. *

V. Vulnerabilities.

A. General.

Electricity is essential to the production of petroleum products, aluminum, refined copper, high-grade steel, and chemicals and is by far the most economical and practical form of energy used in many other industries. In the Transcaucasus, a rapid expansion of generating and transmission facilities has been and is required to satisfy the industrial need for electric energy. Since World War II the demand has exceeded the supply, and, except for Georgia, the systems have been severely strained. Another unfavorable condition is the inability to shift power from nonessential to essential consumers. Production of electric energy has been tightly geared to industrial requirements and an austerity program has been in effect which curbed all other electric consumption. Consequently, any decrease in power output cannot be offset by shifting current from less essential consumers, but will unavoidably have a direct effect on the industrial potential of the area.

The three power systems serving the industries of the Transcaucasus are all vulnerable because of a high concentration of generating capacity in some locality on their system. Destruction or serious damage at such points would cripple system operation and seriously affect vital industries. The location of the more important areas of high concentration, and therefore of vulnerability, is discussed below.

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* Table 5 follows on p. 29.

Table 5

Electric Power Requirements in the Transcaucasus
for Known Heavy Industry
End of 1953

	Million Kilowatt-Hours per Year
Azerbaydzhan	
Ministry of the Petroleum Industry	2,200
Sumgait Aluminum Plant	360
Sumgait Metallurgical Plant	84
Sumgait Caustic and Chlorine Plant	27
Neftechala Iodine Bromide Plant	8
Synthetic Alcohol Plant No. 438	3
Baku Iodine Plant	1
Construction Materials	35
Georgia:	
Chiatura Manganese Complex	374
Zestafoni Ferroalloy Plant	219
Rustavi Metals Plant	130
Georgian Coal Combine	54
Oil Refineries, Tiflis and Batumi	48
Kutaisi Automobile Plant	24
Kaspi Cement Plant	18
Tiflis Aircraft Plant No. 31	11
Armenia:	
Kirovakan Electrochemical Combine	115
Heavy Water Production at Kirovakan	250
Yerevan Carbide Plant	203
Yerevan Synthetic Rubber Plant	30
Yerevan Tire Plant	8
Yerevan Polyvinyl Acetate Plant	5
Alaverdi Chemical Plant	1
Yerevan Aluminum Plant	330
Alaverdi Copper Mining and Smelting	20

B. Azerbaydzhan SSR.

At the end of 1953, more than 80 percent of the generating capacity of the Azerbaydzhan electric power system was located in the greater Baku area. Even after the completion of Mingechaur GES in 1954, 4 large stations in the area will still account for more than 60 percent of the generating capacity of the system. Furthermore, the system has been strained since the end of World War II to meet the mounting demands of the expanding industrial economy of Azerbaydzhan and does not have any reserve capacity for emergencies. The 200,000 kw added in 1954 at Mingechaur will still provide no surplus. This concentration makes the power system peculiarly susceptible to malfunction of any major components of the system, with the possibility of paralyzing the economy of Azerbaydzhan.

C. Georgian SSR.

Although the generating facilities of Georgia are more geographically dispersed than are those of the other republics, there is nevertheless a generating capacity of over 200,000 kw, almost half the entire capacity of the Georgia system, concentrated in the Tiflis area. Of this, 90,000 kw are generated at the Khram GES hydroelectric plant which is reported to be automatically controlled from Tiflis by telemechanization over the Khram-Tiflis 110-kw transmission line. The city is fed by two major substations, Navtlugi on the eastern outskirts, and Bol'shoye Didube on the western outskirts. From the last substation, power must be fed to the western part of the system to supply part of the ferroalloy and manganese industry power requirements. Tiflis is the dispatching and transmission center of the system. Damage to the Tiflis network would seriously curtail operation of the Georgia power system.

D. Armenian SSR.

In the Armenian SSR, 65 percent of the republic's generating capacity is located on the Zanga River between Lake Sevan and Yerevan; with the completion of Arzni GES, the figure will rise to 67 percent. All of these stations are dependent upon the controlled flow of water from Lake Sevan. The water is controlled by three sluice gates in a steel-reinforced dam at the outlet of Lake Sevan. If the headwater control of the river were badly damaged, the output of all the generating stations on the river would be seriously disrupted for a considerable time. The concentration of power facilities also means that the industrial consumers are dependent on the high-tension electric power network radiating from the Zanga River Valley. Major plants which would be affected by disruption of this power network are the Kirovakan Electrochemical Combine, the Yerevan Carbide Plant, and the Yerevan Aluminum Plant.

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APPENDIX A

ELECTRIC POWER STATIONS IN AZERBAYDZHAN SSR

1. BNZ TETs.

a. Location.

Baku, approximately 12 kilometers from Lake Zykh 31/; 3,200 meters from Catalyst Plant No. 11 of BNZ (New Baku Oil Refinery). 32 /

b. Estimated Capacity.

12,000 kw.

c. Description of Plant. 33/

BNZ TETs consists of 2 turbogenerating units and 4 boilers. Each turbogenerator is 6,000 kw, 6 kv. Generator No. 1 was put into operation in September 1952, and generator No. 2 began operation on 9 April 1953 while undergoing adjustment. Each boiler is capable of delivering 75 tons of steam per hour. Boiler No. 3 was being tested and adjusted on 9 April 1953. Construction on boiler No. 4 had not been completed at that time.

The station has a 6-kv bus with 35 oil-circuit breakers 34/ in concrete cells for the distribution net. These feed the facilities of the New Baku Oil Refinery.

BNZ TETs is believed to be connected to the Azerbaydzhan power system, since parts of the refinery were operating and consuming electricity before this plant went into operation. The local distribution network in Baku is known to be 6-kv.

There is a 5,600-kva transformer feeding unit No. 11 (catalyst unit) of the refinery. 35/

Although the plant normally burns oil, there is reference to the installation of hydraulic ash removal equipment; Lake Zykh was to be used as an ash dump. Use of this equipment suggests that the boilers are also fitted to burn coal. 36/ The station has a 60-meter high smokestack.

2. Karabakh GES.

a. Location.

Unknown. This name suggests that the station is located in the Karabakh plateau region east of Lake Sevan. There is a possibility that Karabakh GES is part of the Terter River development, which has been publicized in the Soviet press

b. Estimated Capacity.

50,000 kw by 1955 (possible).

c. Description of Plant.

This plant is under construction by organizations of the Ministry of Electric Power Stations. 37/

An article which appeared in 1937 reported that Terter GES would have a capacity of 50,000 kw. It further stated that the combined capacity of Terter GES No. 1 and No. 2 would eventually be 140,000 kw. 38/ The Terter River, a tributary of the Kura River, flows from the Karabakh highlands. Although no positive connections have been established between Karabakh GES and this development, this station is assumed at present to be one of the Terter stations.

3. Krasin GRES.

a. Location.

Baku, Barlovo Sector on the shore of the Caspian in the Stalinski District, 40°23'N.-49°52'E.

b. Estimated Capacity.

91,000 kw. 39/

c. Description of Plant.

Although estimates of the 1952 capacity of Krasin GRES have ranged from 90,000 to 120,000 kw, the above estimate is believed to be accurate on the basis of the following information 40/:

Five turbogenerators have been reported at the station, including two 24,000-kw units, one 25,000-kw unit, one AEG 8,000-kw unit, and one AEG 10,000-kw unit. 41/

A Siemens turbine
probably belongs to one of the first generators. 42/

The production figures of this plant from August 1947 to September 1948 confirm this estimate of capacity. 43/

the existence of nine boilers at the station.

d. Operation.

Reports on operating efficiency for periods in 1948, 1949, 1950, and 1952 are available The expenditure of standard fuel in kilograms per kwh ranged from 0.589 to 0.527, averaging 0.549. The percentage of total production of electric energy used for the plant's own needs ranged from 5.51 percent to 4.62 percent, averaging 4.95 percent. 44/

Between August 1947 and September 1948, Krasin GRES operated at an average plant factor (average load/rated plant capacity) of 86 percent.

There is evidence of replacement of equipment, installation of automatic boiler control, and plans for the construction of a shore pumping station. 45/

Since 1950, there have been indications of a regular repair policy. Each turbogenerator and boiler was overhauled once a year.

4. Krasnaya Zvezda GRES.

a. Location.

Baku, southeast part of the city, Shaumayamovsky District, 40°22'N-49°55'E. 46/

b. Estimated Capacity.

161,000 kw to 163,500 kw.

c. Plant Description.

The station was first put in operation in 1900. 47/ The last exact known capacity was given in 1935. At that time, there were in operation 8 generators, totaling 109,000 kw. There were two 7,500-kw, 1,500-rpm AEG generators which were installed in 1914; also, three 10,000-kw, two of which were rated at 1,500 rpm and one at 3,000 rpm. The first two were manufactured by Esher-Viss and the third by VKE. They were installed in 1920, 1924, and 1925 respectively. Two other generators were 20,000-kw, 3,000-rpm Metro Vickers installed in 1928 and 1930; and one 24,000-kw, 3,000-rpm generator was manufactured by LMZ (Leningrad Metals Plant). 48/ The following machines

one AP-25-1 of 25,000-kw capacity, one AK-25-1 of 25,000-kw capacity and one 12,000-kw turbogenerator.

Thus the station had 11 turbines at one time or another having a total capacity of 171,000 kw.

the station had only ten generators in operation in 1953.

There are output figures extending over the period August 1947 to September 1948. During this period the average daily output never exceeded 150,000 kw

Operating statistics for Krasnaya Zvezda GRES are given in Table 6.*

Considering the average output figures above and the size and age of installed generators it seems probable that one of the 7,500-kw or 10,000-kw generators was removed. Thus the station capacity is estimated to be between 163,500 kw and 161,000 kw.

the station has 16 boilers in operation.

d. Operation.

Krasnaya Zvezda GRES is the oldest and least efficient of the three thermal-electric stations in the Baku area. As soon

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* Table 6 follows on p. 38.

Table 6

Operating Statistics for Krasnaya Zvezda GRES 51/
August 1947 - September 1948

	Output		
Date	Thousand KWH	Average Thousand KW	Plant Factor a/ (Percent)
30 Aug 47	3,046	127	78.8
3 Sep 47	2,761	115	71.4
8 Sep 47	2,710	113	70.2
9 Sep 47	2,712	113	70.2
18 Sep 47	2,857	119	73.9
20 Sep 47	2,690	112	69.6
1 Oct 47	3,240	135	83.6
6 Oct 47	3,361	140	87.0
Nov 47	3,072	128	79.5
13 Nov 47			
20 Nov 47	2,968	123	76.4
21 Nov 47	3,072	128	79.5
18 Feb 48	3,248	135	83.6
6 Mar 48	3,220	134	83.2
7 Mar 48	2,757	115	71.2
16 Apr 48	3,551	148	91.9
17 Apr 48	3,364	140	87.0
18 Apr 48	3,517	146	90.7
8 May 48	2,973	123	76.4
9 May 48	3,270	136	84.5
14 Jun 48	3,463	144	89.4
17 Jun 48	3,015	125	77.6
29 Jun 48	3,025	126	78.2
6 Jul 48	3,060	127	78.9
9 Jul 48	3,015	125	77.6

a. Computed.

Table 6

Operating Statistics for Krasnaya Zvezda GRES 51/
August 1947 - September 1948
(Continued)

	Output		
Date	Thousand KWH	Average Thousand KW	Plant Factor a/ (Percent)
30 Aug 48	3,018	126	78.2
31 Aug 48	3,046	127	78.9
7 Sep 48	3,130	130	80.7
8 Sep 48	3,368	140	87.0
9 Sep 48	3,598	150	93.2

a. Computed.

as there is any spare capacity in the Azerbaydzhan power system, this plant will probably be used more for peaking power than for base load.

Reports on capital repair show a consistent maintenance program under which all boilers and generators are overhauled once a year.

Operation reports of 1948 through 1952 give a range of fuel expenditure from 0.598 kilograms per kwh to 0.536, averaging 0.568 kilograms per kwh. Station usage in percentage of total generated electric power ranged from 5.82 percent to 5.36 percent, averaging 5.68 percent. 52/

Krasnaya Zvezda GRES operated at an average plant factor of 80.3 percent during 1947-48. Although no new units are known to have been installed at the station, the efficiency of the plant increased after December 1949. This rise is interpreted as a result of increased power capacity of the power system. New units at Sumait TETs were cut in approximately at this time, thus reducing the strain on the system. Krasnaya Zvezda was then able to conduct a regular maintenance program and to operate at a lower plant factor.

5. Mingechaur GES.

a. Location.

Mingechaur, on the Kura River where the river cuts 53/ through the spur of the Boz Dag mountain ridge, 300 kilometers northwest of Baku, 40°45'N-47°03'E.

b. Estimated Capacity.

100,000 kw in December 1953; ultimate capacity 300,000 kw.

c. Description of Plant.

When completed, Mingechaur GES will be the largest power station in the Transcaucasus. The plant will have 6 generators, 5 of which are either being installed or awaiting installation. 54/ No reference to the exact capacity of the generators has been noted. Since a figure of 300,000 kw for the station is reported in the Soviet press

they are possibly rated at 50,000 kw. 55/ They have a generator voltage of 13.8 kv and a normal frequency of 50 cycles. 56/ One generator is known to be an SV217/6140. 57/

In November 1952, work began on the installation of the stators of two turbines. 58/ A complete set of special bushings for the first two units was ordered for delivery not later than July or August 1953. 59/ The first two units were put under industrial load 4 January 1954. As of 11 January 1954 unit No. 3 was 34 percent completed, and unit No. 4 was 11 percent completed. 60/

There is reference to a 70,000-kva, 50-cycle transformer with 13.2-kv primary and 230- and 220-kv secondary taps, the secondary currents being 176 and 184 amperes respectively. 61/ From the data given, it is apparent that this is a 3-phase transformer. How the transformer will be fitted in the transmission system is not known. The only identified 220-kv transmission lines from Mingechaur are those to Baku. 62/

d. Dam Construction.

According to the Soviet press, the dam is to be 1.5 kilometers long, 500 meters wide at the base, and 76 meters high; the penstock is to be 500 meters long. 63/ The reservoir will contain 16 billion cubic meters of water and will have a length of approximately 50 kilometers, a width of 15 kilometers, and a depth of 60 meters. It is an arc-shaped dam of clay earth and gravel, with a concrete facing. 64/

6. Nukha Hydroelectric Plants No. 1 and No. 2.

a. Location.

Nukha, 41°13'N-47°12'E.

b. Estimated Capacity.

No. 1: 600 kw. No. 2: 1,600 kw.

c. Description of Plant.

Plant No. 1 at Nukha was completed in 1934 and has a capacity of 600 kw. 65/

Plant No. 2 was completed in 1935 and has two horizontal Pelton turbines produced by LMZ (Leningrad Metals Plant). The machines are rated at 830 kw at 600 rpm. 66/

d. Dam and Headworks.

Plant No. 1 has a diversion intake to a 1,430-meter-long penstock supplying the plant with a 40-meter head. The diameter of the penstock is 0.8 meters. The surge tank is cylindrically inclined, of reinforced concrete, 2.0 meters in diameter and 13.5 meters high. 67/

Plant No. 2 has a 160-meter head.

e. Operation.

Both of these plants supply the Silk Combine in Nukha.

7. Severnaya GRES.

a. Location.

Northeast of Baku, 40°29'N-50°12'E.

b. Estimated Capacity.

100,000 kw. 68/

c. Description of Plant.

The first section of Severnaya GRES, which contains 2 boilers and 2 condensing turbogenerators, was put in operation in February 1954. 69/

Construction of the station began in 1949, but the main group of construction workers did not arrive until early 1950. 70/

In November 1952 the Soviet of Ministers decreed that two turbogenerators were to be put into operation in 1953, and there is evidence that work is proceeding on schedule. 71/ In July 1953, arrangements were made for adjustment of the thermal system of the plant. This process usually takes place at least 4 months before a power plant begins operation. In August 1953 a 31,500-kva transformer was being installed at the station. 72/

d. Operation.

Severnaya GRES will operate as part of the Azerbaydzhan power system and will use coal or oil as fuel. 73/

8. Sumgait TETs.

a. Location.

Sumgait, 40 kilometers northwest of Baku; about 300 meters from the Caspian Sea shore, between the Sea and the Tube Rolling Mill, 40°33'N-49°37'E. 74/

b. Estimated Capacity.

250,000 kw. 75/

c. Description of Plant.

The Sumgait Central Heat and Power Station went into operation in 1941 with two generating units, having a total capacity of 50,000 kw. Turbogenerators No. 1 and No. 2 have been identified as AP-25-1 and OM-25-1 respectively, each with a capacity of 25,000 kw. 76/

Expansion of the station began in 1947, and in 1948 expansion of a

third section were noted.

The following turbogenerators have been identified as installed 77/ since 1947: No. 3, a 50,000-kw unit, began operation in October 1948; No. 4 was identified as an AK-50 with a capacity of 50,000 kw and began operating in April 1950; No. 5, probably a 50,000-kw unit, was scheduled for completion in October 1951, although assembly work was still going on in November 1951; No. 6 is assumed to be a 50,000-kw unit because the other units installed since 1947 have had this capacity. It was "about ready" for operation in January 1953, but had not yet started operation on 13 April 1953. 78/ The fact that this machine is hydrogen cooled suggests that the other new machines may also be hydrogen cooled. 79/

Fuel consumption data indicates that turbogenerator No. 5 was in operation by the end of November 1951, bringing the capacity at that time to 200,000 kw. By June 1953 at the latest, turbogenerator No. 6 should have gone into operation, making the station total 250,000 kw. 80/

There are 7 boilers in Sumgait TETs; boilers No. 3 through No. 7 were installed during the expansion. The exact capacity of No. 3, which began operating in 1948, is unknown; No. 4 began operation on 31 March 1949 with a capacity of 200 tons per hour; boiler No. 5 has a capacity of 400 tons per hour and was put under load on 20 December 1949; boiler No. 6, a TP-200 with a capacity of 200 tons per hour, began operating at the end of 1951 or early in 1952. 81/ With the operation of No. 7 on 25 March 1953, the boiler installation was completed. 82/

Sumgait TETs is connected to the Azerbaydzhan power network.

ly

in November 1953 discuss plants to convert this plant to coal operation. 83/

Power production at Sumgait TETs for the period 1947-50 is given in Table 7.

Table 7

Electric Power Production at Sumgait TETs 84/ a/*
1947-50

Date	Number of Days	Computed Average KWH/Day	Computed Average KW	Computed Plant Factor	Efficiency b/	Capacity
Jul 1947	31	993,917	41,413	82.8	0.60	50,000
Aug 1947	31	1,033,954	43,081	86.2	0.60	50,000
Aug 1948	31	1,184,488	49,353	98.7	0.554	50,000
Sep 1948	20	1,180,320	49,180	98.4	0.554	50,000
Oct 1948	10	1,383,063	57,628		0.554	Turbine No. 3 cut in
Nov 1948	10	936,740	39,864		0.528	100,000
Dec 1948	23	1,609,776	67,074	67.0	0.528	100,000
Jan 1949	31	1,884,457	78,519	78.5	0.528	100,000
Feb 1949	24	2,059,945	85,831	85.8	0.509	100,000
Mar 1949	31	1,913,450	79,727	79.7	0.520	100,000
Apr 1949	30	1,673,670	69,736	69.7	0.520	100,000
Jul 1949	15	1,538,022	64,084	64.1	0.530	100,000
Sep 1949	30	2,365,888	98,703	98.7	0.520	100,000
Nov 1949	30	2,291,604	95,484	95.5	0.520	100,000
Dec 1949	31	2,427,693	101,153	101.1	0.508	100,000
Jul 1950	20	2,629,332	109,555	73.8	0.511	150,000 Turbine No. 4 cut in
Oct 1950	31	3,181,789	132,575	88.4	0.511	150,000

* Footnotes for Table 7 follow on p. 46.

Table 7

Electric Power Production at Sumgait TETs 84/ a/
1947-50
(Continued)

a. Derived from amounts of mazut received when electric energy is computed from fuel quantities; the following formula used 85/:

$$\frac{QM \times VM}{QC \times E} = \text{kwh for whatever period the fuel quantities cover.}$$

QM = the heat value of mazut, which is 9,600 kilocalories per kilogram 86/;

QC = the heat value of conventional fuel, which is 7,000 kilocalories per kilogram;

VM = mazut in kilograms;

E = efficiency value in kilograms per kwh.

b. Expenditure of standard fuel in kilograms per kwh.

Figures for any one month may not show the exact average for the station since no actual mazut consumption figures are given, but since mazut inventories may be assumed to be constant over this period of time they are indicative of the output of this plant. Where actual output data are available, these figures agree very closely. These figures also conform to the increase in output expected from the known installation time of new turbogenerators.

d. Operation.

Sumgait TETs, along with Mingechaur, can be expected to be used as a base load plant for the Azerbaydzhan power system.

This plant is the largest and most efficient thermal plant on the system.

Operating statistics for specific days from August 1947 to September 1948 are given in Table 8. 87/

Table 8

Operating Statistics for Sumgait TETs
August 1947 - September 1948

Date	Output: Thousand KWH	Output: Average Thousand KW	Computed Plant Factor a/* (Percent)
3 Sep 47	1,124	46	92
8 Sep 47	1,100	45	90
9 Sep 47	1,122	46	92
18 Sep 47	1,120	46	92
20 Sep 47	1,130	47	94
1 Oct 47	504	21	42
6 Oct 47	352	14	28
Nov 47 b/	1,153	48	96
13 Nov 47			
20 Nov 47	1,107	46	92
21 Nov 47	1,065	44	88
18 Feb 48	1,162	48	96
6 Mar 48	1,179	49	98
7 Mar 48	1,203	50	100
16 Apr 48	1,206	50	100
17 Apr 48	1,205	50	100
18 Apr 48	655	27	54

* Footnotes for Table 8 follow on p. 48.

Table 8

Operating Statistics for Sumgait TETs
August 1947 - September 1948
(Continued)

Date	Output: Thousand KWH	Output: Average Thousand KW	Computed Plant Factor a/ (Percent)
8 May 48	1,189	49	98
9 May 48	587	24	48
14 Jun 48	600	25	50
17 Jun 48	1,162	48	96
29 Jun 48	1,166	48	96
6 Jul 48	1,176	49	98
9 Jul 48	1,164	48	96
25 Jul 48	1,087	45	90
30 Aug 48	1,129	47	94
31 Aug 48	1,172	49	98
7 Sep 48	1,111	46	92
8 Sep 48	1,188	49	98
9 Sep 48	1,205	50	100

a. Average plant factor is 86 percent.
b. Day of month unknown.

9. Varavary GES.

a. Location.

Exact location unknown; within 10 kilometers of Mingechaur. 88/

b. Estimated Capacity.

100,000 kw.

c. Description of Plant.

Varvary GES is currently under construction and will cost over 100 million rubles. 89/ One generator will be a 145-rpm machine from plant No. 659 of the Ministry of the Electrical Industry. 90/ Turbines will be supplied by LMZ (Leningrad Metals Plant). 91/

If the specified capacity of the exciters were twice as large as necessary, the generators would have a capacity of approximately 50,000 kw. Since the station has at least 2 generators, a conservative estimate would make Varvary GES a 100,000-kw station.

d. Dam and Headworks.

Basic preparations for building of the dam were under way in the summer of 1952. 93/

10. Zurnabad (also known as Suraabat) Diesel and Hydroelectric Plants.

a. Location.

Zurnabad, 40°30'N-46°15'E. Located on Gyandzha River below Kirovabad.

b. Estimated Capacity.

Diesel station, 5,750 kw. Hydroelectric station, 1,256 kw. 94/

c. Description of Plant.

No physical description of these plants is available. The hydroelectric station has a head of 87 meters. 95/

d. Operation.

The average available capacity* of Zurnabad Hydroelectric Station is 1,256 kw; in the wintertime the minimum is 650 to 430 kw. 96/

It is believed that these plants are connected to the Kirovabad city network and thus connected to the Azerbaydzhan power system through the Mingechaur-Kirovabad tie.

11. Rural Electric Power Stations.

There is little information on the rural power stations in Azerbaydzhan SSR.

references could be found in the Soviet press or periodicals. The total capacity of rural stations in the republic is probably under 15,000 kw. The following stations, all hydroelectric, have been mentioned:

a. Aliabadsk GES in Zakatal'skiy Rayon, placed in operation in 1951. 97/

b. Alichevskaya GES, an interkolkhoz station in Kubinskiy Rayon, 98/ placed in operation in 1951.

c. Anikh GES in Kusarskiy Rayon, placed in operation in 1951. 99/

d. Askeranskaya GES in Stepanakertskiy Rayon, placed in operation in 1951. 100/

* The average available capacity refers to the potential utilization of equipment over a period of an entire year as limited by the varying flow of water.

e. Belokani GES, 41°42'N-46°23'E, under construction in 1953. 101/

f. Khoral GES in Kusarskiy Rayon, placed in operation in 1951. 102/

g. Lenkoran GES No. 1 and No. 2 near the city of Lenkoran. Construction 103/ of GES No. 2, which is to have a capacity of 800 kw, was begun 104/ in May 1953.

h. Matsekhskaya GES in Zakatal'skiy, placed in operation in 1951. 105/

i. Mudzukh GES in Kusarskiy Rayon, placed in operation in 1951. 106/

j. Shikhakeran Village GES, placed in operation in 1951. 107/

k. Verkhiyanskiy GES in Zakatal'skiy Rayon, placed in operation in 1951. 108/

12. Other Electric Power Stations.

Minor electric power plants in Azerbaydzhan SSR are listed in Table 9.*

The stations listed in Table 10** were mentioned in a document 109/ published in 1952. Since documentation for the report is not available, and since no other references to these stations have been noted, they are included in a separate list.

* Table 9 follows on p. 52.
** Table 10 follows on p. 54.

Table 9

Minor Electric Power Plants in Azerbaydzhan SSR

Name	Location	Capacity (KW)
Akhtuvinsk GES a/ *	Akhtuvinsk, part of Kura-Arak irrigation system	Unknown, probably small
Artem Oil Trust Power Station	On Artem Island, 40°28'N-50°18'E	2,200 111/
Kirovabad Power Trains b/	Kirovabad, 40°41'N-46°22'E	Unknown; small
Mugan Diesel Stations	Mugan, 40°06'N-48°49'E	One 4,200, other two unknown 114/
Nakhichevan Diesel Power Station c/	Nakhichevan, 39°12'N-45°25'E	Unknown
Sal'yany Thermal Electric Power Station d/	Sal'yany, 39°36'N-48°59'E	1,400
Shamkhor GES e/	Shamkhor, 40°50'N-46°09'E	Unknown, probably small
Siazan Electric Power Station f/	41°02'N-49°10'E	5,000
Stepanakert GES g/	39°49'N-46°45'E	Hydro unknown; thermal 400 kw

* Footnotes for Table 9 follow on p. 53.

Table 9

Minor Electric Power Plants in Azerbaydzhan SSR
(Continued)

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a. Under construction in last quarter of 1949. Two generators were to be installed. A diesel generating station containing a 368-kw generator, probably for construction, also exists at this location. Station belongs to the Ministry of the Petroleum Industry. 110/

b. At least two power trains, No. 52 and No. 67, have been operating in the Kirovabad area. In addition, No. 49 has been at Dashkesan. 112/ Only available reference concerns financing and planning. 113/

c. Only available reference mentioned allocation of 10 tons of solar oil, for which diesel fuel was requested as a substitute. 115/

d. Three 350-kw generators reported installed in 1947, and plans for a fourth unit. 116/ Station to be used mainly for irrigation pumping. 117/

e. station in planning stage in mid-1952. high-pressure hydroelectric station under construction in 1952. 118/

f. Belongs to the Ministry of the Petroleum Industry. Message requested four 16.7-kw exciters, which would provide for 4 generators of at least 1,250 kw each. Total number of generators in station unknown. 119/

g. Under construction in 1947. Hydro station is presumably on the Karkachan River. 120/

Table 10

Electric Power Stations in Azerbaydzhan SSR
Reported but Unconfirmed

Location and Name	Coordinates	Fuel	Capacity (KW)	Consumer
Agadam, 250 kilometers east-southeast of Baku a/*	39°59' N 46°56' E	Oil	Small	
Baku, Lieutenant Schmidt machine factory power station, 1 kilometer northeast of main railway station. b/	40°24' N 49°50' E	Oil	4,000	Lt. Schmidt factory Azenergo
Baku, old power station in east part of city c/	40°24' N 49°50' E	Oil	2,200	Refineries
Baku, Andreev refinery power station on the gulf d/	40°24' N 49°50' E	Oil	2,000	
Baku, street car company power station	40°24' N 49°50' E	Oil	Small	
Baku, Chernogorodskaya TETs e/	40°24' N 49°50' E	Thermal	45,000 (Plan)	Oil refinery
Baku, Neftechala District f/	49°50' E	Oil	Small (Plan)	

* Footnotes for Table 10 follow on p. 56.

Table 10

Electric Power Stations in Azerbaydzhan SSR
Reported but Unconfirmed
(Continued)

Location and Name	Coordinates	Fuel	Capacity (KW)	Consumer
Chiragidzor, 305 kilometers west of Baku g/	40°27' N 46°19' E	Hydro	1,500	
Daskesan, 265 kilometers west of Baku, on the left bank of the Kashkar Chai River at the foot of Shah Dag h/	40°31' N 46°06' E	Oil	1,200	Local industry and iron ore mines
Kedabek, 330 kilometers west of Baku i/	40°35' N 45°48' E	Hydro	Small	Pyrites mines
Khaldan, 210 kilometers west-northwest of Baku	40°43' N 47°13' E			
Kirovabad TETs, 250 kilometers west-northwest of Baku j/	40°42' N 46°21' E	Oil	6,000	
Nasosnaya k/	40°36' N 49°33' E	Oil	4,500	
Shamkhor Thermal Electric Station l/	40°50' N 46°09' E	Oil	Small	

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Table 10

Electric Power Stations in Azerbaydzhan SSR
Reported but Unconfirmed
(Continued)

a. Diesel generator under reconstruction 1947 to give more power.
b. Two diesel generators.
c. Diesel generators.
d. Diesel generators.
e. Planned for construction in 1946-50; work in progress in 1946. Since no other source has reference to this plant, it seems probable it has not been built.
f. Possibly Neftechala, 39°18'N-49°11'E. Three diesel plants planned for construction 1946-50; at least one of these in operation in 1947.
g. Could be Zurnabad Hydroelectric Power Plant since these plants are the same size and located at approximately the same place.
h. Nearing completion in late 1948; 1,700 feet above sea level. Diesel plant.
i. High-pressure plant.
j. Brick building. Old P/S diesel generator, 2 oil tanks, cooling pond.
k. Diesel generator.
l. In operation in 1947; was to be reconstructed to give more power.

APPENDIX B

ELECTRIC POWER STATIONS IN THE GEORGIAN SSR

1. Adzharis-Tskali GES (ATs GES).

a. Location.

24 kilometers southeast of Batumi on the Adzharis-Tskali River; 1 kilometer south of Ut Kiva, 41°35'N-41°52'E. 121/

b. Estimated Capacity.

16,000 kw.

c. Description of Plant.

ATs GES started operation in 1935. It has two 8,000-kw generators operating under a 41-meter head. The plant was designed for an average annual output of 105 million kwh. 122/ "Automatization" of this plant was completed in 1949. 123/

The incorporation of ATs GES into the Georgian power system helped to solve the problem of winter peak load on the system. Because of the subtropical flooding condition of the Adzharis-Tskali River, the river has maximum flow in winter, and ATs GES will therefore be able to operate at full capacity during the season when demand is highest. 124/

2. Alazan Hydroelectric Stations No. 1 and No. 2.

a. Location.

Tsnoris Tskhali, 41°37'N-45°59'E. 125/

b. Estimated Capacity.

Station No. 1: 8,000 kw. 126/ Station No. 2: possibly 4,800 kw. 127/

c. Description of Plant.

Plant No. 1 has two 4,000-kw Soviet generators with voltage of 6.6 kv. The 2 turbines are Francis horizontal turbines of 4,500 hp at 500 rpm. They were manufactured in the USSR. The plant has a 33-meter head and is believed to be connected to the Georgian power system. 128/

The details of Plant No. 2 are unknown. the station was under construction in March 1953. 129/

3. Chitakhevi GES.

a. Location.

Four kilometers downstream from Dviri on the left bank of the Kura River, 10 kilometers south of Borzhomi; 41°37'N-43°17'E. 130/

b. Estimated Capacity.

24,000 kw.

c. Description of Plant.

This station was reported under construction in 1948. Although subordinate to the Ministry of the Coal Industry, it is connected to the Georgian power system. The plant has three 8,000-kw generators. All three units have been reported automatized. 131/ For a photograph of the station, see Figure 3.*

* Following p. 78.

d. Dam and Headworks.

The dam is near Kvabiskevi, 3 kilometers upstream from Dviri. It is made of concrete and is 60 meters long and 13 meters high. There are 4 sluice gates and a concrete channel running 2.5 kilometers downstream near the left bank to a tunnel 4 kilometers long. From here, 3 metal penstocks 2.3 meters in diameter and 500 meters long carry water to the powerhouse. 132/

4. Gori GES.

a. Location.

50 kilometers west-northwest of Tiflis, 3 kilometers west of Gori, 41°58'N-44°07'E.

b. Estimated Capacity.

1,000 to 1,500 kw.

c. Description of Plant.

The capacity estimates of this plant are based on the attached photographs, one of which shows two generators. These generators appear to be 500 to 750 kw each.

The station is probably connected to the 110-kv transmission network through the Gori substation. (See Figs. 4-7* for photograph of the 110-kv transmission line, the penstocks, and the hydroelectric turbines.)

5. Ortachala GES.

a. Location.

"300 Aragvintsev Bridge" where the Kura River emerges from a rocky gorge, 133/ 41°42'N-44°45'E.

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* Following p. 78.

b. Estimated Capacity.

20, 000 kw (probable minimum).

c. Description of Plant.

The two pictures (see Figs. 8 and 9*) show a model of the station and the construction site. The plant is still under construction. 134/ One report indicated that a 20,000-kva transformer was about to be connected in March 1953. 135/ When completed, the Ortachala hydroelectric station will be connected to the Georgian power system.

6. Khram GES.

a. Location.

100 kilometers southwest of Tiflis, between Tsalka and Molotovo on the Khram River.

b. Estimated Capacity.

90, 000 kw.

c. Description of Plant.

Khram GES (see Figs. 10 and 11*) consists of 3 generating units, each of which has an estimated capacity of 30,000 kw. This estimate is based upon the consideration of the following three factors:

(1) The plant has a 480-meter head and 3 penstocks (see Fig. 10*), each of which is capable of delivering 8 cubic meters of water per second, or enough to provide 33, 000 kw. 136/

* Following p. 78.

(2). Power production figures

covering periods between October 1949 and September 1950. The highest peak load noted was 78,000 kw, attained in February 1950. 137/

(3). Plans published in Electric Power Development in the USSR, Moscow, 1936, show that the first section of the Khram development was to have 90,000-kw capacity.

, the "first section" probably refers to this station, Khram GES No. 1.

The first unit was placed in operation on 31 December 1947. 138/ Operation of the third unit on 31 May 1949 marked the completion of the station. 139/

d. Operation.

According to Soviet press releases, Khram GES is completely operated by remote control from Tiflis, 100 kilometers away. 140/

The 110-kv Khram-Tiflis transmission line is utilized for sending and receiving electrical remote control signals. 142/ The control system is thus independent of the usual lines of communication

143/

e. Transmission Lines.

The station is part of the Georgian power system. Transmission lines of 110 kv connect Khram GES, Bol'shoy Didube substation on the west side of Tiflis, and Zemoavchala GES on a 6-wire parallel circuit, and another line connects Khram GES to Bol'shoy Navtlug substation on the east side of Tiflis so that the city of Tiflis, 144/ is fed from 2 sides. It is also probable that Tiflis is a power dispatching center for the Georgian power system, since the telemechanical controls for Khram GES are located there. Tiflis is therefore the nerve center of the system and its most vulnerable point.

f. Dam and Reservoir

The 30-meter high dam, constructed of large stones covered with stainless steel, is located at Barmaksys. The reservoir has a capacity of 350 million cubic meters and covers an area of 30 square kilometers. Because of this large area, the Khram station assures the Georgian power system of evening peaking power and steady power supply during the winter, when operation of most of the hydroelectric plants in the area is curtailed by lack of sufficient water. 145/

g. Overhaul.

A consistent repair policy is carried out at the Khram GES. generators undergo overhaul approximately once a year. Capital repair of generator No. 1, which went into operation in December 1947, was completed on 23 June 1950; generator No. 2 was put on line in December 1948 and was overhauled in April 1950, and repair generator of generator No. 3 was completed 13 months after it went into operation--on 31 May 1949. 146/

7. Hydroelectric Power Stations on the Samgori Irrigation Canal: Satskhenisi, Tetrikhevi, Sioni, and Martkopskaya.

a. Location.

The canal starts near the village of Sioni in Tianetskiy Rayon on the Samgori Steppe. 147/

b. Estimated Capacity.

29,000 kw (planned) 148/; 7,000 kw as of 1953.

c. Description of Plants.

(1) Tetrikhevi GES.*

The first turbines of Tetrikhevi GES were reported ready for installation 13 February 1951. The first generating unit of this station was incorporated into the Georgian power system on 12 September 1952. Because of low water in the canal, it could carry only 60 percent of capacity. 150/

(2) Satskhenisi GES.*

The first turbogenerator was ready to start up about mid-1952. 151/

(3) Sioni GES.

Under construction in June 1953. 152/

(4) Martkopskaya GES.

According to Soviet sources, this station is to be built on the canal, but there has been no indication that it is being constructed. 153/

* The capacity of these stations is unknown. In November 1952 the "Samgori Hydroelectric Stations" produced 3,470,550 kwh. This output was presumably that of the 2 stations listed above, since they were the only 2 known to have been in operation at that time. 149/

8. Rioni GES.

a. Location.

Five kilometers south-southeast of the Kutaisi Railroad Station on the Rioni River, 42°15'N-42°42'E.

b. Estimated Capacity.

48,000 kw.

c. Description of Plant.

The plant, which has a 60-meter head, was completed in 1934. It contains 4 generators which are rated at 12,000 kw, 6,600 volts, and were manufactured in the USSR by LMZ (Leningrad Metals Plant). The turbines for these generators are of the Francis vertical type with 12,500 hp at 300 rpm, and a wheel diameter of 1,750 millimeters. 154/ Automatic control was reported installed in the plant on 19 March 1952. 155/

d. Operation.

The plant follows a seasonal pattern in power production, having low water in the autumn-winter period. 156/ Operation statistics on this plant during 1947 and 1948 show an average plant factor of 50 percent for this plant. The highest average loads were carried in May, June, and July. 157/

e. Dam and Reservoir.

The geological structure underlying the foundation of the dam is rock. The dam is 79 meters long, 15 meters high, and has 6 sluice gates. It feeds into a canal 5.2 kilometers long with a maximum capacity of 75 cubic meters per second. The plant intake feeds into a tunnel, 4 kilometers long, horseshoe shaped with cross-sectional area of 21.3 cubic meters. It is drilled through clayey sandstone. Because of the surge characteristics of the long penstocks on varying loads, the Rioni station must be a base load plant rather than a governing plant. 158/

9. Rustavi TETs.

a. Location.

Rustavi, in the southern outskirts of town, on the premises of the Transcaucasus Metallurgical Plant (see Fig. 12*), downstream from the new bridge over the Kura River; 41°38'N-45°03'E. 159/

b. Estimated Capacity.

75,000 kw.

c. Description of Plant.

Three generators are installed at Rustavi TETs, each of which is believed to have a capacity of 25,000 kw. This estimate is based on the following information:

(1) Rustavi TETs would be the largest thermal power installation in the Georgian SSR. 160/

(2) the first turbogenerator was delivering 11,000 kw and that total production would be 25,000 kw. work on the second turbogenerator was being delayed because of lack of equipment. a turbine was scheduled for delivery in May 1951. This can be assumed to be turbogenerator No. 2, whose installation took approximately one year. Work on the third turbogenerator was being completed in March 1953. 161/

* Following p. 78.

(3) The suggested plan for the production of electric power for the fourth quarter of 1953,

called for an output of 30,000 million kwh a month. 162/ This planned output in relation to the average operating time of the Georgian power system in 1953, 43 percent plant factor, tends to confirm the above estimate.

d. Transmission System Connection.

Although the plant is subordinate to the Ministry of Ferrous Metallurgy, it is connected to the Georgian power system.

the transfer to the Georgian power system of the 110-kv Rustavi TETs-Navtlugi transmission line. This line connects with Khram GES and therefore with Tiflis. 163/

10. Sukhumi GES.

a. Location.

Twenty kilometers north of Sukhumi, beyond the villages Michaelovka and Andreyuskoye, 43°09'N-41°01'E. 164/

b. Estimated Capacity.

20,400 kw.

c. Description of Plant.

Sukhumi GES has 3 generators, each of which is believed to have a capacity of 6,800 kw.

all

three units had been put into operation, thereby bringing the station to full-planned capacity. 166/ Although other sources cite estimates up to 8,000 kw, the 6,800-kw figure has been accepted pending further information. 167/

The station is reported to have a 280-kw, 750-rpm horizontal Pelton house unit. 168/ (For photographs of the station, see Figs. 13 and 14*).

d. Operation.

Although the station was completed in January 1949, the only high-voltage transmission line connected with it at this time went to Sukhumi, which could only use 20 to 25 percent of the station's capacity. 169/ The next transmission line connected to the station was the Sukhumi-Afoni substation line (27 July 1949). 170/ The lack of sufficient transmission line capacity through 1951 is reflected in the load data from June 1949 through March 1951. The average daily load never exceeded 5,800 kw. 171/

Sukhumi GES was included in the general system of electric power stations of the Georgian SSR in June 1951 when the transmission line between Sukhumi and Tkvarcheli was completed. 172/ This line was originally planned in 1947, but difficulty in receiving the material caused stoppages. These delays prevented the station from becoming fully useful for a period of 2-1/2 years.

e. Dam and Headworks.

Sukhumi GES is a high-head plant, with a head of approximately 212 meters. The headworks are located in Tsumuri Gorge. The dam is 100 to 150 meters long and 4 meters wide at the top. There is a 2,640-meter-long pressure tunnel, 2 meters in diameter, flowing via the Ostesh Mountains 173/ to the regulating chamber and penstock. The water comes to the powerhouse through one large penstock. At the powerhouse, the penstock divides into 3 pipes, 1 for each machine. 174/

* Following p. 78.

11. Tiflis TETs.

a. Location.

Tiflis, 2 kilometers northwest of the town center on the east bank of the Kura in Molotov District, 175/ 41°43'N-44°48'E.

b. Estimated Capacity.

8,000 kw.

c. Description of Plant.

The existence of two turbogenerators has been noted 176/ The exact size of these machines is unknown, but the load reports suggest that each is a 4,000-kw unit. 177/

The efficiency of this TETs is very low. This fact, together with information showing the number of days on which the plant was idle, indicates that the station is probably used only as a peaking plant. 178/

12. Tkvarcheli GRES.

a. Location.

Tkvarcheli, south bank of Galiza River, 1,000 yards south of Tkvarcheli and 13.5 miles northeast of Ochacuchure; 45°50'N-41°41'E.

b. Estimated Capacity.

49,000 kw.

c. Description of Plant.

This brick building was under construction in 1936, and one 24,000-kw turbogenerator was to be completed in 1936. 179/ The second turbogenerator is a 25,000-kw hydrogen-cooled unit. 180/

Pictures of the plant (see Figs. 15 and 16*) show 5 smoke-stacks, and lists 5 boilers, 2 of US and 3 of Soviet manufacture. 181/ Only boilers No. 1 through No. 4, however, have been noted 182/ and available photographs of the plant invariably show only four smokestacks in use at one time. It is therefore concluded that one boiler is used as a spare.

d. Operation.

Originally this plant was built to carry peak loads during the winter season and to take the load in case of low water periods. Coal consumption figures and electric load figures from 1947 into 1952, however, indicate that the station is being used as a base load plant. The average coal consumption per day computed on the basis of reports for 203 days over the period 1947-52 was 821 tons. This figure corresponds to an average load of 37,000 kw and a plant factor of 75 percent. 183/

e. Transmission Lines.

110-kv transmission lines run from Tkvarcheli GRES to Rioni GES, to Akhamara substation, to Zugdidi, and to Sukhumi, forming part of the 110-kv network of the Georgian power system. 184/

13. Tkvibuli GES.

a. Location.

Between Tkvibuli, 42°20'N-43°00'E, and Chkhari, 42°22'N-42°59'E.

* Following p. 78.

b. Estimated Capacity.

14, 000 kw (probably). 185/

c. Description of Plant.

This plant was reported under construction in 1950. Since the plant was still receiving cement shipments in March 1953 186/ and had requisitioned metal shipments for the fourth quarter of 1953, it seems likely 187/ that the station will not be completed until 1954.

d. Dam and Headworks.

The headworks and reservoir are located at the back of the Nakeralsk mountain range; the reservoir is in the Shaorsky depression. 188/

14. Zages.

a. Location.

Zemo Avchala village near Tiflis on the Kura River, 41°54'N-44°45'E.

b. Estimated Capacity.

36, 800 kw.

c. Description of Plant.

The plant has six generators. The first 3 were installed in 1927, each rated at 4, 000 kw, 6, 600 volts, and were manufactured in the USSR. The turbines for these generators are Francis verticals of 4, 500 hp at 214 rpm, with a 1, 950-millimeter wheel, and were manufactured in Germany. (For pictures of the station, see Figs. 17, 18, 19, and 20*).

* Following p. 78.

Generator No. 4 was installed in 1933 and is the same as the first three, except that the turbine is of Soviet manufacture. Generators No. 5 and No. 6 have Kaplan vertical turbines, one of Swedish and one of Soviet manufacture. These turbines are rated 17,500 hp at 167 rpm. 189/ No rating of the generator end is given on these machines.

If we consider that 1 kw equals 1.34 hp and assume 100-percent efficiency, these machines would be rated at 13,000 kw each, making the total plant 42,000 kw rather than the given Soviet figure of 36,800 kw. An analysis of stream flow data gives the average flow as 235 cubic meters per second at a 20-meter head. This would make the average capabilities of the plant 40,000 kw. Because further clarifying data are lacking, the more conservative Soviet capacity figure has been accepted. 190/

The station was being fitted out for remote control from Tiflis in November 1953. 191/

In 1947 the cost of operation (excluding amortization) per kw installed was 61 rubles. In 1947, for every 1,000 kw installed this power station employed 3.5 workers. 192/

d. Dam and Reservoir.

The dam is about 1 kilometer below the town of Mtskheta near the point where the Aragvi flows into the Kura. There is an intake canal 3 kilometers long with a maximum capacity of 324 cubic meters per second. 193/ The length of this canal would give the station very poor governing characteristics even with the best governors.

Maximum river flow is 1,100 cubic meters per second, and minimum flow 35 cubic meters per second. The average stream flow is 235 cubic meters per second. 194/

e. Transmission Lines.

There is a 110-kv high-tension line to Rioni GES via Kutaisi, 195/ and a 110-kv line connects Khram GES to Zages. 196/

15. Rural Electric Power Plants.

a. Description of Plants.

More than 226 rural electric power plants are in operation in the Georgian SSR. As of 1 January 1952 their total capacity was 25,500 kw. 197/

These rural stations are being connected to the Georgian power system and into rural power systems of their own. In 1952 the rural stations located in the Kakhetiya Rayon were being connected by a high-voltage network. 198/

The location of a majority of these stations is unknown. The following are the larger and therefore better known stations:

(1) Abasha Hydroelectric Power Station, 42°12'N-42°13'E, on the Abasha River waterfalls, 40 kilometers west of Kutaisi. The station has a rated capacity of 1,800 kw and is connected to the Georgian power system. 199/

(2) Adlari Hydroelectric Power Station, in the Akhalkalak Rayon. The plant, whose capacity is unknown, is to begin operation "soon." 200/

(3) Berizhskaya Hydroelectric Power Station, in Gudantskey Rayon. This station has a capacity of 1,500 kw. 201/

(4) Dashbash Hydroelectric Power Plant, 41°35'N-44'08'E, just upstream on the Khram River from where the tailrace of Khramges No. 1 flows into the Khram. 202/

(5) Dmanis Hydroelectric Power Station, location unknown.

203/

(6) Motla Hydroelectric Power Station, located in Ochemshirskiy Rayon. The plant was "nearly completed" in October 1953. 204/

(7) Orbelk Hydroelectric Power Station, in the Kutaisi District of the Republic. The plant was completed by 25 May 1951. It has a capacity of 450 kw. 205/

(8) Skuri Hydroelectric Power Plant, location unknown. It appears to be near Gudauta, 43°06'N-40°39'E,

06/

(9) Sulori Hydroelectric Power Station, location unknown. the plant

began operation in the spring of 1953. 207/

(10) Tiriponskaya Hydroelectric Power Station, located near Kveshi Village in Katalinia. This station was completed on 15 July 1951. It has a capacity of 3,000 kw and is "automatized." 208/ It is incorporated in the Georgian power system. 209/

Although the largest of these stations is probably not over 3,000 kw, the total capacity is planned to be about 35,000 kw by the end of 1954. 210/ Thus a considerable amount of emergency power is available to the Georgian power system.

16. Other Electric Power Stations.

Minor electric power stations in the Georgian SSR are listed in Table 11.*

* Table 11 follows on p. 74.

Table 11

Minor Electric Power Plants in the Georgian SSR

Name	Location	Capacity
Batumi Refinery No. 429 Thermal Electric Power Station	Batumi 41°39'N 41°39'E	ne plant is estimated to have a probable capacity of 5,000 kw. This figure was derived by using a plant factor of 70 percent. 211/
Bagnari GES	Gantiadi (formerly known as Pilen-kovo) 212/ 43°24'N 40°05'E	Capacity unknown. 10,000 kw reported 213/ but planned production of 1 million kwh for the second quarter of 1951 a/* which would indicate a capacity of not over 1,000 kw. 215/
Bzhuzha GES, near Makhasadze b/ -- probably on Natanbi River	41°55'N 42°00'E	Unknown
Daryzal GES	Unknown	To be built in next 5 years. c/ Planning by Tbilgidep. 218/
Gumati GES, on Rioni River	42°15'N 42°45'E	Unknown

* Footnotes for Table 11 follow on p. 75.

Table 11

Minor Electric Power Plants in the Georgian SSR
(Continued)

Name	Location	Capacity
Kutaisi Thermal Electric Power Station, subordinate to Kutaisi Automobile Plant d/	Kutaisi -- at the automobile plant	Unknown -- probably over 20,000 kw, since a 20,000-kw transformer was connected in April 1952. 220/
Ladzhanuri GES, near Tsageri e/	42°39'N 42°46'E	Unknown
Shaori GES, apparently subordinate to Ministry of Railroad Transportation f/	42°20'N 42°59'E	16,000 (planned)
Stalinir State Electric Power Station g/	42°14'N 43°58'E	Unknown
Tskhaltubo GES h/		-

a. The station was put in operation early 1951. 215/
b. A high-tension line to Makhasadze 216/ is reported.
c. Still under construction February 1953. 217/
d. Construction started in mid-1950. One generator being installed May 1952. Substation at the plant connected to Georgian Power System. 219/
e. Station planned by Tiflis Branch Hydroelectric Planning Trust. Construction started in 1953. 221/

Table 11

Minor Electric Power Plants in the Georgian SSR
(Continued)

f.. Plant still under construction July 1952. 222/ Dam at Dide Chala at Village of Khurga; water will be diverted to region of Khvreliyetskiy Springs to pressure tunnel which will be cut through the Nakeralskey Range. Plant to have 303 meter head. 223/

g. July 1949 construction of this power station was reported. 224/

h.

225/

The stations listed in Table 12 were mentioned in a document 226/ published in 1952. Since documentation for the report is not available, and since no other references to these stations have been noted, they are included in a separate list.

Table 12

Electric Power Plants in the Georgian SSR
Reported but Unconfirmed

Name and Location	Coordinates	Type	Capacity (KW)
Agara, 90 kilometers west-northwest of Tiflis	42°05'N 43°50'E	Oil	1,500
Ambrolauri-Ritseuli Power Station, 163 kilometers northwest of Tiflis on Rits River	42°31'N 43°09'E	Oil	1,500

Table 12

Electric Power Plants in the Georgian SSR
Reported but Unconfirmed
(Continued)

Name and Location	Coordinates	Type	Capacity (KW)
Akamara, 10 kilometers east of Tkvarcheli	42°52'N 41°50'E	Thermal	3,000
Akhalkalaki-Taparvan Power Station, 115 kilometers west-southwest of Tiflis	41°25'N 43°29'E	Hydro	3,000
Bulachauri, 40 kilometers west-northwest of Tiflis	42°03'N 44°46'E	Oil	Small a/*
Digomi, 8 kilometers north-west of Tiflis on Kura River b/	41°45'N 44°40'E	Hydro	3,000 (planned)
Koremshskaya Power Station, 210 kilometers west-north-west of Tiflis, Tsageri District c/	42°38'N 42°47'E	Hydro	Small
Mtskheta, 10 kilometers north-northwest of Tiflis on Tiflis-Kutaisi route, where railroad crosses Kura d/	41°50'N 44°43'E	Hydro	Small
Ochemchiri Refinery Power Station, northeast of rail-road station e/	42°43'N 41°29'E	Oil	Small
Poti, slightly north of and near mouth of Rioni River	42°09'N 41°41'E	Hydro	Small

* Footnotes for Table 12 follow on p. 78.

Table 12

Electric Power Plants in the Georgian SSR
Reported but Unconfirmed
(Continued)

Name and Location	Coordinates	Type	Capacity (KW)
Rachka GES f/	42°09'N 41°41'E	Hydro	Up to 7,000
Sukhumi, old municipal power station near town center, between RR station and Black Sea, just off Blatina Street g/	43°00'N 41°02'E	Thermal	3,000
Sukhumi, Shipyard Power Station northwest of pier	43°N. A.'N 41°02'E	Thermal	Small
Zugdidi	42°30'N 41°53'E	Oil	1,500

a. Two diesel generators in May 1948.
b. Construction planned for 1946-50 but thought not to be under construction since no mention has been noted as of October 1953.
c. Recent completion announced in November 1949.
d. Dam observed in May 1949. Could be dam for Gori Hydro Plant.
e. Brick building, 2 diesel generators.
f. Expected to go in operation after November 1949.
g. White painted building, peak tiled roof with spire carrying high tension line, 3 diesel generators.

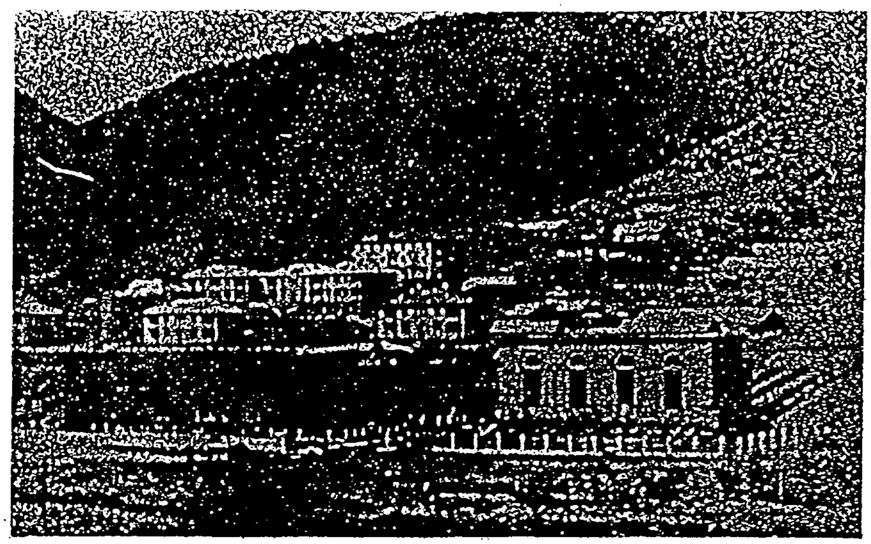

FIGURE 3. View of Chitakhevi GES in the Georgian SSR.

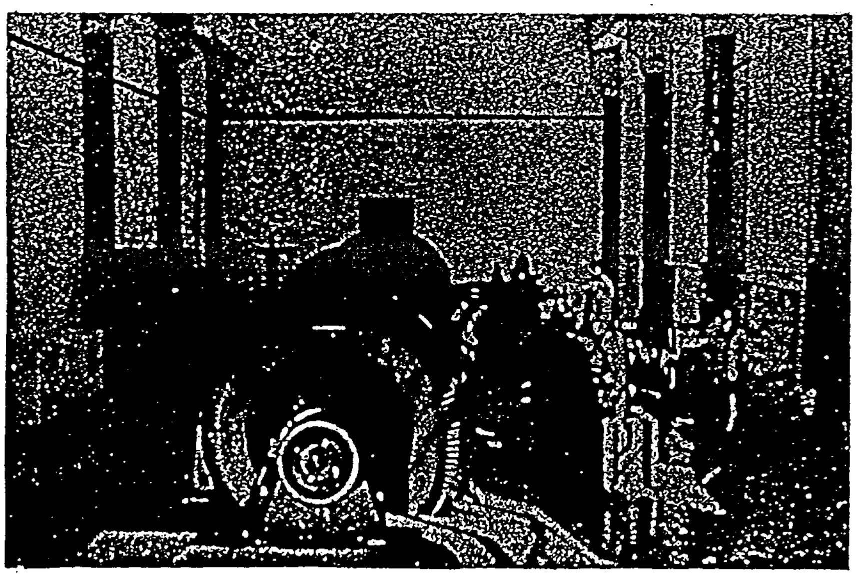

FIGURE 4. Two Generators in Gori GES
in the Georgian SSR.

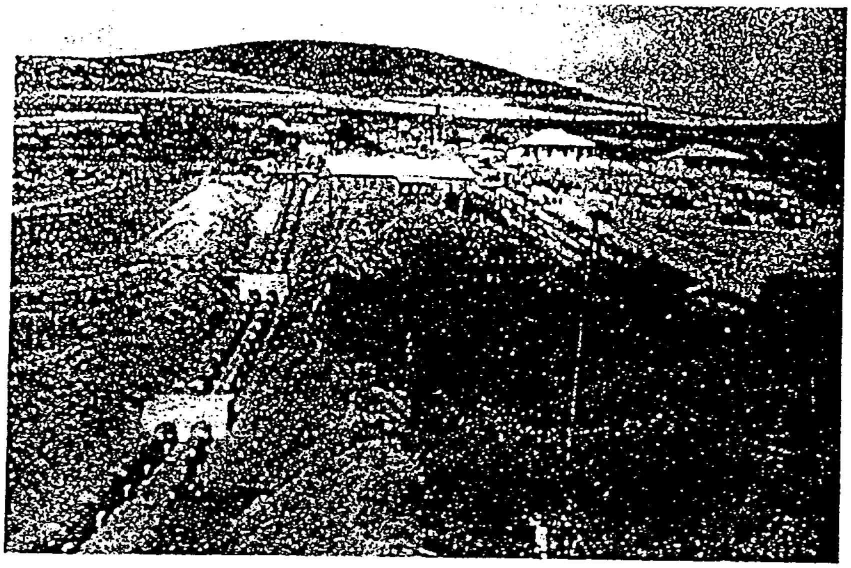

FIGURE 5. Hydroeletric Turbine in Gori GES.

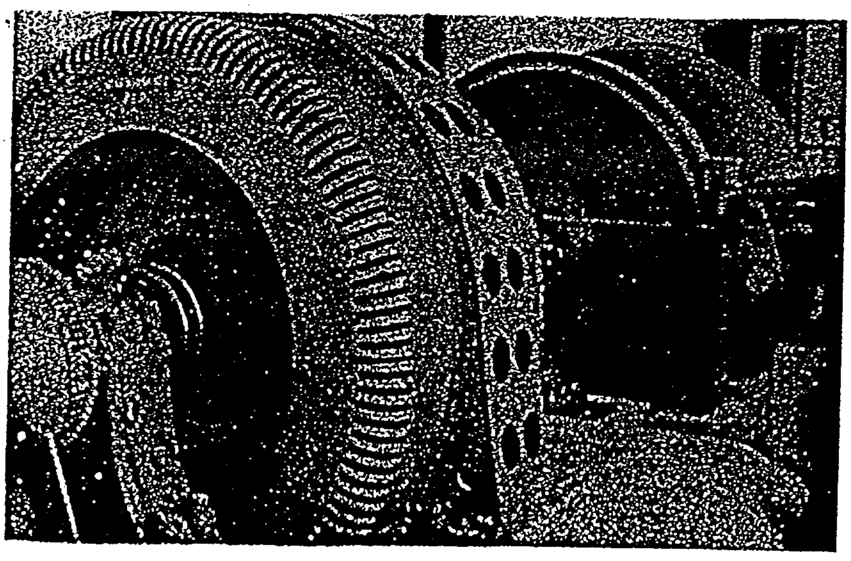

FIGURE 6. Penstocks of Gori GES.

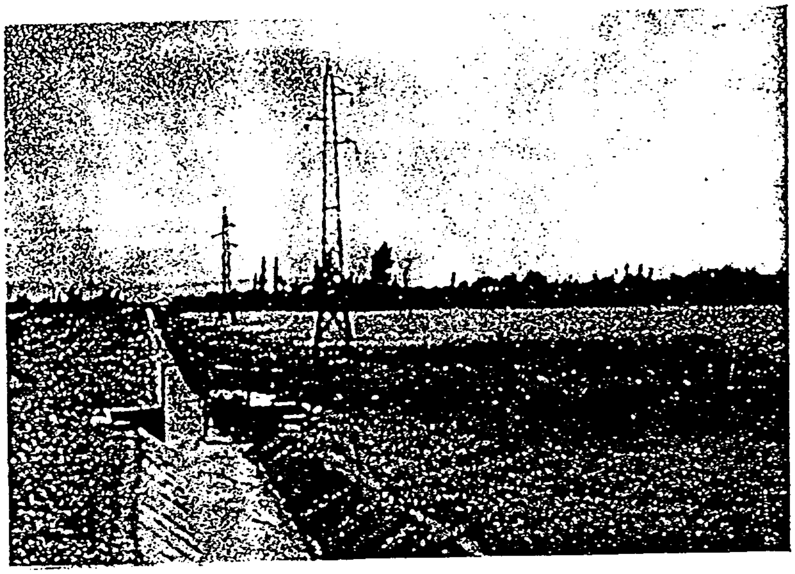

FIGURE 7. Irrigation Canal and High-Tension, 110-kv Transmission Lines at Gori GES.

FIGURE 8. Ortachala GES under Construction in 1952.

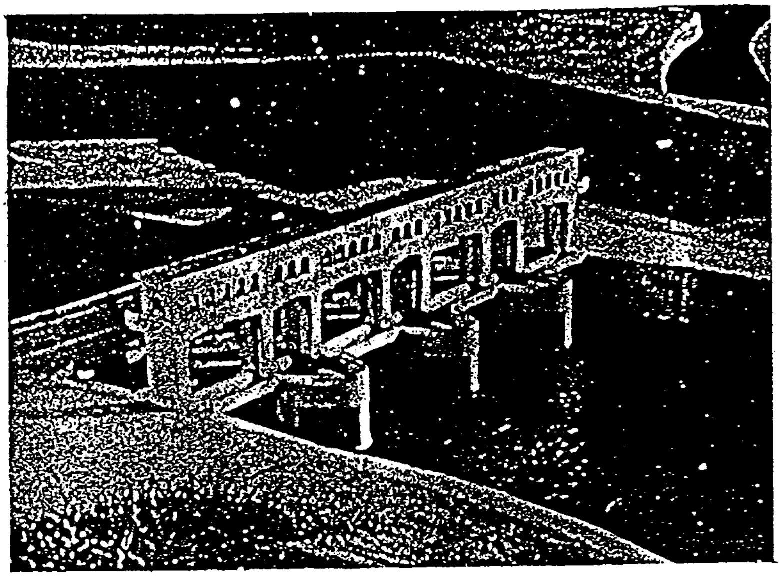

FIGURE 9. Model of Ortachala GES (Now under Construction).

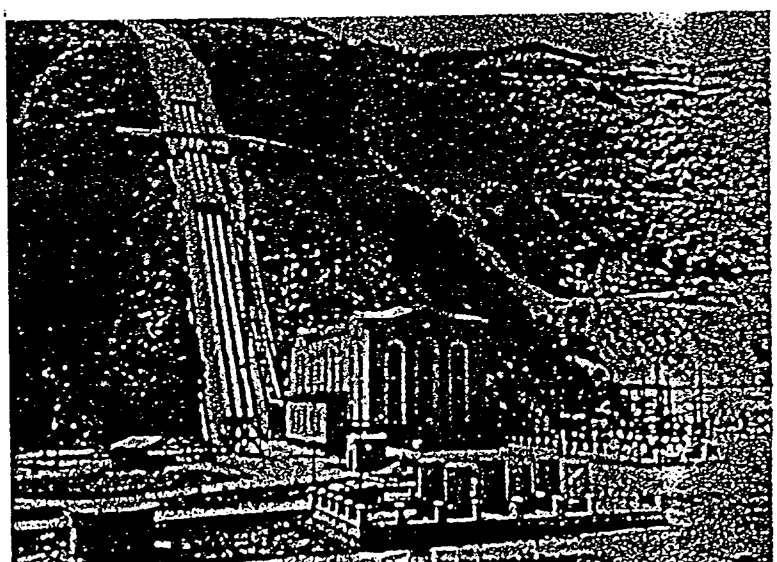

FIGURE 10. View of Khram GES, Showing Penstocks, Powerhouse, and Switchyard.

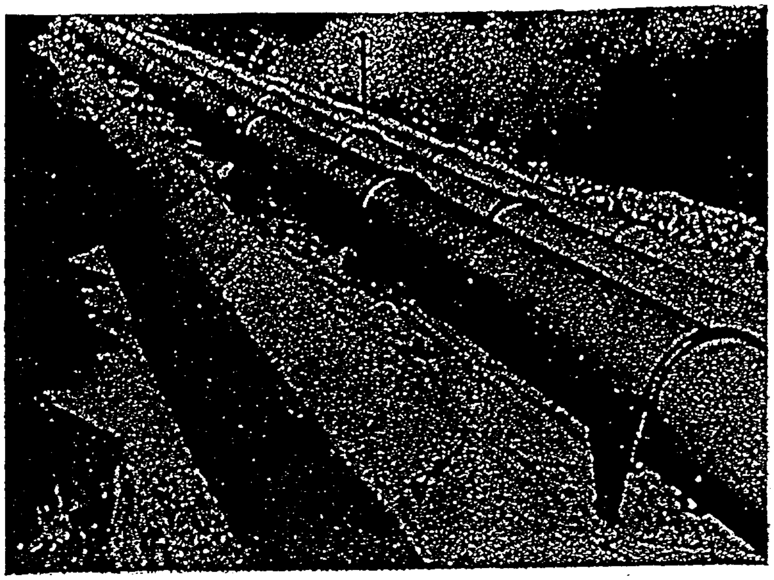

FIGURE 11. Penstocks of Khram GES.

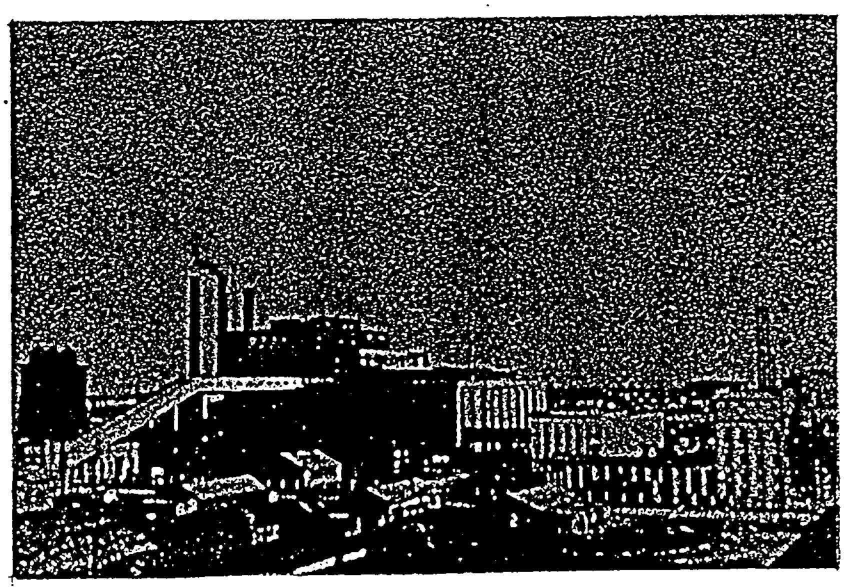

FIGURE 12. Transcaucasus Metallurgical Plant and Rustavi TETs, 1952.

FIGURE 13. Penstock of Sukhumi GES.

FIGURE 14. Transmission Line of Sukhumi GES.

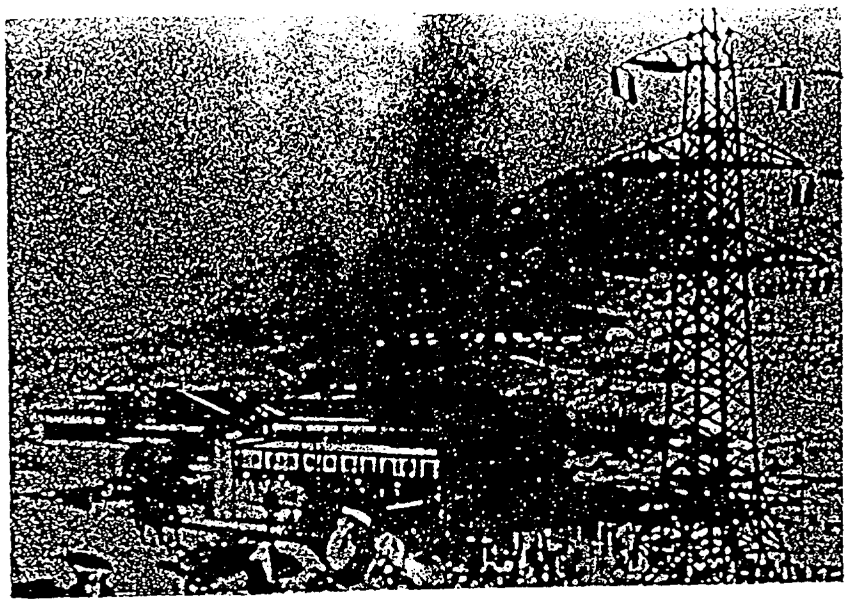

FIGURE 15. View of Tkvarcheli GRES Showing 4 of the 5 Smoke-stacks in Use.

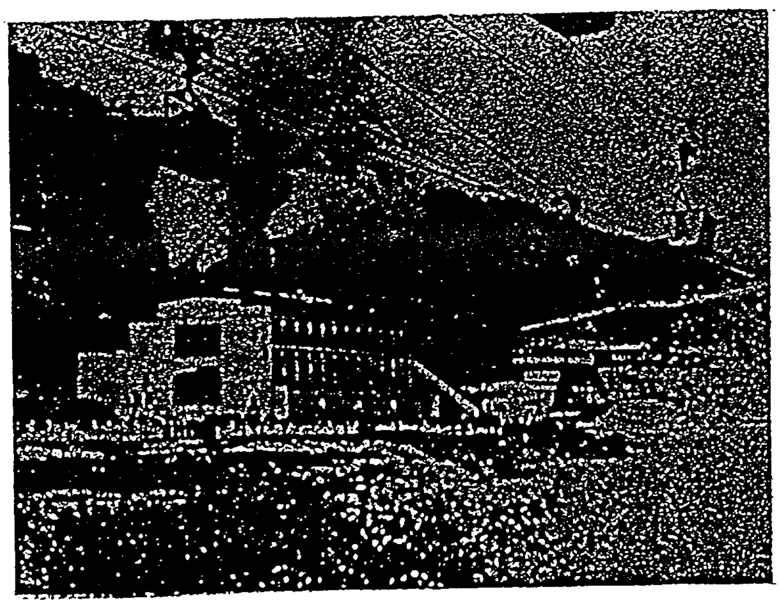

FIGURE 16 Another View of Tkvarcheli GRES Showing 4 of the 5 Smokestacks in Use.

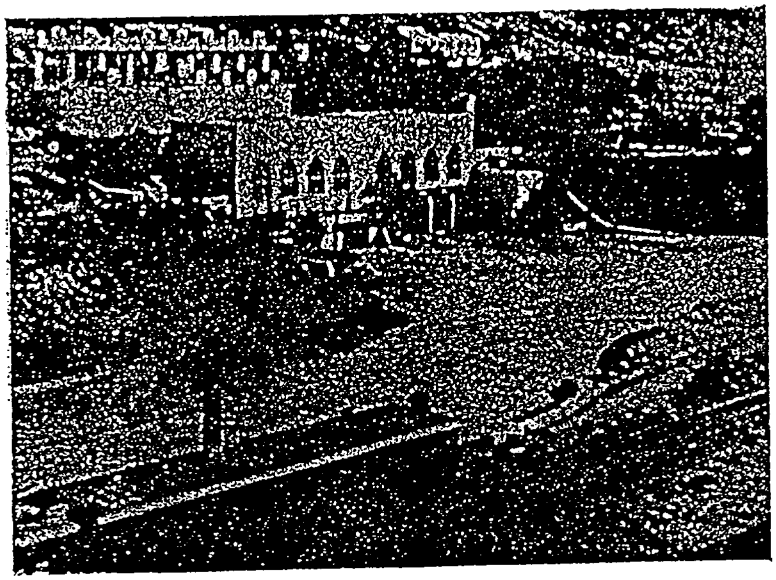

FIGURE 17. Zages Hydroelectric Power Plant at Zemo Avchala. (An Electric Railroad Is Shown in the Foreground.)

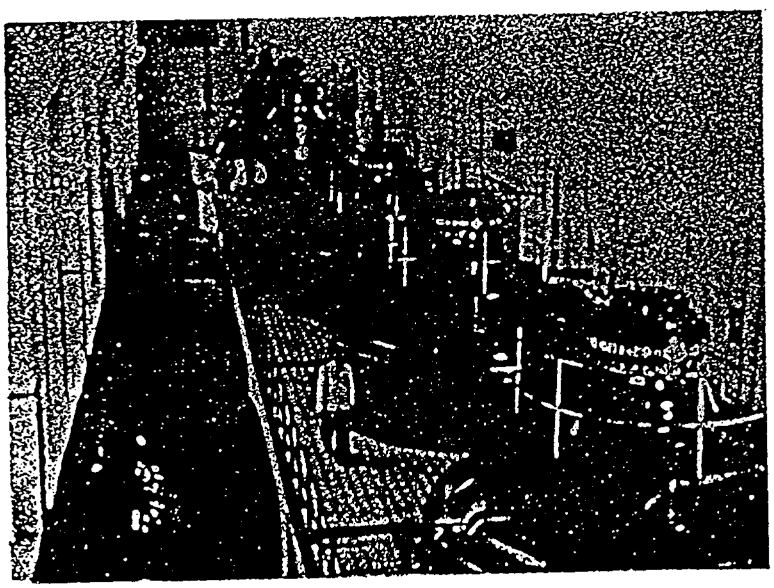

FIGURE 18. Hydroelectric Generators at Zages.

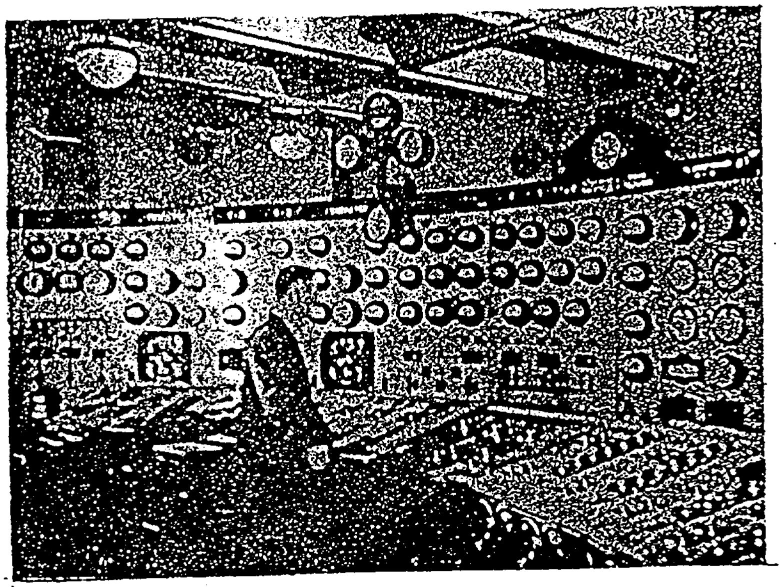

FIGURE 19. Control Panel of Zages
Hydroelectric Power Plant.

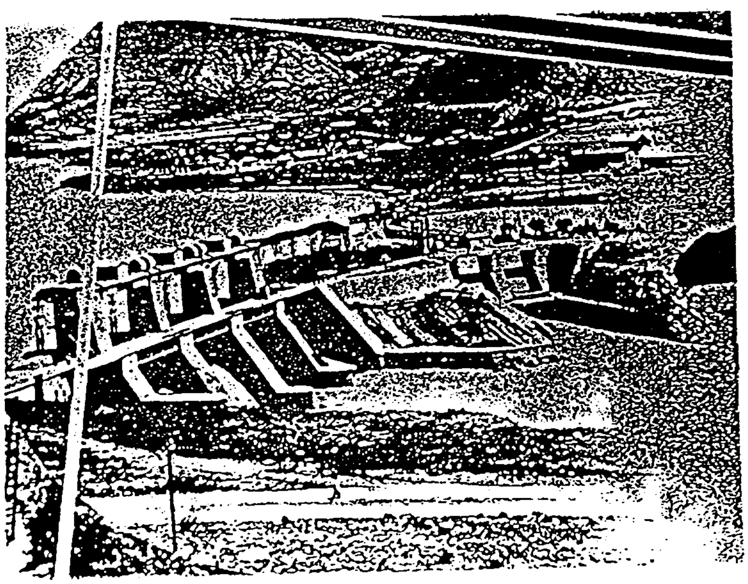

FIGURE 20. Zages Dam Located at Miskheta,
41°22' N - 44°46' E.

APPENDIX C

ELECTRIC POWER STATIONS IN THE ARMENIAN SSR

1. Arzni GES, Station No. 4 of the Sevan-Zanga Cascade.

a. Location.

Fifteen kilometers north-northeast of Yerevan.

b. Estimated Planned Capacity.

47,000 kw. 227/

c. Description of Plant.

Construction of Arzni GES will probably begin in late 1953. An article in a Soviet periodical reported that construction would begin in 1952, that the first unit would be put in operation in 1955, and that the station would be put in full operation by 1956. Plans seem to be lagging at present by about a year. 228/ Designing of hydromechanical equipment was to be assigned to the Armenian Branch of the Hydroelectric Planning Trust in 1952. 229/

Arzni GES was originally planned to have a capacity of 47,000 kw and an annual output of 323 million kwh. The plant was to have a 110-meter head. No current confirmation of these plans is available. 230/

2. Dzora GES.

a. Location.

On the Dzoraget River, near the Kalageran Railway Station, directly south of Alaverdi 231/; 40°57'N-44°39'E. 232/

b. Estimated Capacity.

46,500 kw.

c. Description of Plant.

Dzora GES went into operation in 1936. It has three 7,500-kw hydrogenerators with rated voltages of 6,600. The turbines are 10,500 hp vertical Francis turbines rated at 500 rpm. The diameter of the wheels is 1,300 millimeters. 233/ One new generator, probably ~~24,000 kw, was installed in 1949.~~ This machine is believed to have gone into operation at the end of 1949, since the stator-winding connections were completed in August 1949. 234/

In November 1950, preparations were being made to install automatic equipment. 235/ According to a report on 3 February 1952, automatization was completed. 236/

d. Dam and Headworks.

The penstock construction for the new generator is unknown. The three 7,500-kva generators are supplied by a tunnel 2.4 kilometers long which runs through porphyrite. It has a diameter of 3.2 meters. The water flow is from the tunnel through 3 metal penstocks 250 meters long and 1.5 meters in diameter. The surge tank is 4.7 meters in diameter and 25 meters high. It is a cylindrical tank, made of concrete and embedded in rock. The plant head is 105 meters. 237/

3. Gyumush GES; Station No. 3 of the Sevan-Zanga Cascade.

a. Location.

30 kilometers north of Yerevan on the Zanga River; 40°30'N-44°36'E.

b. Estimated Capacity.

214,000 kw.

c. Description of Plant.

Information on Gyumush GES is contradictory and suggests that preliminary plans for the station, published in 1936, 238/ were revised before construction actually began after World War II. It appears that four 53,500-kw units had been installed by mid-1953. 239/

According to the original plans, Gyumush GES was to have 6 vertical 43,300-kw turbines. It was to be built in 2 stages of 130,000 kw each. The first stage was to be used for base load, and the second stage, which was to be used for peaking power, could be developed as the peak loads of the system expanded. 240/

The loads on the system probably rose faster than anticipated, because postwar data indicate that four 53,500-kw units were to be installed, bringing the station capacity to 214,000 kw. 241/

In 1946, Moscow News announced that initial operation of the station with one 53,500-kw unit was planned for 1950. 242/ the fourth unit of the station was tested and took on part of the system's load on 15 May 1953. 243/ Also, a 1948 article reported construction of four penstocks. 244/

In view of this evidence, a figure of 214,000-kw for the plant's present capacity has been accepted.

d. Dam and Headworks.

The plant is fed by a diversion canal 18.3 kilometers long. Water flows through a tunnel of 11.3 kilometers with a cross section of 22 square meters inside diameter and a coefficient of roughness of 0.014. The last 7 kilometers are open canal with a coefficient of roughness of 0.016. 245/

The dam and canal give the plant a 300 meter head and the reservoir will have a capacity of 5.5 million cubic meters. 246/

According to a 1948 article in a Soviet periodical, Gyumush GES was estimated to cost 585 million rubles. 247/

Gyumush GES is the largest generating plant in the Armenian power system.

4. Kanaker GES.

a. Location.

8 kilometers north of Yerevan. 1.6 kilometers northwest of Kanaker, on the east bank of the Zanga River; 40°13'N-44°31'E. 24./

b. Estimated Capacity.

88,000 kw.

c. Description of Plant.

Kanaker GES is made up of 2 sections which have a total capacity of 42,000 kw and 46,000 kw, respectively. Section I consists of four 10,500-kva vertical Francis-type hydrogenerators with a generator voltage of 11 kv. The turbines were manufactured in the USSR and are 15,000 hp at 500 rpm. Section II has two 23,000-kw units of unknown type and make. 249/ (For pictures of the plant and illustrations of its location, see Figs. 21, 22, 23, and 24.*)

d. Dam and Headworks.

The dam is at Arzni, more than 11 kilometers from the power station. The water flows via a horseshoe-shaped tunnel

* Following p. 93.

4.1 kilometers long through marl clay and then through a canal 8.3 kilometers long to a compensating basin of 150,000 cubic meter capacity. From here, four steel penstocks lead to the power plant. 250/ The plant has a head of 170 meters, and the canal a capacity of 60 cubic meters per second. The plant therefore has a possible output of 94,000 kw. 251/

e. Operation.

Kanaker is dependent on the discharge water from Sevan hydroelectric plant for part of its water supply. Without discharge water from Sevan, Kanaker can only carry half load. 252/

5. Leninakan GES.

a. Location.

On the Shirak Irrigation Canal, north of the city of Leninakan, 40°47'N-43°51E. 253/

b. Estimated Capacity.

5,200 kw. 254/

c. Description of Plant.

The plant was planned to have five 1,300-kw units for a total of 6,500 kw. 255/ In 1936, however, only 4 of the 1,300-kw units were installed, and no changes have since been noted. The plant has a 115-meter head and an average annual output of 28 million kwh. 256/

6. Sevan GES (Ozernaya).

a. Location.

Sevan, near where the Zanga flows out of Lake Sevan, on the lake side of the road, 40°32'N-44°56'E.

b. Estimated Capacity.

35,000 kw (first section).

c. Plant Description.

Sevan GES has two 17,500-kw generators which make up the first section. These units were put into operation in July 1949. 257/ The sharp decrease in number of construction workers at the site after that date indicates that construction of a second section was not undertaken. There are additional indications that, for the present, the station is considered completed. Sevan GES was being converted to permanent hook-up in March 1951, and completion of automatization was reported in 1952. 258/ Automatic equipment is usually the last to be installed in a power station.

Sevan GES is often referred to as an "underground station." The generator room is reported to be built in rock, 100 meters underground. 259/

The waters of the lake and river are controlled by a dam 150 meters north of the powerhouse. The waters flow via sluice gates of 5-centimeter steel to the canal and thus to the powerhouse. The dam is of steel-reinforced concrete 92 meters high and 20 by 30 meters cross section. 260/

7. Yerevan GES, Power Plants I and II, Stations No. 6 and No. 7 of Sevan-Zanga Cascade. 261/

a. Location.

Yerevan I: 4 kilometers west-northwest of Yerevan railroad station, on the east bank of the Zanga River (see Fig. 25*);

Yerevan II: 3 kilometers north-northwest of Yerevan railroad station, on the east bank of the Zanga River (see Fig. 26*). **

* Following p. 96.
** For the locations of this and other power stations considered in this report, see Figures 27-31, which follow p. 140.

b. Estimated Capacity.

Yerevan I, 4,600 kw; Yerevan II, 2,200 kw. 262/

c. Description of Plant.

Yerevan I was first put in operation in 1926. It has a 54-meter head and is fed by an open canal which feeds into one short steel penstock. The annual output of the station in 1936 was, according to a Soviet source, 30 million kwh. 263/

The station was originally planned to be expanded to 36,000 kw. Up to the end of 1953 no indications of expansion had been noted.

Yerevan II has a capacity of 2,200 kw and an original planned capacity of 33,000 kw. As far as is known, no expansion from the original installed capacity has taken place.

These stations were the first automatic stations in the USSR. Controls are connected between Yerevan I and II. 264/ A third station was planned but apparently has never been built. 265/

8. Rural Electric Power Stations.

There are about 30 rural electric power stations in the Armenian SSR. 266/ The total capacity of these plants is estimated, on the basis of known rural stations in the republic and known figures for the Georgian SSR, to be approximately 15,000 kw. As is the case in the Georgian SSR, a concerted effort is being made to connect these rural plants to the Armenian power system and to each other. The creation of such networks will allow the most efficient usage of water power and will significantly reduce costs. The Oktemberyan, Artashat, and Agarag hydroelectric stations are known to be operating in parallel with the Armenian power system. 267/

Ten rural power stations in the Armenian SSR are known by name or location:

a. Agarag GES, location unknown; station known to be connected to the Armenian power system. 268/

b. Akner GES, location unknown. 269/

c. Areni GES, location unknown. 270/

d. Artashat GES, on the Garni River near Artashat (39°57'N-44°53'E) and Lovashen village. The station has 4 horizontal hydro-generators totaling 1,800 kw. Operation began on 6 November 1951; operates as part of the Armenian power system. 271/

e. Azatek GES, location unknown. The station has two generators. 272/

f. Idzhevan GES, 40°52'N-45°06'E, on the Akstafa River. The plant was constructed between 1935 and 1940. 273/

g. Megri GES, 38°45'N-46°30'E, on a small river tributary of the Araks River near Megri. Capacity unknown. 274/

h. Mikoyan GES, 39°48'N-45°20'E; capacity unknown. 275/

i. Oktemberyan GES, located on the irrigation canal at Oktemberyan. This station has three 700-kw horizontal generators, and is connected to the Armenian power system. 276/

j. Shaki GES, near Kafan in Zangezuri range, exact location unknown. The station was completed in 1935 and is reported to have two 600-hp turbines. 277/

9. Other Electric Power Stations.

The stations listed in Table 13 were mentioned in a document 278/ published in 1952. Since documentation for the report is not available, and since no other references to these stations have been noted, they are included in a separate list.

Table 13

Electric Power Stations in the Armenian SSR
Reported but Unconfirmed

Name and Location	Coordinates	Type	Capacity (KW)	Consumer
Akhta a/*		Small	Small	
Alaverdi, 105 kilometers north of Yerevan on Debeda Chai River b/	41°05'N 40°40'E	Hydro	1,000 to 3,000	Alaverdi copper mines and smelters -- probably Armenergo
Chirchir, 88 kilometers northeast of Yerevan on Zanga River, above where the rail race of Ozernaya flows in about 6 kilometers west of Sevan c/	40°35'N 44°55'E	Hydro	1,600	
Charbakh P/S No. 7, Sevan-Zanga Cascade, 1 kilometer west-northwest of Yerevan railroad station d/	40°10'N 44°32'E	Hydro		

* Footnotes for Table 13 follow on p. 89.

Table 13

Electric Power Stations in the Armenian SSR
Reported but Unconfirmed
(Continued)

Name and Location	Coordinates	Type	Capacity (KW)	Consumer
Dzhurkhor, 200 kilometers southeast of Yerevan; northwest of Kafan e/	39°15'N 45°25'E	Hydro		Local industry
Dzhul'ya, 190 kilometers southeast of Yerevan; northwest of Kafan f/	38°34'N 45°38'E	Oil	18,000	Arsenic Combine
Goria, Akne g/		Hydro	Small	Mechanical plant and textile.
Karavansary, Station No. 2 of Sevan-Zanga Cascade, about 10 kilometers down Zanga h/	40°34'N 44°46'E	Hydro	50,000 planned	Armenian Electric Power System
Yerevan Rubber and Chemical P/S 22 kilometers southwest of railroad station; in southeast corner of factory area.	40'10'N 44'32'E	Oil	Small	Factory
Yerevan, adjacent to and slightly east of the rubber and chemical plant	40°10'N 44°32'E	Oil	Small	Factory

Table 13

Electric Power Stations in the Armenian SSR
Reported but Unconfirmed
(Continued)

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a. Plans for expansion in 1945.
b. Powerhouse approximately 250 square meters. Believed to be in operation in 1952. High tension line to Dzorages and probably Zages.
c. Two aggregates. An old power station. Will cease to operate when Ozernaya is finished.
d. Canal for this power station will flow from the lower Zanga Canal. Construction considered doubtful as of 1954.
e [illegible] which tends to confirm the existence of this station. No further details are available.
f. Three diesel sets.
g. Possible confusion with Goris, or Akner.
h. Water from Lake Sevan to be conducted to this point through a 7-kilometer tunnel and canal after passing through Ozernaya (Sevan) power station. Scheduled for completion during the next Five Year Plan. Because of the absence of any confirmation of building activity on a station of this size, construction is considered doubtful as of 1954.

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APPENDIX D

SUBSTATIONS AND TRANSMISSION LINES IN THE TRANSCAUCASUS

Table 14

Known Substations of the Electric-Power System of Azerbaydzhan SSR

Substation	Location	Capacity	Remarks
Apsheronskaya	40°30'N-50°00'E	2 sets oil circuit breakers Type MKP-160, 110-kv, 600-ampere, with 2,500-kva interrupting capacity.	First section of 110-kv substation to be put in operation in 1952. 279/
Alyaty	39°57'N 49°24'E		110-kv transmission line to Molotov substation (Baku). 110-kv transmission line to Neftechala. 280/
Artema Ostrov		5,600- and 3,200-kva transformers; VM-35 and VBM-10 oil circuit breaker.	Artem Island power stations; 110-kv transmission line to mainland. 281/
Khurdalan	40°27'N-49°46'E NW of Baku		Under construction in March 1953 by Mingechauer hydroelectric station construction group. From this it is believed that this may be a major receiving substation from Mingechaur. 282/

Table 14

Known Substations of the Electric Power System of Azerbaydzhan SSR (Continued)

Substation	Location	Capacity	Remarks
Kirovabad	40°41'N 46°22'E		110-kv transmission line from Mingechauer line probably under construction. 110-kv transmission line to Dashkesan. 283/
Kirovneft'			Under construction August 1952. Being built by Azerbaydzhan Oil Association. 284/
Kirova	40°28'N 49°50'E		110-kv transmission line from Romany substation, 40°27'N-49°55'E. 285/
Mashtagi	40°32'N 50°00'E	No. 2 transformer installed 3 June 1951	110-kv transmission line to Surakhany, 40°26'N-50°01'E. A 2-circuit 110-kv transmission line to Sumgait, 40°33'N-49°37'E. 286/
Molotovneft'	Baku	7,500-kva synchronous condenser put in operation 4 August 1949	110-kv transmission line to Alyatzy, 39°57'N-49°24'E. A 35-kv transmission line to substation No. 512. 287/
Neftechala	39°18'N 49°11'E		110-kv transmission line to Alyaty, 39°57'N-49°24'E; also a line from the diesel station. 288/

Table 14

Known Substations of the Electric Power System of Azerbaydzhan SSR (Continued)

Substation	Location	Capacity	Remarks
Romany	40°27'N-49°59'E		110-kv transmission line from Kirovo substation, 40°28'N-49°50'E. A transmission line of unknown voltage to substation No. 43. A 22-kv transmission line to substation No. 54. 289/
Siazan'	41°02'N-49°10'E		110-kv transmission line to Sumgait, 40°33'N-49°37'E; a 35-kv transmission line to Sumgait. 290/
Surakhany	40°25'N-50°01'E		Double-circuit 110-kv transmission line to Mashtagi, 40°32'N-50°00'E, 12.9 kilometers, 20-kv line set up for frequency unloading. 291/
Stalinneft'	Unknown, probably Baku area		Ready to begin operation August 1952. Source of power unknown. Substation built by the Azerbaydzhan Oil Association. 292/
Zykh	40°22'N-49°59'E		Completed 16 October 1952. 293/

Table 14

Known Substations of the Electric Power System of Azerbaydzhan SSR (Continued)

Substation	Location	Capacity	Remarks
(The following substations are designated by number only. It is thought that the named substations are the main receiving substations, whereas the numbered substations of the Azerbaydzhan Power System are probably distribution substations.)			
02	Baku		Being modernized by Azerbaydzhan Oil Refineries Association. 294/
18			35-kv transmission line to substation No. 54. 295/
22			Azenergo. Substation being modernized May 1951. 296/
43			Transmission line of unknown voltage, probably 35 kv, from Romany substation. 297/
54			22-kv transmission line to Romany substation. 298/
68	Baku		Under construction May 1952. Being built by Azerbaydzhan Oil Machine Building Association. 299/

FIGURE 21. View of Kanaker GES.

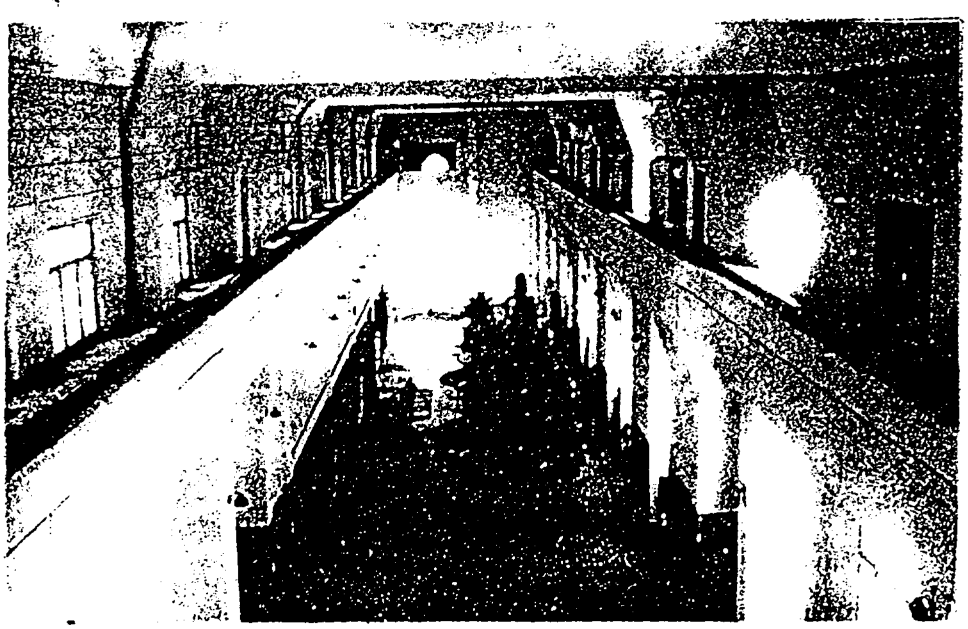

FIGURE 22. Four Francis-Type Hydrogenerators in Section I of Kanaker GES.

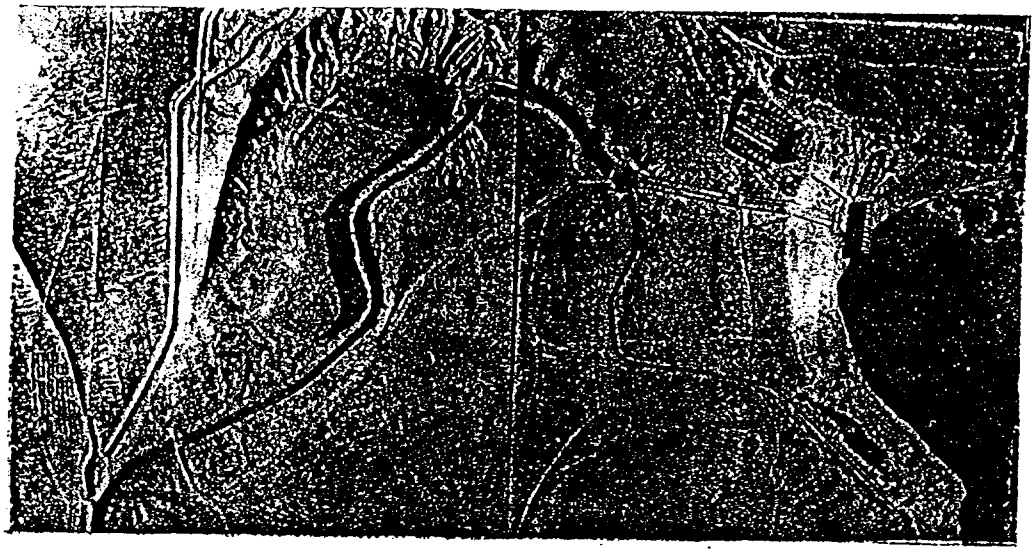

FIGURE 23. Relief Model of Kanaker GES.

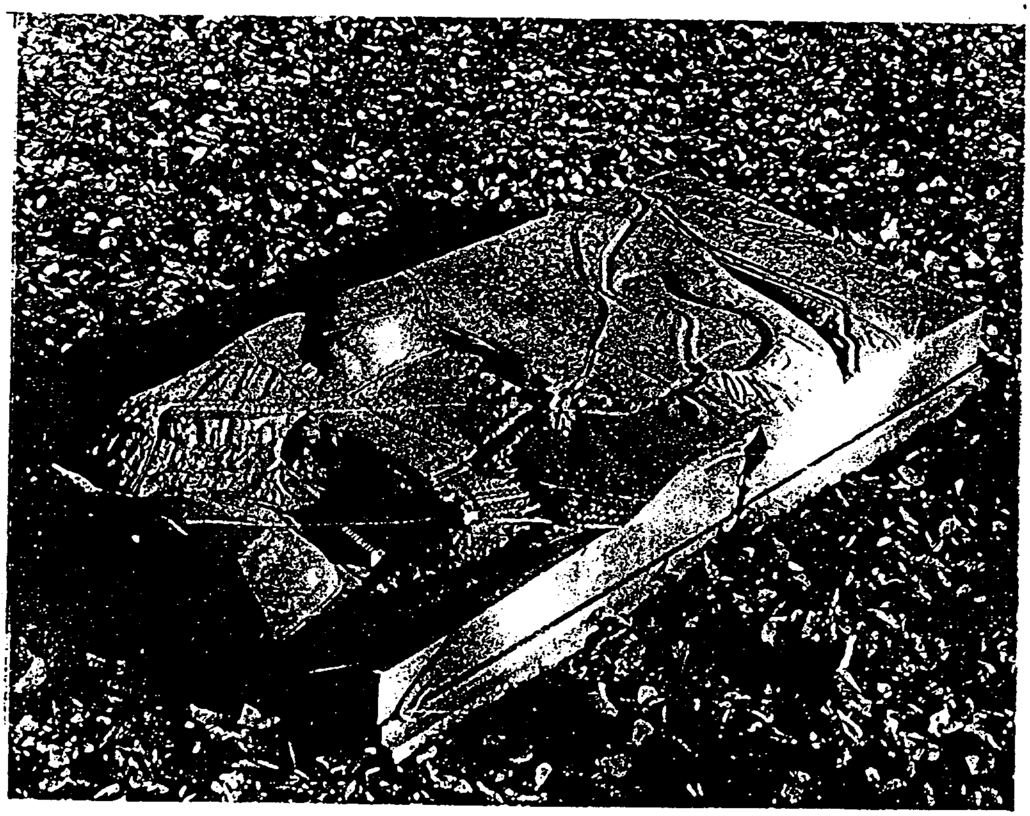

FIGURE 24. Closeup of Relief Model of Kanaker GES.

Table 14

Known Substations of the Electric Power System
of Azerbaydzhan SSR
(Continued)

Substation	Location	Capacity	Remarks
205	40°27'N 49°51'E Kishly	VM-35 oil circuit breakers, solenoid-operated 300/	Azenergo.
226		VMB'oil circuit breakers 301/	
227	Baku		35-kv transmission line to substation No. 249. 302/
249	Baku		35-kv transmission line to substation No. 227. 303/
365	40°28'N 50°07'E Ordzhonikidze Rayon Baku	2 transformers, probably 1,200 kva. 304/	Azenergo
373	40°28'N 50°07'E Ordzhonikidze Rayon		Azenergo 305/

Table 14

Known Substations of the Electric Power System
of Azerbaydzhan SSR
(Continued)

Substation	Location	Capacity	Remarks
510	Baku area		35-kv transmission line to substation No. 532. 306/
512	Baku area		35-kv transmission line to Molotov substation. 307/
514	40°16'N 49°35'E	At least 3 feeders to Kara Dag Cement Plant 308/	Azenergo.
532	Baku area		35-kv transmission line to substation No. 510. 309/

Table 15

Known Transmission Lines of the Electric Power System of Azerbaydzhan SSR

Line Terminal Points	Location North	Location East	Voltage (Kilovolts)	Remarks
Baku Mingechaur	40°25' 40°45'	49°50' 47°03'	220 310/	2 circuits.
Baku Mingechaur	40°25' 40°45'	49°50' 47°03'	110	Carrier frequency communication on this line. 311/
Kirovabad Mingechaur	40°41' 40°45'	46°22' 47°03'	110 312/	
Mingechaur Kirovakan Substation	40°45' 40°48'	47°03' 44°30'	110	Air circuit breaker. 313/ Tie line between Armenian and Azerbaydzhan power systems. Capacity of tie unknown.
Mingechaur Varvara	40°45' 40°41'	47°03' 47°06'	35	Within 10 kilometers of Mingechaur. 314/
Molotov Substation Alyaty Neftechala	(Baku) 39°57' 39°18'	 49°24' 49°11'	110 315/	130 kilometers.
Mashtagi Surakhany	40°32' 40°26'	50°00' 50°01'	110 316/	12.9 kilometers. Two 3-phase lines.
Sumgait Mashtagi	40°33' 40°32'	49°37' 40°10'	110 317/	2 circuits.

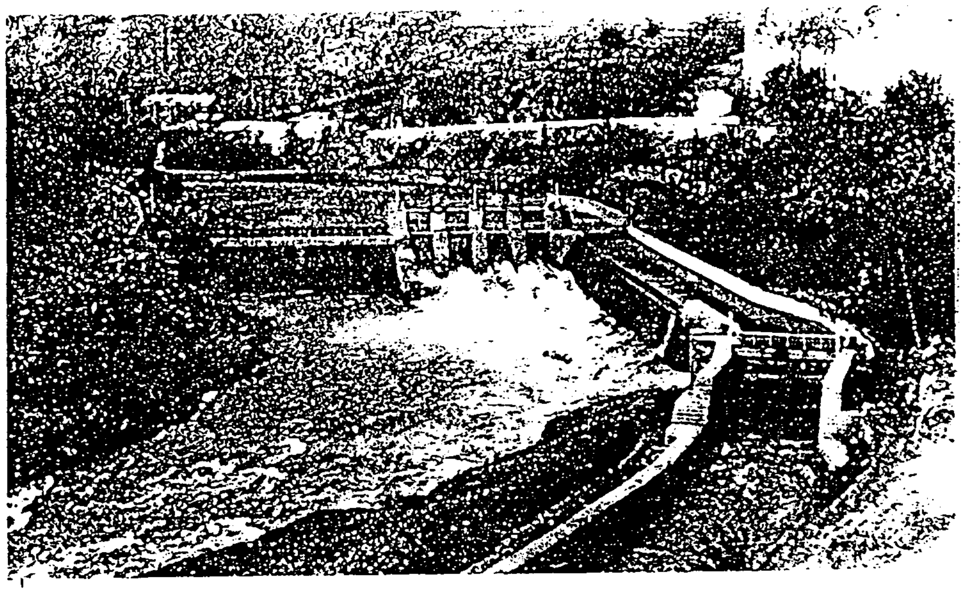

FIGURE 25. Hydroelectric Power Plant I of Yerevan GES.

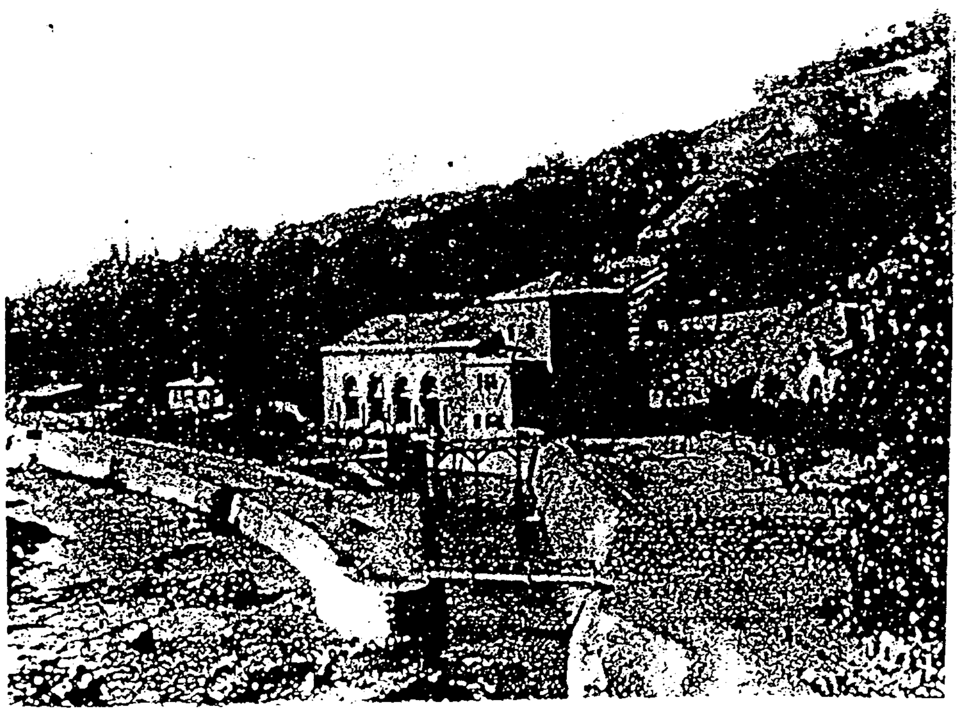

FIGURE 26. Hydroelectric Power Plant II of Yerevan GES.

Table 15

Known Transmission Lines of the Electric Power System
of Azerbaydzhan SSR
(Continued)

Line Terminal Points	Location North	Location East	Voltage (Kilovolts)	Remarks
Sumgait Siazan'	40°33' 40°59'	49°37' 49°10'	110 318/	
Sumgait Kirovo	40°33' 40°28''	49°37' 49°50'	Unknown	28 kilometers. 319/
Sumgait Siazan'	40°33' 40°59'	49°37' 49°10'	35 320/	
Romany Substation No. 43			Unknown 321/	
Molotov Substation No. 512			35 322/	
Substation No. 510 Substation No. 532			35 323/	
Substation No. 249 Substation No. 227			35 324/	
Romany Substation in Leninskiy Rayon Substation No. 54			22 325/	
Substation No. 18 Substation No. 54			25 326/	

Table 15

Known Transmission Lines of the Electric Power System of Azerbaydzhan SSR (Continued)

Line Terminal Points	Location North	Location East	Voltage (Kilovolts)	Remarks
Romany Kirovo	40°27' 40°28'	49°59' 49°50'	110 327/	
Kirovabad Dashkesan	40°41' 40°31'	46°22' 46°07'	110 328/	To be completed in 1953.
Line to Kara-Dag Cement Plant	40°16'	49°35'	35 329/	
Substation No. 22 Plant Bakinskiy Rabochiy of the Azerbaydzhan Oil and Machine Building Trust			6	3 x 120 - 300 meters. 330/
Baku Bigandy Machine Building Plant			6 331/	
Kala (Apsheronskaya Substation) Artema Ostrov	40°26'	50°10'	110 332/	
Artema Ostrov Lines			10 35 333/	

Table 15

Known Transmission Lines of the Electric Power System
of Azerbaydzhan SSR
(Continued)

Line Terminal Points	Location North	Location East	Voltage (Kilovolts)	Remarks
Sal'yany-Neftechala			110	Suspension insulators for 110-kv line NS 2 and PR3.5'S. 334/
Severnaya GRES Kala	40°29' 40°26'	50°12' 50°10'	110	MG No. 150 cable. 335/ PS-4.5 suspension insulators.
Kurdalan Substation Molotov Substation	40°27'	49°53'	110	MG No. 120 cable. 336/ PS-4.5 suspension insulators.
Severnaya GRES Damba	40°29' Unlocated	50°12'	110	MG No. 120 cable. 337/ PS-4.5 suspension insulators.
Mingechaur Navtlug	40°45' 41°40'	47°03' 44°50'	110	Tie line Georgia to Azerbaydzhan. 338/

Table 16

Known Substations of the Electric Power System
of the Georgian SSR

Substation	Location	Capacity	Remarks
Abasha	42°16'N 42°04'E		110-kv transmission line from Mendzhi. Abasha Hydroelectric Power Plant, 1,800 kw. The transmission line from Mendzhi may be double circuited. 339/
Akhali Afoni	43°05'N 40°49'E		110-kv transmission line from Sukhumi Hydroelectric Power Plant. Also transmission line to Gagry which can be fed from the North Caucasus Electric Power System. 340/
Akamara	42°52'N 41°48'E		110-kv transmission line from Tkvarcheli. 341/
Avblabari			Line of unknown voltage from Navtlug Substation. This substation is automatic. 342/

Table 16

Known Substations of the Electric Power System of the Georgian SSR (Continued)

Substation	Location	Capacity	Remarks
Batumi	41°39'N 41°39'E		110-kv transmission line from Batumi Hydroelectric Power Plant. Adzharis-Tskali Hydro Plant and Nagomari Substation. 343/
Bol'shoy Didube	41°46'N	150,000 kva, at least No. 1 transformer, 10,000 kva. No. 2 transformer, 15,000 kva.	One of the two major receiving substations for Tiflis. 110-kv double-circuit transmission line from Khram GES. 110-kv transmission from Zages. Also connected by a 6-kv tie line to Malso Didube. This substation probably controls Khram GES by remote control. 344/
Bzyb' Substation	43°13'N 40°22'E		110-kv line from Gagry and Gudauty. 345/
Chiatura No. 1 and No. 2	42°77'N 43°18'E		110-kv transmission line from Zestafoni, 42°06'N-43°02'E. No. 2 Substation supply unknown. 346/

Table 16

Known Substations of the Electric Power System of the Georgian SSR (Continued)

Substation	Location	Capacity	Remarks
Gagry	43°20'N 40°15'E		110-kv transmission line to this substation from Akhali Afoni, Gantiadi, and Adler. 347/
Gantiadi (formerly known as Pilenkovo)	43°23'N 40°05'E		110-kv regional substation; 110-kv transmission line from Adler. 348/
Gudauty	43°06'N 40°38'E		110-kv substation authorized 24 July 1949. Probably in operation now with supply from Akhali Afoni. 349/
Kaspi	41°56'N 44°25'E		35-kv transmission line from Mtskheta. 350/
Kutaisi No. 1	42°15'N 42°40'E		Connected to Pravoberezhnaya Substation. 351/
Kutaisi Automobile Plant		20,000-kva transformer installed.	110-kv transmission line from Samtredia. Also a power plant being built at the plant. 352/

Table 16

Known Substations of the Electric Power System
of the Georgian SSR
(Continued)

Substation	Location	Capacity	Remarks
Mendzhi	42°15'N 41°57'E		110-kv transmission line from Abasha Substation; 110-kv transmission line from Samtredia, 66 kilometers long; 110-kv transmission line from Zugdidi. 353/
Mukhiani	42°12'N 42°35'E		110-kv transmission line from Rioni GES. 354/
Nagomari	41°59'N 42°07'E		110-kv transmission line from Batumi. 355/
Navtlug	41°40'N 44°51'E		110-kv transmission line from Rustavi TETs. 356/
Vale	41°37'N 42°51'E	3,200 kva	35-kv transmission line from Chitakhevi GES. Transformer at Vale. 357/
Zestafoni	42°07'N 43°03'E	40,000 kva	110-kv transmission line from Chiatura. Transformer installed. 358/ 110-kv transmission line to Samtredia.
Orpiri 359/	42°20'N 42°49'E		

Table 16

Known Substations of the Electric Power System
of the Georgian SSR
(Continued)

Substation	Location	Capacity	Remarks
Pravoberezhnyy		15,000 kva	Transmission line to Kutaisi. Transformer on this line. 360/
Lechkopi	NW suburbs of Sukumi		110-kv line to Sukhumi GES. 361/
Samtredia	42°12'N 42°21'E		110-kv transmission line to Rioni GES. 110-kv transmission line to Mendzhi. 362/
Gori	41°59'N 44°07'E		110-kv transmission line to Mtskehta. 363/

Table 17

Known Transmission Lines of the Electric Power System of the Georgian SSR

Line Terminal Points	Location North	Location East	Voltage (Kilovolts)	Remarks
Abasha	42°12'	42°13'	110 364/	
Mendzhi	42°16'	42°04'		
Adler	43°26'	40°05'		
Pilenkovo (Gantiadi)	43°24'	40°05'	110	Gantiadi substation listed as 110 kv. 365/
Adzharis-Tskali GES	41°35'	41°52'	110 366/	Probable.
Zages	41°54'	44°45'		
Akhali Afoni	43°07'	40°51'	110 367/	
Gagry	43°20°	40°10'		
Akhali Afoni	43°07'	40°51'	110	Assumed to be part of Afoni-Gudanty—Bzyb'—Gantiadi 110 kv tie line. This line is known to be 110 kv. 368/
Sukhumi	43°00'	41°02'		
Avblabari			Unknown 369/	
Navtlug	41'40'	44°50'		
Bagnari (Gantiadi)	43°24'	40°05'	110 370/	
Sukhumi	43°00'	41°02'		
Bol'shoy Didube			110 371/	
Zages	41°54'	44°45'		
Bzyb'	43°15'	40°22'	110	Line authorized 1949. 372/

Table 17

Known Transmission Lines of the Electric Power System of the Georgian SSR (Continued)

Line Terminal Points	Location North	Location East	Voltage (Kilovolts)	Remarks
Chiatura	42°17'	43°18'	110 373/	Probable.
Zestafoni	42°06'	43°02'		
Chitakhevi GES	41°49'	43°17'	35 374/	
Vale Substation	41°36'	42°51'		
Gantiadi	43°24'	40°05'	110 375/	
Gagry	43°20'	40°15'		
Gumati GES	42°15'	42°45'	Unknown 376/	
Sioni	41°59	45°02'		
Khashuri	41°58'	43°28'	110	43 kilometers Chitakhevi GES to Khashuri. 377/
Borzhomi	41°50'	43°22'		
Chitakhevi GES	41°49'	43°17'		
Khram GES	41°36'	44°06'	110	Double circuit. 378/
Bol'shoy Didube Substation	41°46"	44°47"		
Kutaisi	42°15'	42°42'	110 379/	Probable.
Tkvarcheli GRES	42°51'	41°41'		
Mendzhi	42°15'	41°57'	110	66 kilometers. 380/
Samtredia	42°11'	42°20'		

Table 17

Known Transmission Lines of the Electric Power System of the Georgian SSR (Continued)

	Location		Voltage	
Line Terminal Points	North	East	(Kilovolts)	Remarks
Mtskheta	41°51"	44°43"	35 381/	
Kaspi	41°56'	44°25'		
Mukhiani	42°12'	42°35'	110 382/	
Rioni GES	42°11'	42°43'		
Nagomari	42°00'	42°07'	110 383/	
Batumi	41°29'	41°39'		
Rioni GES	42°11'	42°43'	110 384/	
Abashages	42°12'	42°17'		
Rioni GES	42°11'	42°43'	110 385/	
Samtredia	42°12'	42°21'		
Rioni GES	42°11'	42°43'	110 386/	Probable.
Tkibuli	42°22'	42°59'		
Rustavi TETs	41°33'	45°02'	110 387/	
Navtlug Substation	41°40'	44°50'		
Samtredia	42°15'	42°20'	110	P-4.5 suspension insulators. MG-70 cable. M-70 tension clamps. 388/
Kutaisi Auto Plant	42°15'	42°42'		

Table 17

Known Transmission Lines of the Electric Power System
of the Georgian SSR
(Continued)

Line Terminal Points	Location North	Location East	Voltage (Kilovolts)	Remarks
Samtredia	42°15'	42°40'	110 389/	
Nagomari	42°59'	42°07'		
Samtredia	42°12'	42°21'	390/	
Poti	42°09'	41°40'		
Sioni	41°59'	45°02'	Unknown	
Satskhenisi			391/	
Sukhumi	43°00'	41°02'	110	Probably includes Adler-Khosta-Gantradi, 110 kv, Gagra-Afoni-Sukhumi mentioned in other parts. It is the Georgian Power system tie to the North Caucasus. Capacity of this tie is unknown. 392/
Khosta	43°30'	39°54'		
Sukhumi	43°00'	41°02'	110 393/	
Ochemchiri	42°73'	41°28'		
Sukhumi	43°00'	41°02'	110 394/	
Sochi	43°35'	39°45'		
Tiflis	41°42'	44°45'	110 395/	
Zages	41°49'	44°46'		
Mtskheta	41°55'	43°00'		
Gori	41°58'	44°07'		

Table 17

Known Transmission Lines of the Electric Power System of the Georgian SSR (Continued)

Line Terminal Points	Location North	Location East	Voltage (Kilovolts)	Remarks
Tkvarcheli GRES	42°51'	41°41'	396/	
Akarmara Substation	42°52'	41°47'		
Tkvarcheli GRES	42°51'	41°41'	110 397/	
Ochemchiri	42°43'	41°28'		
Tkvarcheli GRES	42°51'	41°41'	110 398/	Probable.
Rioni GES	42°12'	42°44'		
Tkvarcheli GRES	42°51'	41°41'	110 399/	MG-70 cable.
Sukhumi	43°00'	41°02'		
Tkvarcheli GRES	42°51'	41°41'	110 400/	Probable.
Tiflis	41°42'	44°45'		
Zugdidi	42°30'	41°53'	110 401/	From size of cable and insulators, MG-70 cable.
Mendzhi	42°15'	41°57'		
Zugdidi	42°30'	41°53'	110 402/	
Tkvarcheli GRES	42°51'	41°41'		
Bzhuzha GES	41°55'	42°00'	Unknown	
Makharadze	41°56'	42°00'	403/	
Samgori	41°40'	45°10'	Unknown	
Navtlug	41°40'	44°51'	404/	

Table 18

Known Substation of the Electric Power System of the Armenian SSR a/

Substation	Location	Source of Electric Energy
Kirovakan	40°49'N-44°30'E	110-kv transmission line from Mingechaur is connected to this substation. This line is the tie line between the Azerbaydzhan Power System and the Armenian Power System. 110-kv transmission line from Sevan is connected to this substation so that power may be fed into this line from all the stations of the Sevan-Zanga Cascade. This is a double-circuited line. 405/

a. Although one substation on the Armenian Power System has been specifically mentioned, it is obvious that substations exist at the termini of the high-tension transmission lines. Since no details of these substations are available, however, they are not listed in this section.

Table 19

Known Transmission Lines of the Electric Power System of the Armenian SSR

Line Terminal Points	Location North	Location East	Voltage (Kilovolts)	Remarks
Mingechaur	40°38'	46°57'	110 406/	
Kirovakan	40°49'	44°30'		
Kirovakan Network Rayon of the Armenian Power System			35 407/	
Dzora GES	40°56'	44°36'	110 408/	
Kirovakan	40°49'	44°30'		
Dzora GES	40°57'	44°39'	22 409/	
Alaverdi	41°08'	44°38'		
Dzora GES	40°57'	44°39'	110 410/	
Lenges	40°47'	43°51'		
Lenges				
Leninakan (assumed)				
Leninakan	40°47'	43°51'	High-tension 411/	
Amamlu	40°49'	44°16'		
Sevan	40°33'	44°54'	High-tension 412/	
Leninakan	40°47'	43°51'		
Sevan	40°32'	44°56'	110	AS 150, cable. 413/
Kirovakan	40°49'	44°30'		

Table 19

Known Transmission Lines of the Electric Power System
of the Armenian SSR
(Continued)

Line Terminal Points	Location North	Location East	Voltage (Kilovolts)	Remarks
Sevan Kanaker GES	40°32' 40°13'	44°56' 44°32'	110	Also ties in to Gyumush GES. Second circuit planned; may be in. 414/
Gyumush Kadzharan	40°30' 39°08'	44°36' 46°06'	220 415/	
Kanaker Akhta	40°13' 40°29'	44°32' 44°47'	110 416/	
Kanaker Amamlu	40°13' 40°49'	44°32' 44°16'	110 417/	
Kanaker Yerevan	40°13' 40°11'	44°32' 44°30'	110 418/	
Kanaker Yerevan GES No. 1	40°13'	44°32'	22 419/	
Yerevan GES No. 1 and No. 2			High-tension 420/	
Yerevan Oktemberyan GES	40°11' 40°10'	44°30' 44°02'		Line is assumed, since station is reported to be connected to Armenian power system. 421/

Table 19

Known Transmission Lines of the Electric Power System of the Armenian SSR (Continued)

Line Terminal Points	Location North	Location East	Voltage (Kilovolts)	Remarks
Yerevan Artashat GES	40°11' 39°57'	44°30' 44°33'		Line is assumed, since station is reported to be connected to Armenian power system. 422/
Artashat GES Agarag GES	39°57' Unknown	44°33'		Line is assumed, since station is reported to be connected to Armenian power system. 423/

APPENDIX E

METHODOLOGY

APPENDIX F

GAPS IN INTELLIGENCE

APPENDIX G

BIBLIOGRAPHY

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APPENDIX H

SOURCES

Evaluations, following the classification entry and designated "Eval.," have the following significance:

Source of Information	Information
Doc. - Documentary	1 - Confirmed by other sources
A - Completely reliable	2 - Probably true
B - Usually reliable	3 - Possibly true
C - Fairly reliable	4 - Doubtful
D - Not usually reliable,	5 - Probably false
E - Not reliable	6 - Cannot be judged
F - Cannot be judged	

"Documentary" refers to original documents of foreign governments and organizations; copies or translations of such documents by a staff officer; or information extracted from such documents by a staff officer, all of which may carry the field evaluation "Documentary."

Evaluations not otherwise designated are those appearing on the cited document; those designated "RR" are by the author of this report. No "RR" evaluation is given when the author agrees with the evaluation on the cited document.

~~TOP SECRET~~

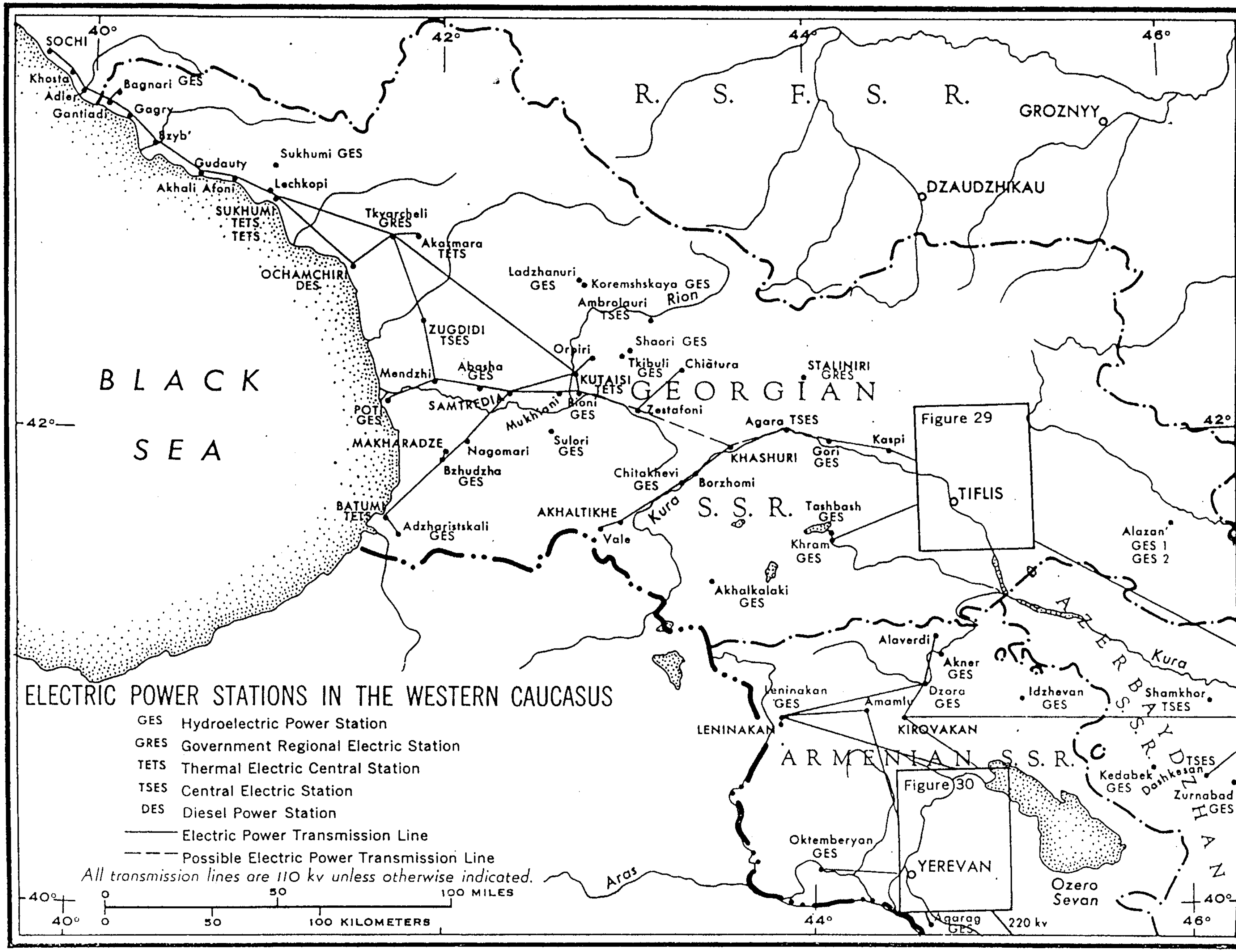

Figure 27

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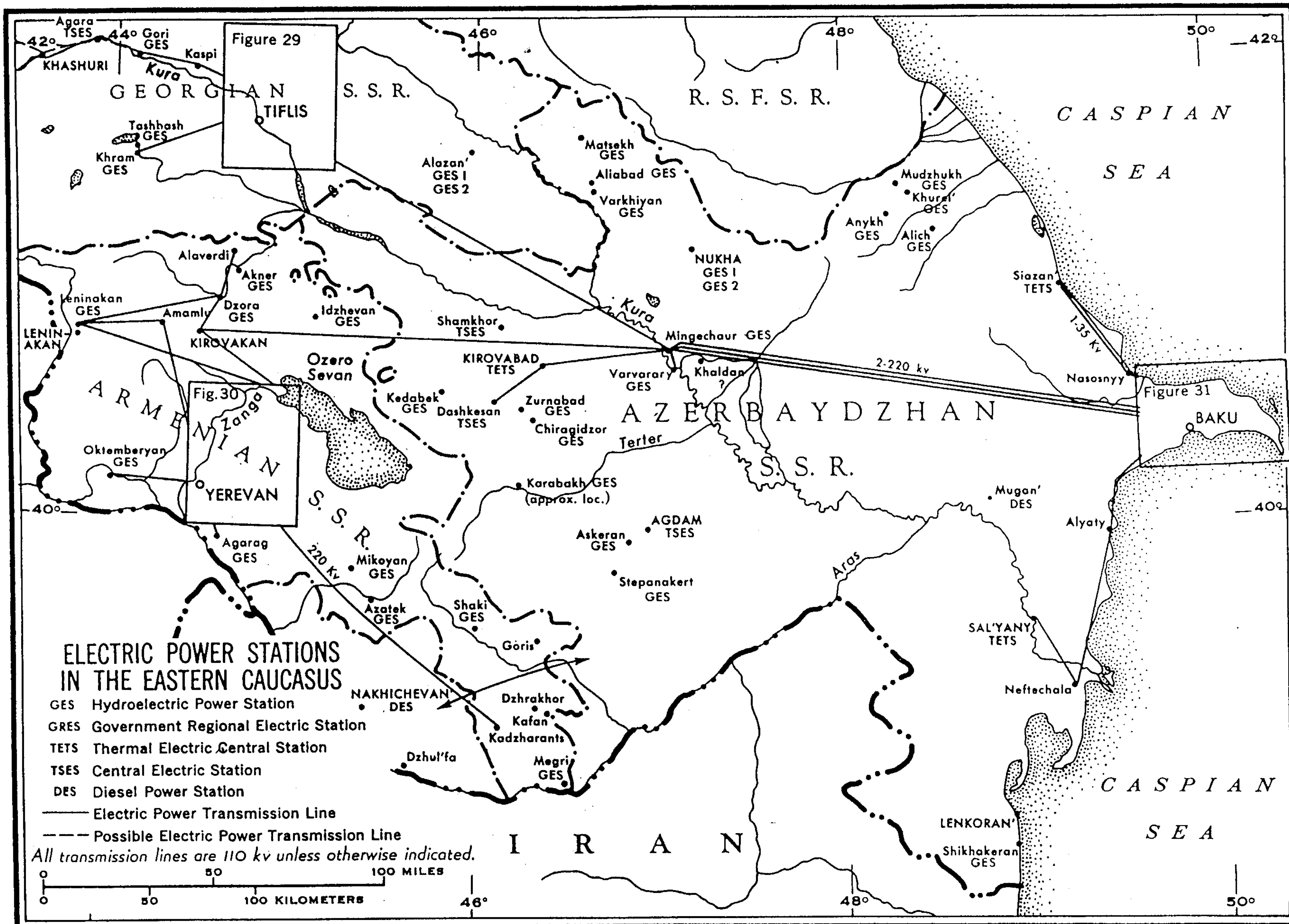
TOP SECRET



14436 8-54

Figure 28

~~TOP SECRET~~

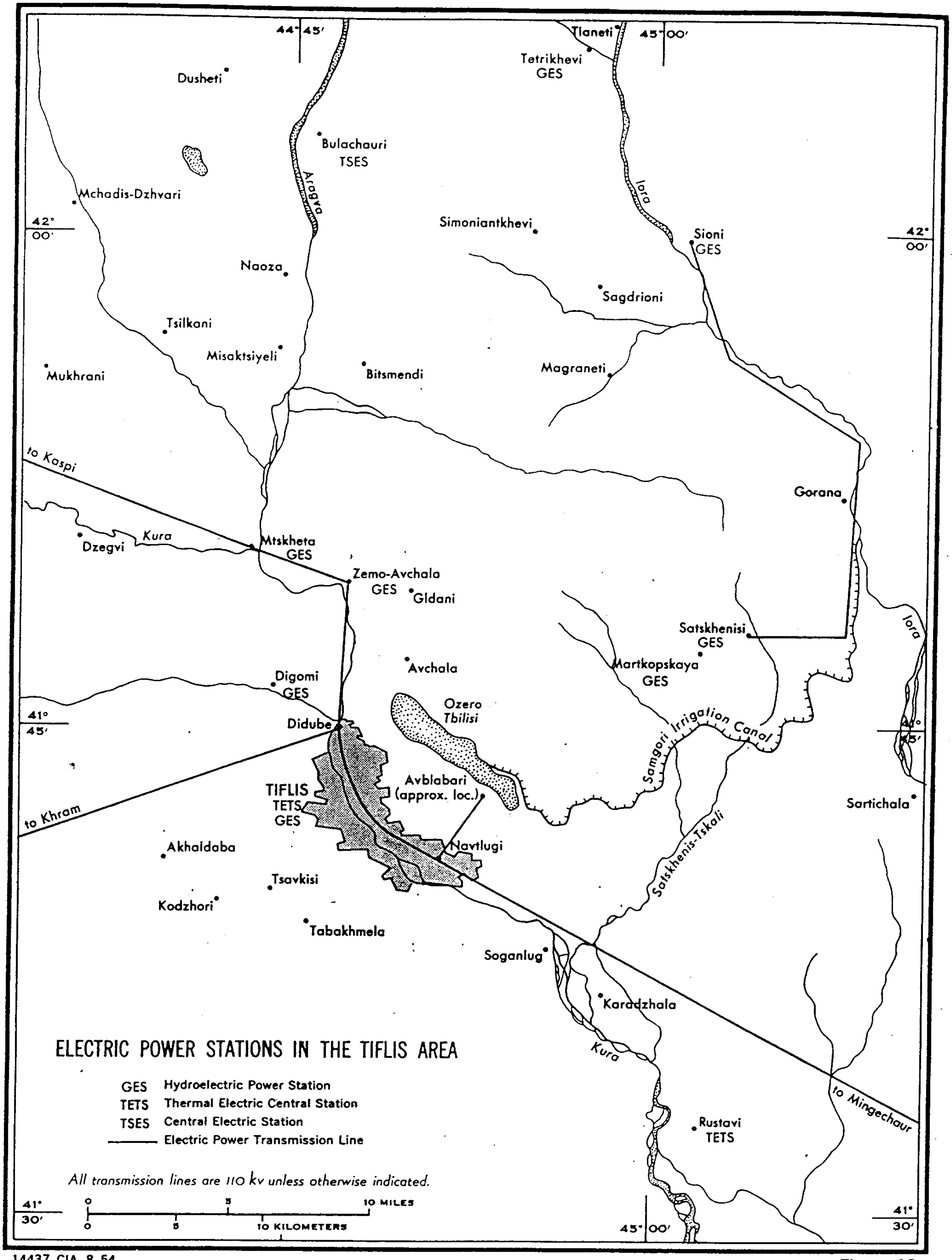


Figure 29

TOP SECRET

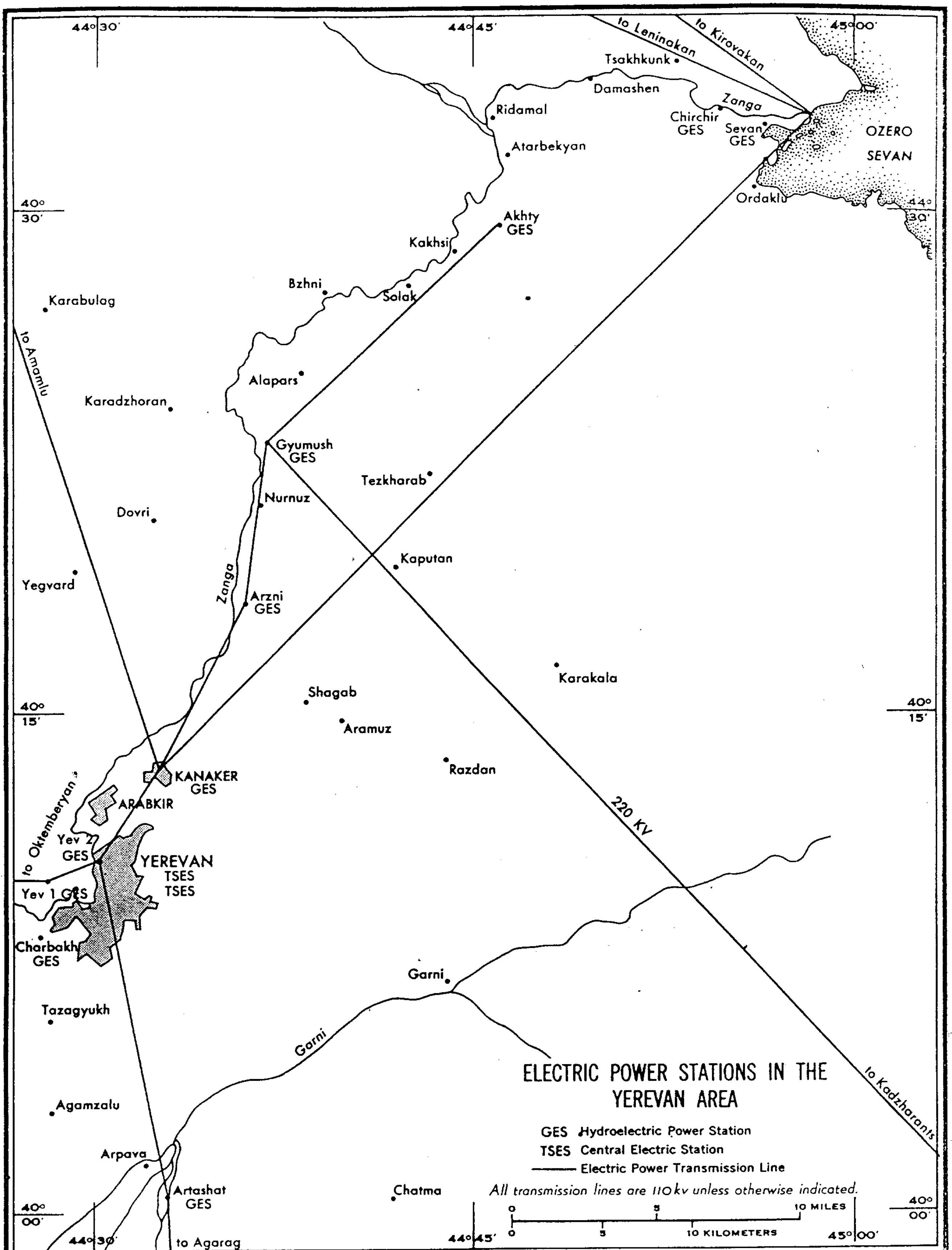


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Figure 30

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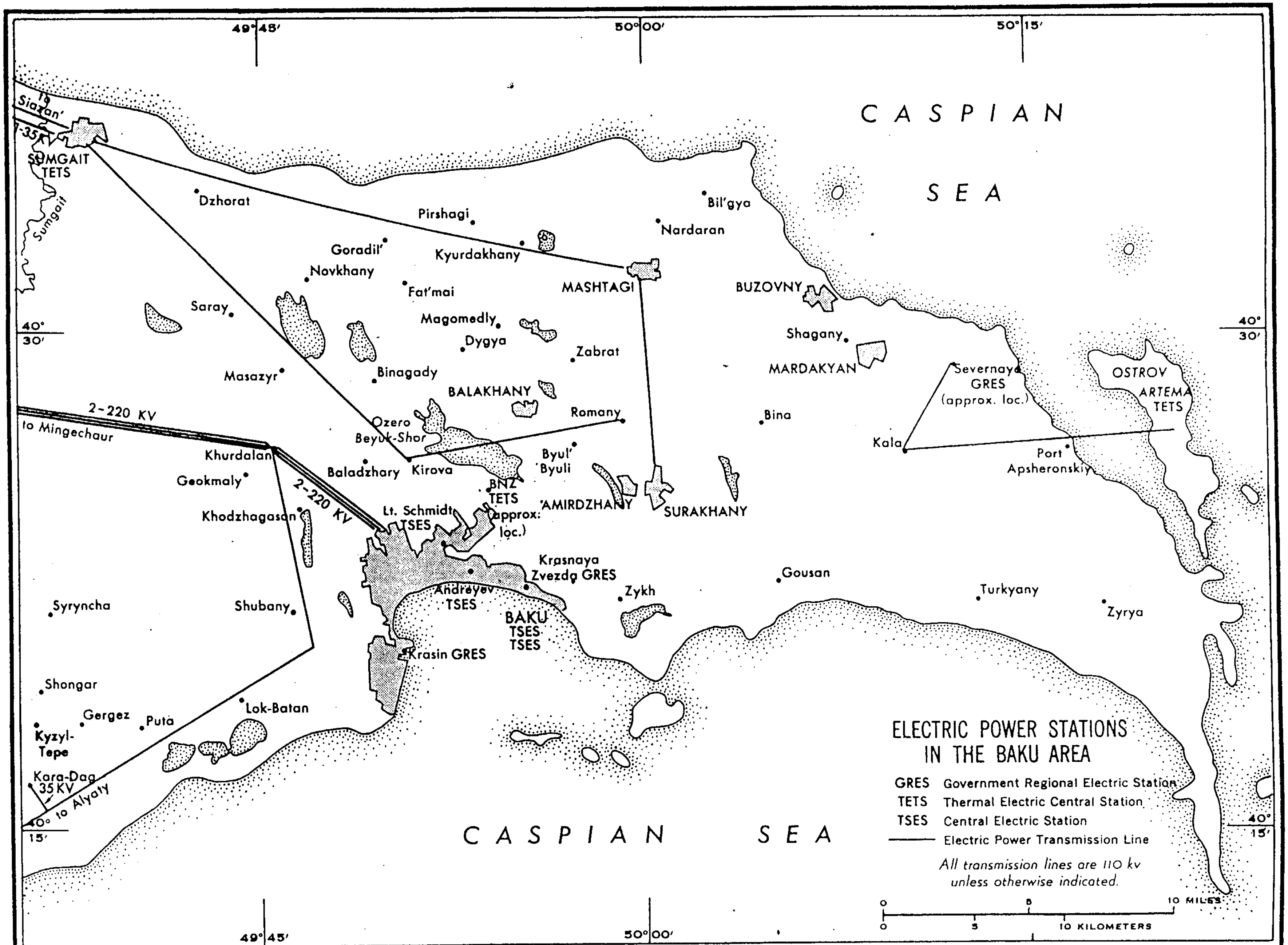

Figure 31

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