CENTRALES ELECTRICAS DEL CAUCA S. A.

REPUBLIC OF COLOMBIA

FEASIBILITY REPORT ON JULUMITO HYDRO-ELECTRIC PROJECT

AUGUST 1972

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

PREFACE

The Government of Japan, in response to the request of the Government of the Republic of Colombia, undertook to conduct a feasibility study on the Julumito Hydroelectric Project, and entrusted the execution to the Overseas Technical Cooperation Agency.

The Agency, in consideration of the present state of electric power demand and supply in the Republic of Colombia and of the importance of economic progress of the country to be boosted by electric power development, dispatched a survey mission comprised of six specialists, headed by Mr. Tokie Kawashima, civil engineer, of the Hydroelectric Power Construction Department of Electric Power Development Co., Ltd.

The study includes field investigations and the technical and economic feasibilities of the Julumito Hydroelectric Project in the Rio Cauca Basin in the vicinity of Popayan, the capital city of Departamento del Cauca, the Republic of Colombia.

Fortunately, the field investigations and the analyses were carried out without hitch and the study report is now ready for presentation here.

Should this survey contribute to the friendship and rapprochement between Japan and the Republic of Colombia, and economic exchange between the two countries, there would be nothing more rewarding.

In closing, I, on behalf of OTCA, would like to take this opportunity to express my sincerest gratitude to those concerned in the Government of the Republic of Colombia and ICEL who have so unselfishly worked to cooperate in carrying out this survey and those persons in CEDELCA who gave us hearty support in the field surveys, as well as to the Ministry of Foreign Affairs, the Ministry of International Trade and Industry and the Electric Power Development Co., Ltd. who were most willing to dispatch the survey mission.

August, 1972

Keiichi Tatsuke, President
Director General
Overseas Technical Cooperation Agency

Letter of Transmittal

August, 1972

Mr. Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

Presented herewith is the report of Feasibility Studies on Julumito Hydroelectric Project, the Republic of Colombia. This survey, upon your request, has been carried out by the survey mission organized by the Overseas Technical Cooperation Agency, consisted of five specialists of Electric Power Development Co., Ltd. and one official of the Ministry of International Trade and Industry. The mission was dispatched to the Republic of Colombia for the purpose of a feasibility studies on Julumito Hydroelectric Project on the upstream reaches of the Rio Cauca in Departamento del Cauca, the Republic of Colombia. The mission, based on "Report of Preliminary Studies on Julumito Hydroelectric Project" submitted in May 1970 to the Government of the Republic of Colombia by the Government of Japan, conducted investigations of topography, geology, materials, hydrology, etc. of the project site, studied the electric power demand of the service area, and collected information required in preparation of a plan for the Project.

Upon return of the mission to Japan, the Electric Power Development Co., Ltd., basing on the results of the field surveys and the data gathered in Colombia, made load forecasts, analyses of hydrologic data, analyses and studies of geological data, detailed studies of the power generation plan, preliminary designs, construction cost estimations, economic evaluations, etc. to prepare this report on the Julumito Hydroelectric Project.

The Julumito hydroelectric project is aimed at economical and stable production of electric power utilizing the head of approximately 125 meters obtained between the main stream of the Rio Cauca, a large river flowing from south to north through the western part of the Republic of Colombia, and Julumito Reservoir on a tributary, the Rio Sate, which would regulate the waters of the main stream of the Rio Cauca. Its catchment area including main stream and tributaries is approximately 1,100 square kilometers. In essence, a rockfill dam 80 meters high would be constructed on the Rio Sate, a right bank tributary of the Rio Cauca, to provide Julumito Reservoir with an effective storage capacity of approximately 50 million cubic meters into which the water of the mainstream Rio Cauca and tributaries such as the Rio Palacé comprising approximately 950 million cubic meters would be gathered annually through diversion waterways. Following effective regulation at this reservoir, the water would

be conducted through a headrace tunnel of approximately 1,800 meter long to Julumito Power Station to be provided at the right bank of the mainstream Rio Cauca for power generation of a maximum output of 53,000 kW and annual energy production of 285 million kWh. This energy would be sent by a transmission line of approximately 10 kilometers to be constructed to the existing Popayan Substation from where it would be distributed to the service areas of CEDELCA and CEDENAR.

For realization of this Project, a construction period of approximately 3 years and a construction cost of approximately 352 million Colombian pesos would be required. However, this Project would be less costly as compared with import of electric power from the CVC System, with a larger cost-benefit ratio than other alternative facilities, and therefore it is considered to be a reasonable plan both technically and economically.

Besides the direct benefit from power generation described above, this Project would contribute greatly to the regional development of the Departamento de Cauca and Departamento de Nariño while it is firmly believed that the materialization of Julumito Reservoir coupled with the picturesque scenery of the surrounding countryside will enchance the value of the area as a national recreation center. In the service areas of CEDELCA and CEDENAR, there has been a marked increase in power demand in recent years and when this situation is taken into consideration, the project is thought necessary to be completed by the end of 1981. It is therefore thought that additional surveys and various preparations such as detailed designing should be performed possible.

In closing, it is wished to extend the sincerest gratitude to Dr. AURELIO IRAGORRI HORMAZA, President of Centrales Electricas del Cauca and his staffs, Dr. GERARDO SILVA VALDERRAMA, President of Instituto Colombiano de Energia Electrica and engineers concerned of the Instituto, Dr. EDUARDO BARRERA, QUINTERO Chief of Division de Energia, Departamento Nacional de Planeacion and the officials of the division, and all staffs with whom the mission came into contact during its stay in the Republic of Colombia for their whole-hearted assistance and cooperation.

Respectfully yours,

T. Kawashima

Tokie Kawashima
Chief of Japanese Survey Mission
for Julumito Hydroelectric Project
in the Republic of Colombia

CENTRALES ELECTRICAS DEL CAUCA S. A.

REPUBLIC OF COLOMBIA

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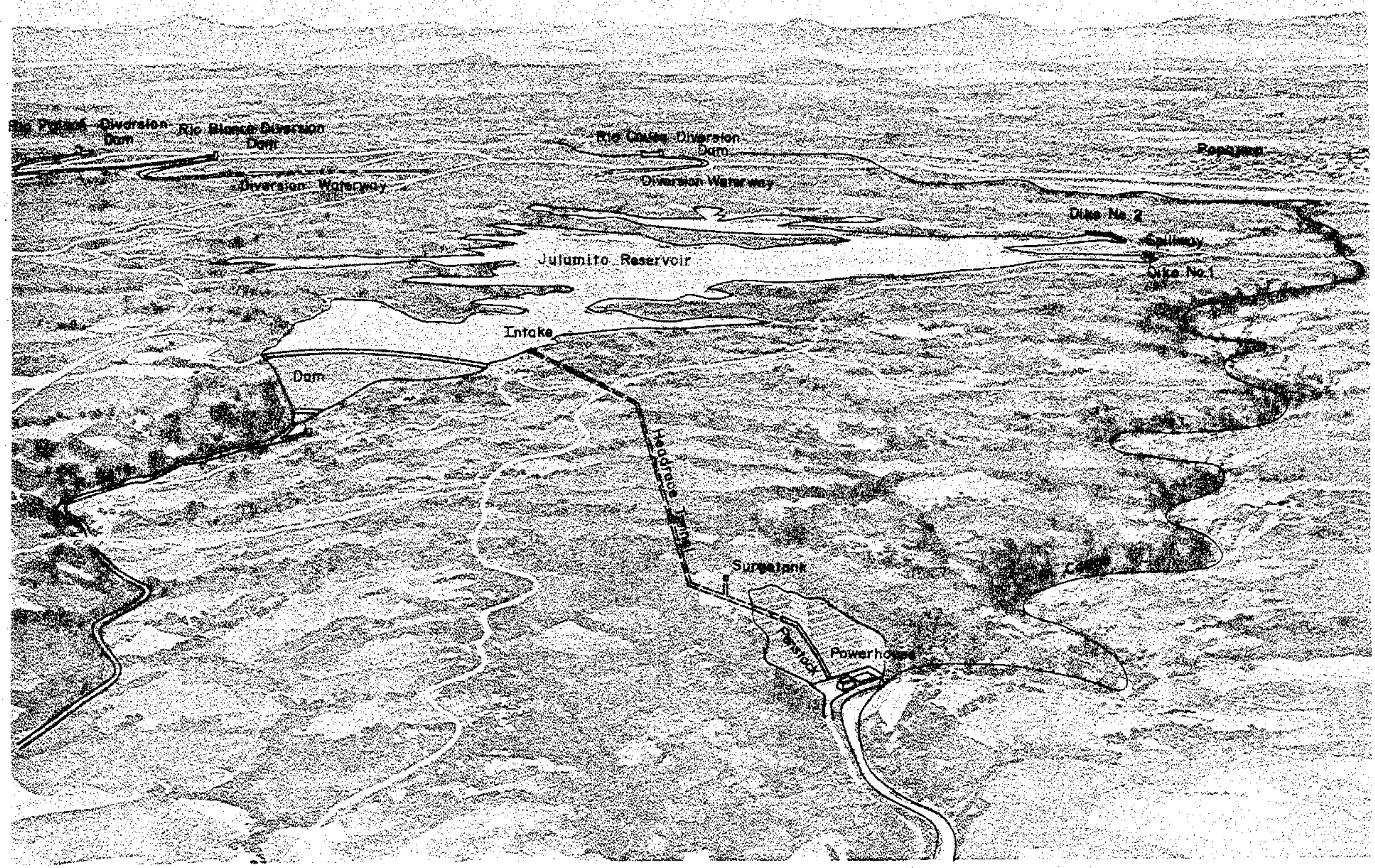
Diversion Dam
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Headrace Tunnel
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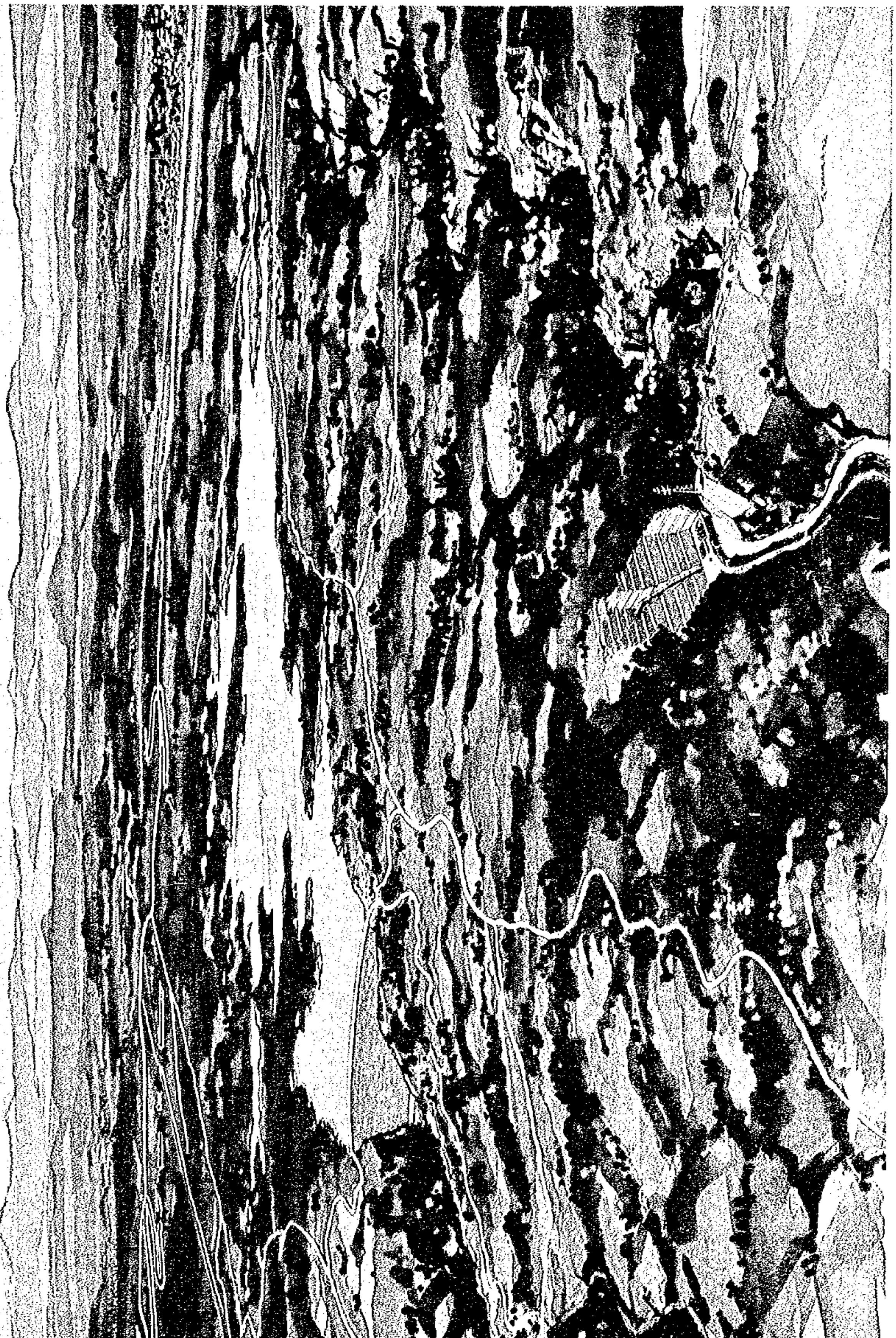
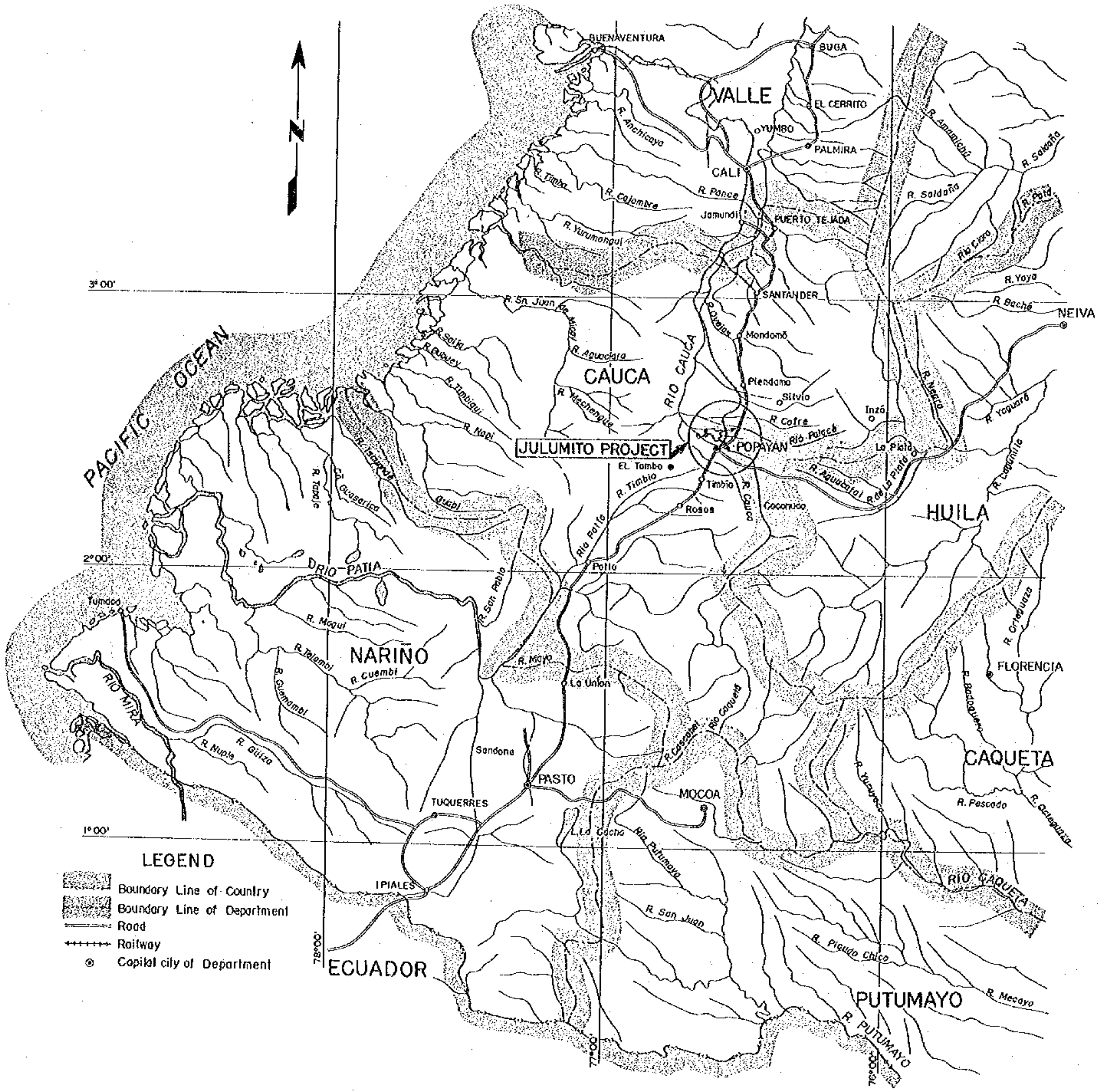
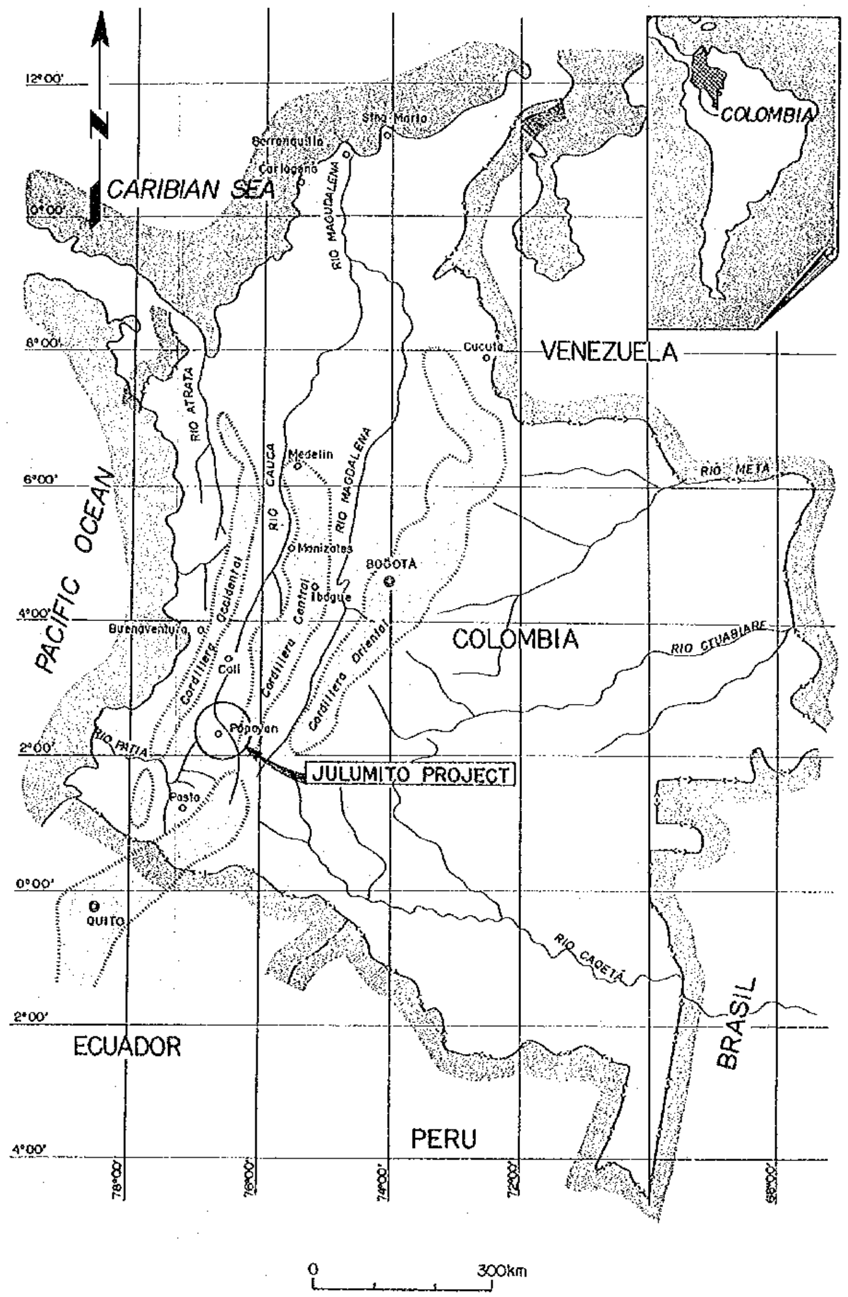






LOCATION	DATE	DESCRIPTION	BY
REVISION			

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

CENTRALES ELECTRICAS DEL CAUCA S.A.

JULUMITO HYDRO-ELECTRIC PROJECT

KEY AND LOCATION MAP

ELECTRIC POWER DEVELOPMENT CO., LTD. (E P D Consultants) TOKYO JAPAN

D.R.:	SUBMITTED: K. Yamamoto
T.R.:	RECOMMENDED: T. Kawashima
C.K.:	APPROVED: M. Takahashi

DATE: 31 July '72 — — — DWG. No. 1

SHEET NO. OF

CONTENTS

DRAWING LIST

CHAPTER 1

INTRODUCTION

CONTENTS

CHAPTER 1 INTRODUCTION

1.1 Antecedents

The electric power demand in the Republic of Colombia has in recent years been increasing at an extremely high rate and Departamento de Cauca and Departamento de Nariño in the southern part of the country have also indicated high growth rates averaging about 12 per per cent. In order to meet this growing demand, Centrales Energia del Cauca (hereinafter called CEDELCA) has been actively engaged in pushing ahead with countermeasures such as construction of hydroelectric power stations and installation of diesel generators, and for further development in the near future, is planning construction of Julumito Hydroelectric Power Station on the upstream reaches of the Rio Cauca.

CEDELCA, in order to expedite the implementation of Julumito Hydroelectric Project, requested in 1969, the Government of Japan through Instituto Colombiano de Energia Electrica (hereinafter called ICEL) and the Government of the Republic of Colombia for execution of a preliminary study in regard to the Julumito Hydroelectric Project. Acknowledging this request, the Government of Japan through the Overseas Technical Cooperation Agency (hereinafter called OTCA), dispatched three specialists in civil engineering, electrical engineering and geology for a two-month period from February to April 1970 to conduct a survey.

Based on the recommendations of the report of this preliminary study, CEDELCA subsequently performed survey and geological investigations of the project site, and in June 1971, requested the cooperation of the Government of Japan in carrying out a feasibility study of the Julumito Hydroelectric Project. Consequently, the Government of Japan commissioned OTCA to execute this study and OTCA dispatched a survey mission comprised of five engineers in the fields of civil engineering, electrical engineering and geology of the Electric Power Development Co., Ltd. (hereinafter called EPDC) and one officer of the Ministry of International Trade and Industry to the Republic of Colombia for a period of 45 days from February 8 to March 28, 1972 to carry out field surveys for the feasibility study.

The mission upon its return to Japan prepared this feasibility report at the head office of EPDC where the work was carried out by the engineers of the company based on the various data collected in the field surveys.

1.2 Existing Reports

The Julumito Hydroelectric Project was proposed by CEDELCA around 1968 and there were a few field reconnaissances made, byt until the Preliminary Study by specialists dispatched by the Government of Japan in 1970, there were no reports made in particular.

In other words, during the two months from February 14 to April 13, 1970, the preliminary study by the Government of Japan based on the request of the Government of Colombia was carried out by the three specialists, Hisanobu Okamoto, electrical engineer, Ministry of International Trade and Industry, Kei Yamamoto, Civil Engineer, EPDC and Yozo Fukutake, Geologist, EPDC. The results of the survey were submitted to the Government of the Republic of Colombia in June 1970 under the following title:

> "Report of Preliminary Studies on Julumito Hydro-Electric Project - Centrales Electricas del Cauca, S.A., Republic of Colombia - " (Overseas Technical Cooperation Agency, Government of Japan – June 1970)

This report comprises a preliminary study of the Julumito Hydroelectric Project from technical and economic viewpoints based on the field reconnaissance carried out by the abovementioned three specialists and information provided by CEDELCA and ICEL, resulting in the conclusion that development of a scale of about 50 MW was feasible both technically and economically, and further, in the recommendation that various field surveys necessary for a feasibility study should be carried out at an early date.

Subsequently, from April 1970 to July 1971, with Dr. Aurelio Iragorri H., President, Mr. Gonzalo Paz R., Engineer, and Mr. Mauricio Muñoz D., Engineer of CEDELCA, and further, Mr. Juvenal Peñalosa R., Engineer, Chief of Division de Ingenieria Hydraulica and Mr. Elkin Molina E., Geologist in ICEL as the central figures, surveying of the dam and power house sites, geological investigations and material studies were carried out. The results were published in July 1971 by the Division de Ingenieria Hydraulica of ICEL under the following title:

> "Proyecto 274 – Central Hydroelectrica de Julumito Analysis de los Trabajos Realizados" (ICEL, Division de Ingenieria Hydraulica, Bogota – Julio de 1971).

Also, during this time, Dr. Carlos Sanclamente, former manager of the Electraguas (predecessor of ICEL) and later consulting engineer with Banco Interamericano (BID) presented in October 1970 his opinions on the preliminary study report on the Julumito Project submitted by the Japanese Government specialists and some comparative proposals under the following title:

"Comments and Alternative Scheme for Julumito Hydro-Electric Power Project – Oct. 1970" by Dr. Carlos Sanclamente.

The above opinion paper, while recognizing the reasonability of the preliminary survey results of the Japanese Government specialists, offered a number of alternatives in regard to details of the proposed plan.

EPDC carried out an examination of the above opinions of Dr. Sanclamente and reported to CEDELCA by the following letter in December 1970 that his alternative plans were not necessarily of advantage both technically and economically:

"Result of Study of Alternative Plans Proposed by Dr. Carlos Sanclamente in Regard to Julumito Project" (EPDC – 11 Dec. 1970).

1.3 Purpose and Scope of Report

1.3.1 Purpose

The Departamento Nacional de Planeacion, the Government of the Republic of Colombia (hereinafter called PLANEACION), ICEL and CEDELCA, in order to cope with the rapidly increasing power demand of the Departamento del Cauca and Departamento de Nariño in the southern part of the country, have pushed forward with surveys for the Julumito Hydroelectric Power Project and are planning for its realization.

Therefore, this Report, together with clarifying the technical and economical feasibilities of development of this Project, and providing authorization for the development plan, was prepared with the purpose of serving as necessary and sufficient explanatory information for raising of construction funds for the Project.

1.3.2 Scope

The Julumito Project is solely for the purpose of power generation. Therefore, the scope of investigations and studies summarized in this Report is most suited for the power demand of the CEDELCA and CEDENAR service areas, and moreover, is for establishement of the most economical form for the Julumito Hydroelectric Project.

This Report, thus places emphasis in this regard, and basides clarifying the technical and economic problems concerned, involves concrete studies in connection with the scale of the Project and the timing of development.

1.4 Survey and Study

1.4.1 Field Survey by Survey Mission

Field surveys for the feasibility study on the Julumito Hydroelectric Power Project were conducted for 45 days between February 8 and March 23, 1972.

The survey mission was headquartered chiefly at CEDELCA at Popayan City in Departamento del Cauca, and besides the various field surveys conducted by each specialist, various data were collected, added to which information was gathered from CEDENAR in the adjacent Departamento de Nariño which is within the service area of this Project, from CVC in Cali City, and further, from government agencies in the capital city, Bogota.

The survey mission was comprised of the six men listed below.

Chief	Tokie Kawashima	Civil Engineer	EPDC
Member	Katsumi Taniuchi	"	MITI
"	Kei Yamamoto	"	EPDC
"	Makoto Abe	Geologist	"
"	Morihiro Sato	Electrical Engineer	"
"	Akira Kinoshita	Econnomist	"

1.4.2 Work in Japan

After return of the mission to Japan, from April until September 1972, based on the survey results and the data collected in the field, a study of the Project was made by the engineers of EPDC under the direction of the Chief Engineer, Mr. Mitsuo Takahashi, at the head office of EPDC. Analyses of hydrologic data, analyses of geological data, load forecast, detailed study of the development plans, preliminary design, estimation of construction costs, economic evaluation and financial plans were carried out for preparation of this Report.

1.5 Fundamental Data

The fundamental data provided by the various agencies concerned for the feasibility study consisted of the following:

(1) Hydrologic and Meteorological Data

Observation data by day, month and time at the observation stations existing in the project area and surrounding districts were provided by ICEL and CEDELCA.

(2) Topographical Survey Map

Topographical maps of the project area as a whole (scale: 1/70,000 and 1/10,000), and the topographical maps (scale: 1/1,000～1/500) of the sites of dams, power stations, etc. were provided by CEDELCA.

However, for part of the sites not covered by the surveys as of February 1972, outline topographical maps were prepared by performing simplified surveying during the field investigations.

(3) Geologic Survey Data

The results of geological surveys of sites of the dam, powerhouse, headrace tunnel, quarries and borrow areas (surveys through excavation of adits, borings and vertical shafts) were furnished by ICEL and CEDELCA.

Tests of the geological natures of projected sites of major structures and dam embankment materials were carried out at Cauca University, Mexico City University and the Colombian Ministerio de Minas y Petréleos at the request of ICEL and CEDELCA.

The survey mission took back part of the materials sampled in the field and necessary tests were conducted at the Civil Engineering Laboratory of EPDC.

(4) Power Demand and Supply Data

Data on power demand to present, outlines of facilities and various data required for load forecasts of the CEDELCA and CEDENAR service areas were furnished from CEDELCA, CEDENAR, ICEL, PLANEACION and other agencies.

CHAPTER 2

CONCLUSIONS AND RECOMMENDATIONS

CONTENTS

FIGURE LIST

CHAPTER 2 CONCLUSIONS AND RECOMMENDATIONS

2.1 Conclusions

As a result of investigations and studies on the Julumito Hydroelectric Project, the conclusions described below have been reached.

(1) In the Departamento de Cauca and Departamento de Nariño areas in the southern part of Colombia to which CEDELCA (Centrales Electricas del Cauca) and CEDENAR (Centrales Electricas de Nariño) are supplying electric power, there have been marked increases in power demand in recent years, the growth rate of the two areas in the past 10 years having been approximately 12% with the demand expected to reach 39 MW, 190 million kWh at the end of 1972. This is considered due to the increased demand from improvement in the livelihood of the people of the region achieved through the "Economic and Social Development Ten-Year Plan (1961 - 1970, presently in force extended to 1972)" of the Government of Colombia and surfacing of latent demand through construction of Rio Mayo Power Station and an interconnecting transmission line tying the two departments together and expansion of the power distribution network.

In the furture, with extension of the abovementioned ten-year plan, policies for industrial development and improvement in national livelihood will be continued and it is anticipated that agricultural productivity will be bettered, industries advanced, roads and highways opened and expaned, new electric power sources exploited and power transmission and distribution lines strengthened. It is thus considered that the power demand of this region will continue to increase at a growth rate of at least about 9 to 10% and it is estimated that 55.9 MW will be reached in 1976, 80.6 MW in 1980 and 124.2 MW in 1985.

(2) To meet this growth in power demand of the area, CEDELCA and CEDENAR are emphasizing development of new power resources leading off with Florida II Hydroelectric Power Station (scheduled for completion in September 1973) to add to the supply capacity (approximately 44 MW) presently owned. Meanwhile, construction of an interconnecting transmission line between Pancé Substation of the CVC System and Popayan Substation of CEDELCA is also being carried out (scheduled for completion in September 1972) by ICEL (Instituto Colombiano de Energia Electrica). Upon completion of this interconnecting transmission line, interchange of electric power between the CVC System and the CEDELCA

and CEDENAR systems will become possible.

In the latter systems, even with completion of Florida II Power Station presently under construction, supply capability will start to become short in 1975, and although for immediate purposes the shortages could be covered by purchasing power from the CVC System, purchased power would increase greatly from year to year, and it is undersirable from the standpoint of economy and of stable power supply to continue to depend on supply from the CVC System in excess of the reserve capacity of the systems.

Therefore, a new supply capability should be provided in the CEDELCA-CEDENAR system as soon as practicable and as the result of the present survey the timing for this is to be the end of 1981.

(3) As a result of surveys and studies of the feasibility of development of the Julumito Hydroelectric Power Project as the new supply capability mentioned above, it was concluded to be an extremely advantageous hydroelectric power generation plan.

This Project would ingeniously utilize the natural conditions of the upstream part of the Rio Cauca, which is not especially favored with suitable sites for reservoir-type power development, to provide a reservoir and a power station having a maximum output of 53,000 kW with a relatively short waterway to make possible long-term stable supply of electric power through appropriate operation of the reservoir.

(4) Although there are no particularly difficult problems in regard to design and construction of the Project, the following judgments may be made as a result of the investigation and study:

(4)-1 The Julumito project area is covered on the whole by a thick layer of volcanic ash and the underlying andesite lava comprising the foundation rock is fairly weathered. Therefore, thorough considerations are necessary in design and construction of civil structures, and in this regard also, it is of extreme importance for accurate geological survey data to be obtained.

(4)-2 Considered from the topographical and geological conditions of the dam site, and the characteristics of dam construction materials available in the neighborhood, it will be most suitable for a curving rockfill dam with an inclined core zone.

(4)-3 As a result of on-site investigations, the dam construction materials available in the vicinity of the dam site cannot necessarily be said to be good, but through adoption of an appropriate dam design and construction method, the materials are judged to be adequately usable.

(4)-4 The route of the headrace tunnel was selected to pass where it will be sufficiently covered by foundation rock. Further, the locations of the penstock, powerhouse, etc. were selected based on judgment of topographical and geological conditions.

(4)-5 For concrete, in consideration of quality and economy, rock from a quarry near the powerhouse and excavated rock from the penstock route will be processed into aggregate while since there would further be a possibility that riverbed deposits of the Rio Timbio would be used supplementarily, surveys of the deposits will be required.

(4)-6 The foundation of the diversion dam site on the Rio Cauca is covered by a thick terrace deposit and there is a necessity for thorough foundation treatment to be carried out through grouting the foundation of the dam.

(5) The construction cost for realization of the Julumito Hydroelectric Power Project including the construction cost of the transmission line to Popayan Substation and the cost of additional transforming facilities at the substation would amount to a total of 352,400,000 Colombian pesos.

Of this amount, payments in foreign currency would be 220,900,000 pesos and payments in local currency 131,500,000 pesos.

Further, the above construction cost includes interest during construction of 7.25% per annum for foreign currency and 12.0% per annum for local currency totalling 31,000,000 pesos.

(6) In consideration of the demand and supply balance of the CEDELCA-CEDENAR System and of transmission loss, the annual salable energy of Julumito Power Station delivered at Popayan Substation will be 282,600,000 kWh. Opposed to this, the annual cost of the power station equalized for its service life would be 37,106,000 pesos. Therefore, the electricity cost per kWh delivered at Popayan Substation will be 13.1 centavos.

(7) In economic evaluation of the Julumito Project, assuming an alternative thermal power station of equal scale built in the vicinity of Popayan City, the benefit-cost ratio of the Julumito Project would be 1.7.

As the assumption of a case when electric power is purchased from the CVC System utilizing the interconnecting transmission line, the annual cost divided by that of Julumito would be 1.3, indicating the economic feasibility of the Julumito Project in both cases.

(8) The Julumito Hydroelectric Power Project, in view of the increase in power demand of the CEDELCA-and-CEDENAR system, future load patterns and supply capabilities of existing facilities, would be suited for carrying the peak part of the system load, and coupled with utilization of the interconnecting transmission line, an efficient operation can be anticipated.

(9) To see the future demand and supply balance of the CEDELCA-CEDENAR system, a shortage in supply capability will appear in 1975 and continue up to 1981 when operation of Julumito Power Station will be started. During this period it will be more economical to purchase power from the CVC System utilizing the interconnecting transmission line.

Therefore, the start of operation of Julumito Power Station should be at the end of 1981. Until 1984 when the installed capacity of Julumito Power Station will become fully operative, the interconnecting transmission line would serve as a reserve capacity to improve the supply dependability of the system, while for 1985 and thereafter when there will be a further shortage in supply capacity, it will be necessary to plan development of other power sources, but when this is not practicable, it will be required for the interconnecting transmission line to be operated occasionally as power source while concurrently serving as reserve capacity for the system.

(10) The result of study of repayment of funds shows that sufficient income can be derived from the Julumito Project to make possible the repayment of the construction funds in foreign and local currencies. Also, after full repayment of the local currency funds (12 years after start of operation) there would be annual electricity sales income of approximately 18,400,000 pesos, while further, after repayment in full of the foreign currency (17 years after start of operation), there would be 42,170,000 pesos annually and it is judged the Project will become a great source of income for CEDELCA, S.A.

(11) The development pf the Julumito Project will not only make a contribution as a stable source of power supply having a reservoir in the CEDELCA and CEDENAR areas in Southern Colombia, but is believed will contribute greatly also directly and indirectly to the progress of the industry, economy and tourism of Departamento del Cauca and Departamento de Nariño.

2.2 Recommendations

Based on 2.1, "Conclusions," the following recommendations are made:

(1) Development Pattern and Scale of Julumito Hydroelectric Power Project

Julumito Dam should be built on the Rio Sate 6,300 m upstream from the confluence of the Rio Sate and the Rio Cauca.

The dam would be a curving rockfill dam with an inclined core zone, which has crest elevation of 1,717.0 m, height of 80 m and crest length of 350 m.

The high water surface level of the dam would be at an elevation of 1,715.0 m and with available drawdown of 15.0 m, an effective storage capacity of 50.4 million m^3 would be secured.

The waters of the mainstream Rio Cauca, the Rio Palacé and the Rio Blanco will be conducted to the above reservoir constructing diversion waterways having lengths of 2,620 m and 8,430 m respectively.

An intake is to be provided at the left bank of the reservoir upstream of the dam to draw a maximum of 50.0 m^3/sec of water. The headrace tunnel would be a pressure tunnel with inner diameter of 4.2 m and length of 1,793 m. A surge tank would be provided at the end of the headrace tunnel.

The locations of the penstock and the powerhouse would be at the right bank of the Rio Cauca 2,400 m upstream from the junction of the Rio Sate and the Rio Cauca. The penstock is to be a surface type of welded steel pipe with the upper part in one line and the bottom bifurcated to form two lines.

The powerhouse would also be a surface type and would be a reinforced concrete structure in which two turbine-generator units of 29,500 kVA each would be installed. With the effective head of 125.5 m and maximum available discharge of 50.0 m^3/sec at this power plant, power generation of a maximum output of 53,000 kW will be carried out and 285,400,000 kWh of energy will be produced annually. Water after used for power generation will be discharged into the Rio Cauca from the tailrace.

A 115-kV transmission line is to be newly constructed over a distance of approximately 10 km between the power station and Popayan Substation and the power produced will be transmitted to Popayan Substation. The salable energy at Popayan

Substation would be 282,600,000 kWh.

(2) Timing of Development

When the electric power demand and supply balance of the CEDELCA-CEDENAR System, operation of the interconnecting transmission line and the economy of the entire system are considered, it is desirable for start of operation of Julumito Power Station to be at the end of 1981. Therefore, the construction must be started at the beginning of 1979 in consideration of construction period.

(3) Preparations for Development

The various preparations required prior to start of construction should be commenced as soon as possible and must all be completed during 1978. It is desirable for these to be carried out according to Fig. 2-1, "Schedule of Preparation for Construction."

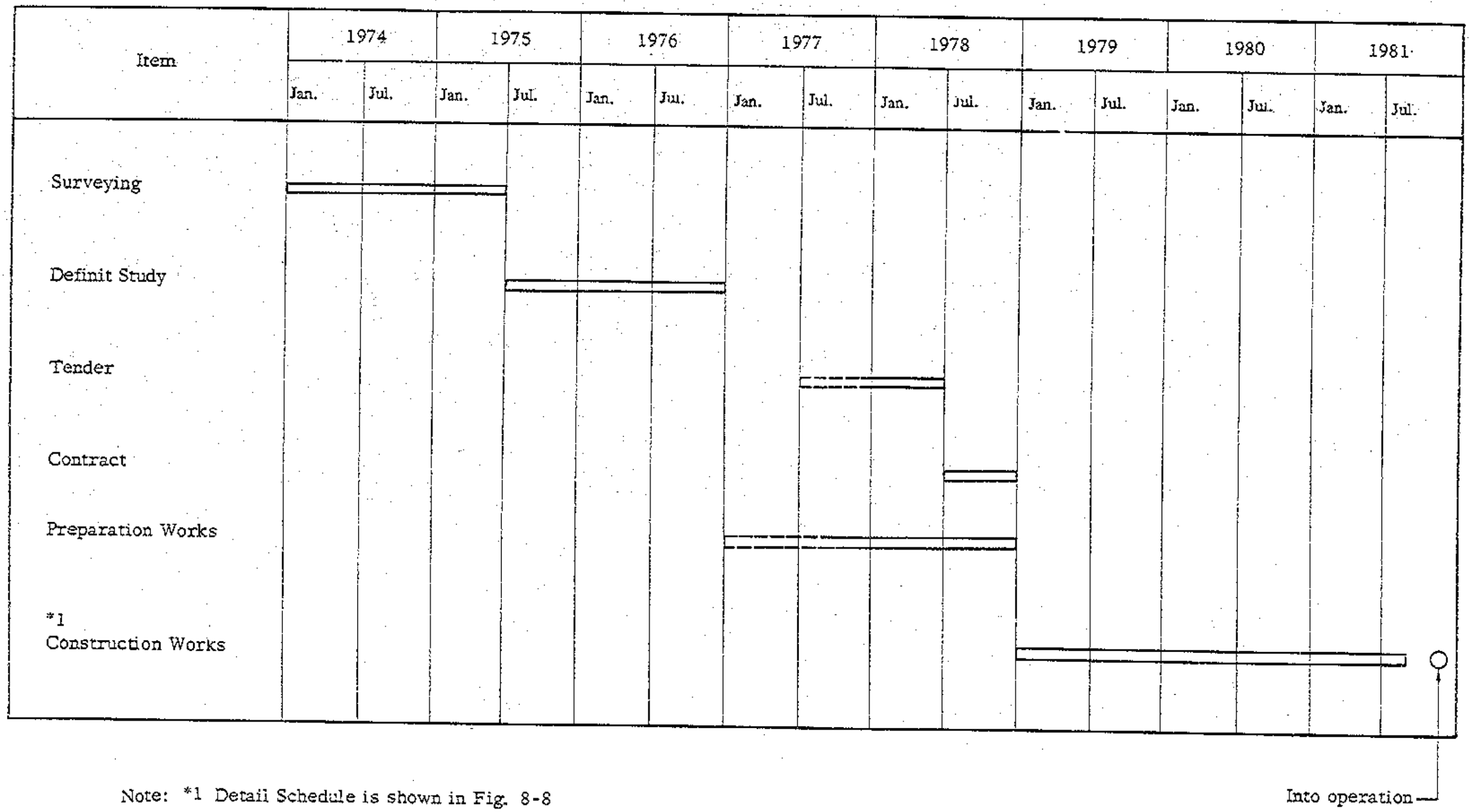
(4) Future Field Survey

Hereafter, in order to carry out detailed design for the Julumito Project, it is necessary for the investigations listed in Appendix-I to be carried out. Especially, it is necessary for efforts to be made in preparation of accurate topographical maps for design of civil structures, and in geological investigations on the sites of civil structures, and surveys and tests on dam construction materials and concrete aggregates.

(5) Others

The timing for development of the Julumito Project is the end of 1981 as described in (2) above, but when it is considered that this project site is emminently suitable in relation to the situation of electric power sources in the southern part of the Republic of Colombia, that the realization of this Project makes possible the effective operation of the transmission line interconnecting this area to greatly improve the reliability of power supply, and that the materialization of this Project will stimulate the industrial development of the Republic of Colombia which in recent years has been showing marked economic growth, and especially, that a great contribution will be made to the economic development of Southern Colombia headed by Departamento del Cauca and Departamento de Nariño in which this project area is situated, it is desirable for the timing of development of this Project to be speeded up by about several years.

Fig. 2-1 Schedule of Preparation for Construction



Note: *1 Detail Schedule is shown in Fig. 8-8

CHAPTER 3

LOAD FORECAST

CONTENTS

FIGURE LIST

TABLE LIST

CHAPTER 3 LOAD FORECAST

3.1 Service Area

The power supply area of the Julumito Project is comprised of Departamento del Cauca centered around Popayan City in the southern part of the Republic of Colombia near the most upstream part of the Rio Cauca and Departamento de Nariño centered around Pasto City even further to the south of Departamento del Cauca and adjacent to the national border with Ecuador.

3.1.1 Departamento del Cauca

Departamento del Cauca with Popayan as the capital city has a population of 727,885 (July 1971 data of Planeacion del Departamento del Cauca), an area of approximately 31,000 km^2, borders on Departamento de Nariño on the south and Departamento de Valle on the north, and is an agricultural province with coffee, tapioca (yuca), maize, potatoes, sugar cane and bananas as the major agricultural products while liverstock farming is also being carried out.

The capital of the department is located at Popayan City the population of which is 101,974.

The manufacturing industry consists of not much more than a sulfur plant on the outskirts of Popayan and a sugar refining factory at Santander, the remainder being extremely small-scale domestic industry-type sash factories, hume pipe works, automobile repair shops and welding plants.

3.1.2 Departamento de Nariño

Departamento de Nariño with Pasto City as its seat of government has a population of 832,589 (1971 data of Planeacion del Departamento de Nariño) and an area of 32,535 km^2 with the southern end of the department bordering on Ecuador while the western side faces the Pacific Ocean.

This department, like Departamento del Cauca, is an agricultural province with coffee, bananas, sugar cane, maize, potatoes and tapioca (yuca) as the main agricultural products while cacao beans are also harvested. The greater part of this agricultural production is concentrated in the southeastern part of the department.

Approximately 40% of the area of Departamento de Nariño is covered by forests, and industries such as lumber manufacturing are found in the western part of the department.

In the center of the department, gold and silver are being produced with still other mines presently being investigated.

As Pasto City there is a soft drink plant, a beer brewery and (licor) distilleries, almost all other industries being small domestic types.

Pasto City is a lively town compared with Popayan City possibly due to its proximity to the border.

3.2 Electric Power Situation

The electric power systems in the Republic of Colombia were developed centered around the three big cities of Bogota, Medellin and Cali operated independently as Bogota Electric Power Company, Medellin Electric Power Company and Cali Electric Power Company, but since last year, the three cities have been connected by a 230 kV interconnecting transmission line constructed by ISA (Interconexión Eléctrica S.A.) with interchange of power made as necessary through ISA.

For provincial departments other than in the service areas of the abovementioned companies, publicly owned electric power corporations under the jurisdiction of ICEL (Instituto Colombiano de Energía Eléctrica) have been established to carry out power supply.

In the supply area of this Project also, there are the two electric power corporations of CEDELCA S.A. (Centrales Electricas del Cauca S.A.)and CEDENAR S.A. (Centrales Electricas de Nariño S.A.) carrying out power supply to their respective service areas.

The facilities owned by the two corporations are described below.

3.2.1 CEDELCA S.A.

The outline of electrical facilities owned by CEDELCA S.A. is as follows:

Power Stations		(kW)	
La Florida	Hydro	2,200	
Sajandi	"	2,400	
Rio Palo	"	1,440	
Ovejas	"	900	
Asnazu	"	450	
Silvia	"	644	
Mondono	"	600	
Toribio	"	63	
Inza	"	450	
San Pablo	Diesel	400	
Guapi	"	130	
Sub-total		9,677	
Florida II		24,000	(under construction Sept. '73.)
Total		33,677	

Substations (including outgoing transforming facilities of power stations)

	(kVA)
Popayan Principal	25,000
"	10,000
"	3,000
La Florida	1,900
Japio	1,600
El Palo	1,800
Sajandi	3,000
Other small substations	4,362
Total	50,662

Transmission Lines

	(km)	
115 kV, 1/2 circuit	105	(Popayan - Rio Mayo)
33 kV	220	
13.2 kV	437	
115 kV	117	(Popayan - Pancé, under construction, Sept. '72)

Distribution Lines (high-voltage trunk lines only, low voltage lines excluded)

93.6 km

3.2.2 CEDENAR S.A.

The outline of electrical facilities owned by CEDENAR S. A. is as follows:

Power Station		(kW)
Rio Mayo	Hydro	21,000
Rio Bobo	"	4,367
Rio Sapuyes	"	1,856
Rio Ingenio	"	200
Julio Bravo	"	2,000
Pasto	Diesel	3,100
Tumaco	"	2,036
Total		34,559

Substations (including outgoing transforming facilities of power stations)

	(kVA)
Rio Mayo	24,000
"	3,000
Pasto Principal	24,000
"	5,000
"	5,000
Rio Bobo	5,000
Rio Supuyes	1,800
Ipiales	1,800
Total	69,600

Transmission Lines

	(km)
115 kV, 1/2 circuit	56 (Rio Mayo - Pasto)
33 kV	122
13.2 kV	176
Distribution Lines (high-voltage trunk lines only, low-voltage lines excluded)	80.9 km

3.2.3 Present State of Power Demand and Supply

The power generation records and peak demand data from 1961 to 1971 are as indicated in Table 3-1.

As shown in this table, the energy demand of CEDELCA at generating end in the 10-year period from 1961 through 1970 indicated an annual growth rate of 11.4% and the increase was approximately threefold from the 21,000 MWh in 1961 to the 61,800 MWh in 1970.

At CEDENAR also, there was an annual growth rate of 11.9% during the 10 years up to 1970 with an increase from the 27,900 MWh in 1961 to 85,700 MWh in 1970.

The electric power consumption performances according to customer category from 1965 and on are as shown in Table 3-2, 3-3 and 3-4.

As seen from Table 3-2, two-thirds of the power demand of CEDELCA are residential demand for cooking and lighting. Therefore, the shape of the load curve indicates a peak at 11 o'clock in the morning and at 7 o'clock in the evening, a trend seen throughout the year.

Since CEDELCA cannot satisfy demand with the power generating facilities it owns, it purchases power from CEDENAR through the 115 kV interconnecting transmission line (owned by ICEL) connecting Rio Mayo and Popayan, while in the northern part of the department close to Departamento de Valle, power is purchased from CVC (Corporación Autonoma Regional del Cauca) through a 33 kV interconnecting transmission line for supply to customers.

However, since there are kW shortages at the peak hours in the morning and evening, these are supplemented by a mobile diesel generating set of 4,200 kW (2,100 kW x 2 units) on loan from ICEL.

This condition will continue until it will become possible to receive power from the Central System through a CVC-CEDELCA interconnecting transmission line (115 kV, 2/2-

Table 3-1 Demand Record (1961 - 1971)

Year	CEDELCA					CEDENAR					TOTAL				
	Maximum Demand (MW)	Generated Energy (GWh)	Growth Rate (%)	Load Factor (%)	Loss Rate (%)	Maximum Demand (MW)	Generated Energy (GWh)	Growth Rate (%)	Load Factor (%)	Loss Rate (%)	Maximum Demand (MW)	Generated Energy (GWh)	Growth Rate (%)	Load Factor (%)	Loss Rate (%)
1961	5.0	21.0		44.9	31.3		27.9					48.9			
1962	6.0	21.5	2.4	40.9	2.0		30.0	7.5				51.5	5.2		
1963	6.6	29.4	36.7	50.9	28.6	6.2	28.5	- 5.0	52.5		12.8	57.9	12.3	51.6	
1964	7.0	35.2	19.6	57.4	26.4	8.0	33.7	18.2	48.1		15.0	68.9	19.0	52.4	
1965	8.3	37.6	6.8	51.7	23.6	9.2	40.0	18.6	49.6	30.0	17.5	77.6	12.6	50.6	23.3
1966	8.2	41.9	11.4	58.3	23.4	9.3	48.4	21.0	59.4	26.7	17.5	90.3	16.2	58.9	25.2
1967	8.4	44.6	6.3	60.6	25.1	9.3	47.5	- 1.8	58.3	25.3	17.7	92.1	2.3	59.4	25.2
1968	8.9	47.6	6.5	61.1	29.3	9.4	47.7	0.2	57.9	24.2	18.3	95.1	3.3	59.3	26.7
1969	11.4	51.2	7.3	51.3	31.3	20.0	61.7	29.3	35.2	26.2	31.4	105.9	11.3	38.5	28.6
1970	12.3	61.8	20.8	57.4	31.5	18.8	85.7	39.0	52.0	20.7	29.2	147.5	39.3	57.7	25.3
1971	13.1	66.7	7.8	58.1	27.9	19.4	103.6	20.9	61.0	20.8	32.5	170.3	15.5	59.8	23.6

Table 3-2 Energy Demand Record in CEDELCA

(MWh)

Year	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Generated Energy	21,000	21,460	29,400	35,170	37,600	41,920	44,580	47,630	51,240	61,770	66,680
Energy at Demand End	14,420	21,040	20,980	25,900	28,739	32,115	33,394	33,678	35,180	42,282	48,068
Residentials					19,329	21,372	22,272	22,478	24,104	28,619	32,528
Commercials					3,662	3,480	3,489	3,385	3,673	4,354	4,649
Industrials					2,064	2,964	3,132	3,424	2,900	3,132	2,916
Officials					2,667	2,776	2,969	2,854	3,031	3,625	4,449
Publics					1,017	1,523	1,532	1,537	1,472	2,552	3,526

Table 3-3 Energy Demand Record in CEDENAR

(MWh)

Year	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Generated Energy	27,880	30,020	28,530	33,670	39,950	48,380	47,500	47,690	61,660	85,720	103,630
Energy at Demand End					30,772	35,469	35,483	36,158	45,484	67,936	82,062
Residentials					23,484	27,173	27,369	27,508	29,202	43,258	53,373
Commericals					-	-	-	1,142	6,489	9,430	11,050
Industrials					3,910	4,511	4,318	3,785	5,558	9,186	9,255
Officials					988	1,097	1,147	1,277	1,815	3,237	5,353
Publics					2,390	2,688	2,649	2,446	2,420	2,825	3,031

Table 3-4 Energy Demand Record (CEDELCA + CEDENAR)

(MWh)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Generated Energy	48,880	51,480	57,930	68,840	77,550	90,300	92,080	95,320	112,900	147,490	170,310
Energy at Demand End					59,511	67,584	68,877	69,836	80,644	110,218	130,130
Residentials					42,813	48,545	49,641	49,986	53,306	71,877	85,901
Commercials					3,662	3,480	3,489	4,527	10,162	13,784	15,699
Industrials					5,972	7,475	7,450	7,209	8,458	12,318	12,171
Officials					5,655	3,873	4,116	4,131	4,846	6,862	9,802
Publics					3,407	4,211	4,181	3,983	3,892	5,377	6,557

circuit, 117 km) presently under construction by ICEL and scheduled to be completed in September of this year.

The maximum peak demand of CEDELCA in 1971 was 13,100 kW, while the electric energy (at generating end) including those purchased from CVC and CEDENAR was 66,680 MWh and the annual load factor was 58% (daily load factors of weekdays 61 - 63%). Of this, the energy purchased was 20,569 MWh (CVC: 4,096 MWh, CEDENAR: 16,473 MWh), the proportion of which took up approximately 31% of the whole.

At present, CEDELCA is purchasing electricity from CVC at 18.5 centavos per kWh (approximately 8.8 mill) and from CEDENAR at 11.8 centavos per kWh (approximately 5.6 mill) which are considerably cheaper than the average generating cost of 26 CVS/kWh (12.4 mill/kWh) in diesel power generation.

Purchase of supplementary electric power from the Central Power System through the interconnecting transmission line is scheduled to be up to September 1973 and from October of that year, Florida II Power Station presently under construction will be brought to start operation so that the necessity for purchase of power will be eliminated.

The load of the CEDENAR System is shown in Table 3-3. Similar to CEDELCA, approximately two-thirds of the entire demand is used for residential lighting and cooking. Therefore, the shape of the load curve is almost identical to that of the CEDELCA System. The demand of CEDENAR is in most part covered by Rio Mayo Power Station, but at peak hours, because of sale of power to CEDELCA, a kW shortage is produced and Pasto Diesel Plant is operated to supplement the deficiency.

The power generation of CEDENAR for consumption within its own system in 1971 was 19,400 kW in maximum peak 103,632 MWh in energy production with annual load factor of 61%. Besides this, 16,473 MWh were sold to CEDELCA.

The installed capacity of Rio Mayo Power Station is 7,000 kW x 3 units for a total of 21,000 kW, but because of wear on the turbines caused by sediment in the water, each unit is required to be shut down for approximately 40 days every year for special welding of guide vanes so that a period of approximately 4 months out of the year is a 2-unit operation or 14,000 kW.

Both the CEDELCA and CEDENAR systems were fairly strained from the standpoint of power demand and supply as shown in Table 3-2 and 3-3 until September 1969 when Rio Mayo Power Station was completed, but since 1970, although a diesel engine generator of high power generating costs is activated at peak hours, a more or less stable supply is being maintained.

3.3 Period and Method of Load Forecast

3.3.1 Period

The period of load forecast was taken to be the 14 years from 1972 through 1985 in compliance with the wishes of CEDELCA.

Also, this period was adopted for forecasting as it was judged adequate for study of the project scale, timing of development and effectivation.

3.3.2 Method of Forecast

The method of load forecast taken for this Report was as described below. Both CEDELCA and CEDENAR already had load forecasts for their own systems, CEDELCA up to 1980 and CEDENAR up to 1977.

Therefore, our forecast for the two systems was made based on these figures and in consideration of the growths in population and in electric power of Departamento del Cauca and Departamento de Nariño, and from the aspect of grasping the picture as whole, taking into account the growth in electric power of the entire Republic of Colombia.

Table 3-5 shows the load forecast made by the two corporations and by the mission.

(1) CEDELCA System

As shown in Table 3-5, according to the forecast of CEDELCA, the growth rate in power demand of the system in 1972 was forecast to be 3.1% (CEDELCA has not reviewed the figures this year). Since this figure is extremely low compared with the growth in the past several years it was altered upward to 10%. Further, for the next 4 years up to 1976 it was assumed there would be continued growth at the same 10% rate, while from 1977 and thereafter, the growth was taken to be 9%.

(2) CEDENAR System

For the CEDENAR System it was decided to adopt the figures forecast by CEDENAR, while for 1978 and thereafter, the same 9% growth as for CEDELCA was assumed in determining the load forecast. However, the CEDENAR forecast contain the load of the Tumaco district which is not included in the service area of the Julumito Project and this is thereofe deducted.

(3) Relation with Interconnecting Transmission Line

Although it is thought advisable to include the CVC System which is scheduled to become interconnected with the CEDELCA System in the area to be supplied with power from the Julumito Project, since it was requested by CEDELCA not in include CVC, the forecast was confined to the CEDELCA and CEDENAR systems with the interconnecting transmission line considered as being a power supply source for supplementing temporary shortages and as a reserve capability. Therefore, a reserve capacity is not considered within the CEDELCA and CEDENAR systems.

(4) Checking of Forecast

In general, there is a high degree of correlation between the population of an area to be supplied with electric power and the power demand of that area. Therefore, a check was made from the standpoint of the relation with population in regard to the loads forecast in the foregoing for CEDELCA and CEDENAR.

The populations of Departamento del Cauca and Departamento de Nariño from 1964 through 1980 would be as indicated in Table 3-6 according to the data of DANE (Departamento Administrativo Nacional de Estadistica). The relations between actual electric power demands and forecast in the past are illustrated as shown in Fig. 3-1 and Fig. 3-2 and it is seen that a high degree of correlation exists between population and power demand

Table 3-5 Load Forecast

				1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
CEDELCA	Original	Peak Demand	MW	13.1	14.0	16.1	17.6	19.0	20.9	23.0	25.3	27.8	30.6					
		Energy Demand	GWh	66.7	68.8	76.0	83.2	89.9	98.8	108.7	119.6	131.6	144.7					
		Growth Rate of Energy	%	7.8	3.1	10.5	9.5	8.1	9.9	10.0	10.0	10.0	10.0					
	Mission	Peak Demand	MW		15.0	16.4	18.1	19.9	21.9	23.9	26.0	28.4	30.9	33.7	36.7	40.0	43.6	47.6
		Energy Demand	GWh		73.4	80.7	88.8	97.7	107.4	117.1	127.6	139.1	151.7	165.3	180.2	196.4	214.1	233.3
		Growth Rate of Energy	%		10.0	10.0	10.0	10.0	10.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
CEDENAR	Original	Peak Demand	MW	19.4	24.6	27.9	30.4	33.0	35.8	39.0								
		Energy Demand	GWh	103.6	117.1	136.2	147.8	162.0	179.0	198.0								
		Growth Rate of Energy	%		13.0	16.3	8.5	9.7	10.4	10.6								
	Mission	Peak Demand	MW		23.3	26.5	28.9	31.4	34.0	37.1	41.8	45.5	49.7	54.2	59.1	64.4	70.3	76.6
		Energy Demand	GWh		114.1	131.1	141.9	155.7	171.8	190.1	207.2	225.8	245.6	268.4	292.7	319.2	348.0	379.4
		Growth Rate of Energy	%		10.0	15.0	8.5	9.7	10.4	10.6	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
TOTAL	Original	Peak Demand	MW	32.5	38.6	44.0	48.0	52.0	56.7	62.0								
		Energy Demand	GWh	170.3	185.9	212.2	231.0	251.9	277.8	306.7								
		Growth Rate of Energy	%		9.2	14.1	8.9	9.1	10.2	10.4								
	Mission	Peak Demand	MW		38.3	42.9	47.0	51.3	55.9	61.0	67.8	73.9	80.6	87.9	95.8	104.4	113.9	124.2
		Energy Demand	GWh		187.5	211.9	230.7	253.4	279.2	307.2	334.8	364.9	397.3	433.7	472.9	515.6	562.1	612.7
		Growth Rate of Energy	%		10.0	12.9	9.0	9.7	10.0	10.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0

in the case of Departamento del Cauca in particular.

For Departamento de Nariño also, except for the period from 1967 through 1969 when supply capacity was lacking, there is a fair degree of correlation.

The elasticity of power demand to population in the past were as given below.

	CEDELCA	CEDENAR	Total
Elasticity	4.45802	5.86923	5.08139
Correlation Coefficient	0.98635	0.95569	0.98408
Standard Deviation	0.0625858	0.113466	0.0665828
t-value	16.94	9.18	15.66

Studying the power demands of respective systems previously forecast by employing these elasticity the results will be as given in Table 3-7.

As a result, although somewhat low compared with calculated values, the forecast may be said to be reasonable.

Next, from the aspect of grasping the general picture, the relation between the power demand of the entire Republic of Colombia and that of the CEDELCA + CEDENAR System is studied.

The relationship between actual energy production for the entire country of Colombia and the actual power generation of the CEDELCA + CEDENAR System is as indicated in Table 3-8.

This, indicated graphically, would be as shown in Figs. 3-3, 3-4 and 3-5. As seen from these figures there is a roughly similar trend between the growths in power generation of the country as a whole and of the CEDELCA + CEDENAR System.

The growth rates of the two are calculated as follows:

	All Colombia	CEDELCA + CEDENAR
1961	3,123 GWh	48.9 GWh
1969	7,345 GWh	112.9 GWh
1969/1961	2.35	2.31
Growth Rate	11.3%	11.0%
Elasticity	0.98	

Table 3-6 Population

Year	Total of Country	Canca	Narino	Canca + Nar.
1964	17,484,508	607,197	705,611	1,312,808
1965	18,043,500	621,200	719,000	1,340,200
1966	18,620,000	635,700	732,900	1,368,600
1967	19,216,500	650,600	747,200	1,397,800
1968	19,830,400	665,900	761,900	1,427,800
1969	20,464,400	681,800	777,000	1,458,800
1970	21,117,800	698,100	792,600	1,490,700
1971	21,793,800	727,885 1/	832,589 2/	1,560,474
1972	22,490,500	732,200	825,300	1,557,500
1973	23,209,300	750,000	842,300	1,592,300
1974	23,952,100	768,400	859,900	1,628,300
1975	24,717,300	787,300	878,100	1,665,400
1976	25,508,100	806,800	896,800	1,703,600
1977	26,323,000	826,900	916,000	1,742,900
1978	27,165,200	847,700	935,900	1,783,600
1979	28,033,400	869,000	956,300	1,825,300
1980	28,929,600	891,000	977,400	1,868,400

1/ Data from Planeacion de Departamento del Cauca
2/ Data from Planeacion de Departamento de Narino

Table 3-7 Relation between Population and Energy

Item	CEDELCA		CEDENAR		TOTAL	
	Population	Energy	Population	Energy	Population	Energy
		GWh		GWh		
1971	727,885	66.7	832,589	103.6	1,560,474	170.3
1980	891,000		977,400		1,868,400	
1980/1971	1.223		1.172		1.197	
Growth Rate (G)	2.26%		1.78%		2.02%	
Elasticity (E)	4.46		5.87		5.08	
(G) x (E)	10.1%		10.4%		10.25%	
Growth in 9 years	2.38		2.43		2.41	
Calculated Value		159		252		410
Forecasted Value		151.7		245.6		397.3

Table 3-8 Generated Energy

	Colombia (GWh)	CEDELCA (GWh)	CEDENAR (GWh)	TOTAL (GWh)
1961	3,123	21.0	27.9	48.9
1962	3,400	21.5	30.0	51.5
1963	3,964	29.4	28.5	57.9
1964	4,565	35.2	33.7	68.9
1965	5,034	37.6	40.0	77.6
1966	5,494	41.9	48.4	90.3
1967	5,936	44.6	47.5	92.1
1968	6,522	47.6	47.7	95.3
1969	7,345	51.2	61.7	112.9
1970	–	61.8	85.7	147.5

Fig. 3-1 Relation Between Population and Energy Demand of Supply Area of CEDELCA and CEDENAR

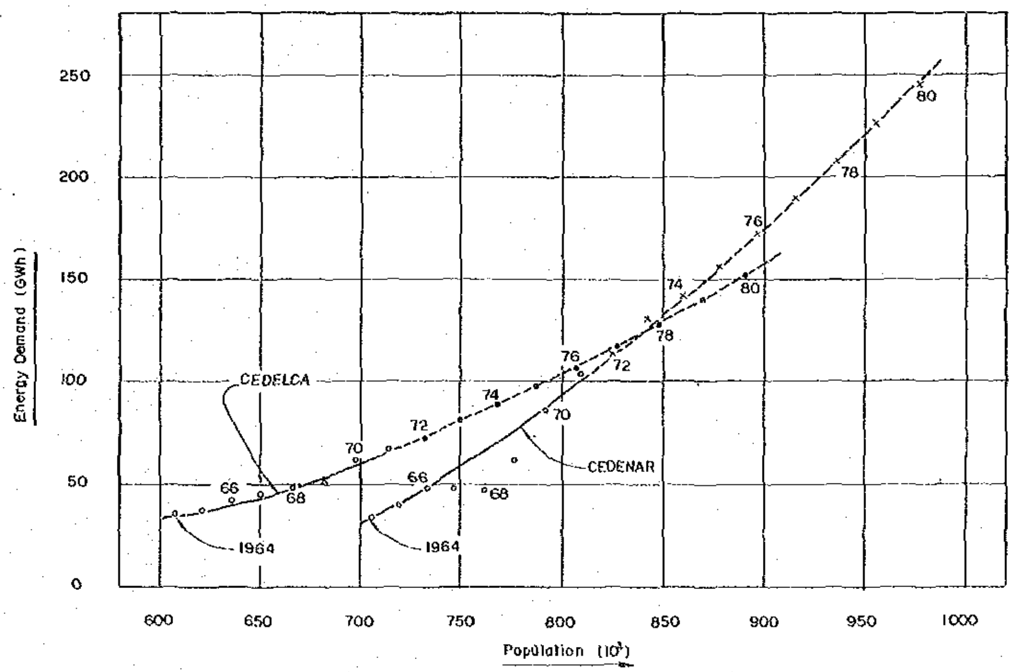


Fig. 3-2 Relation between Population and Energy Demand of Supply Area of (CEDELCA CEDENAR) System

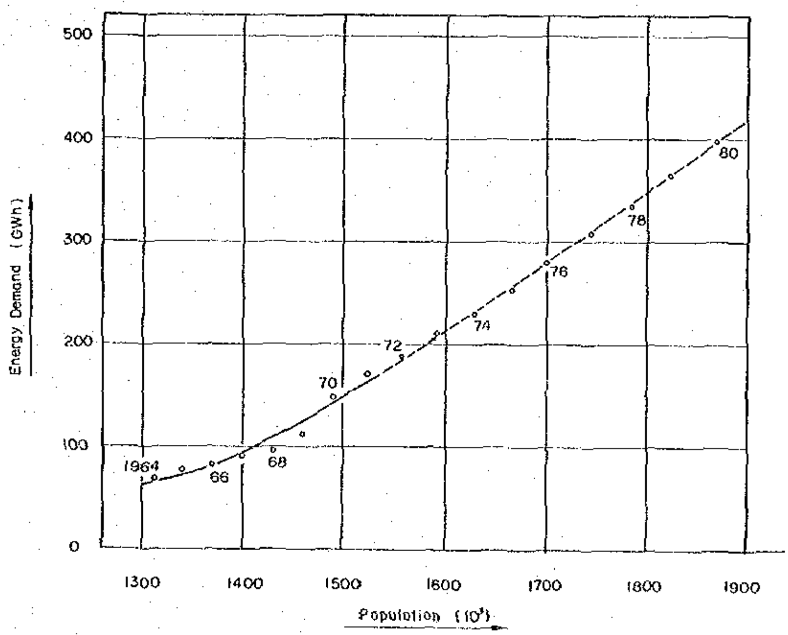


Fig. 3-3 National Wide Energy Demand of Colombia

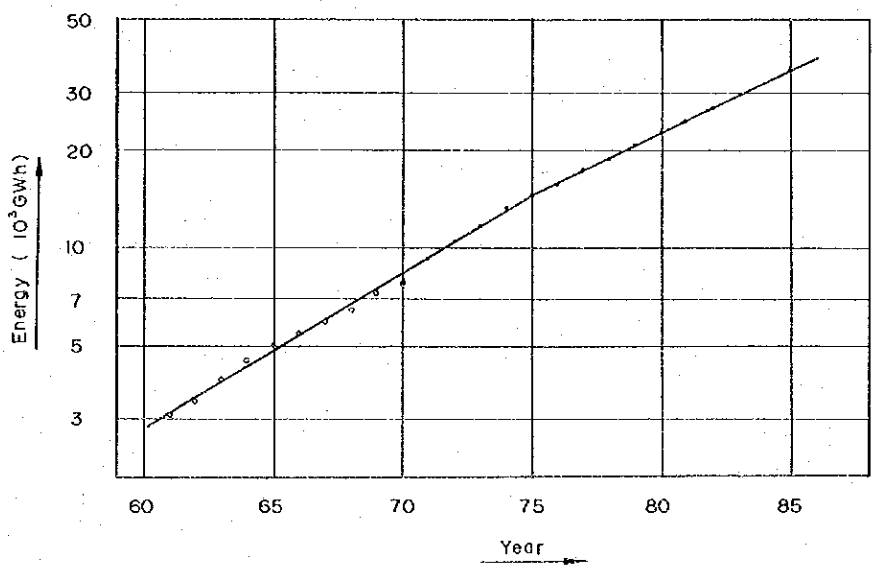


Fig. 3-4 Energy Demand of (CEDELCA + CEDENAR) System

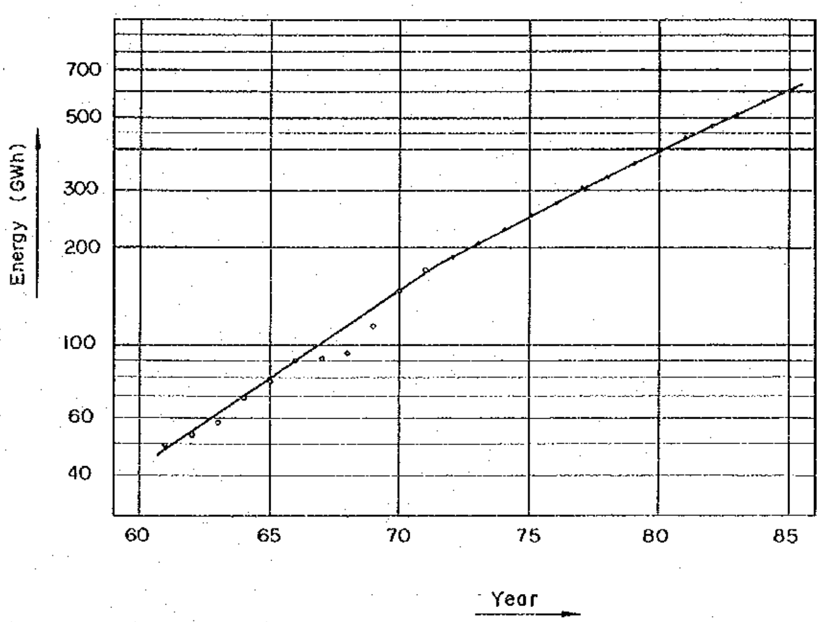
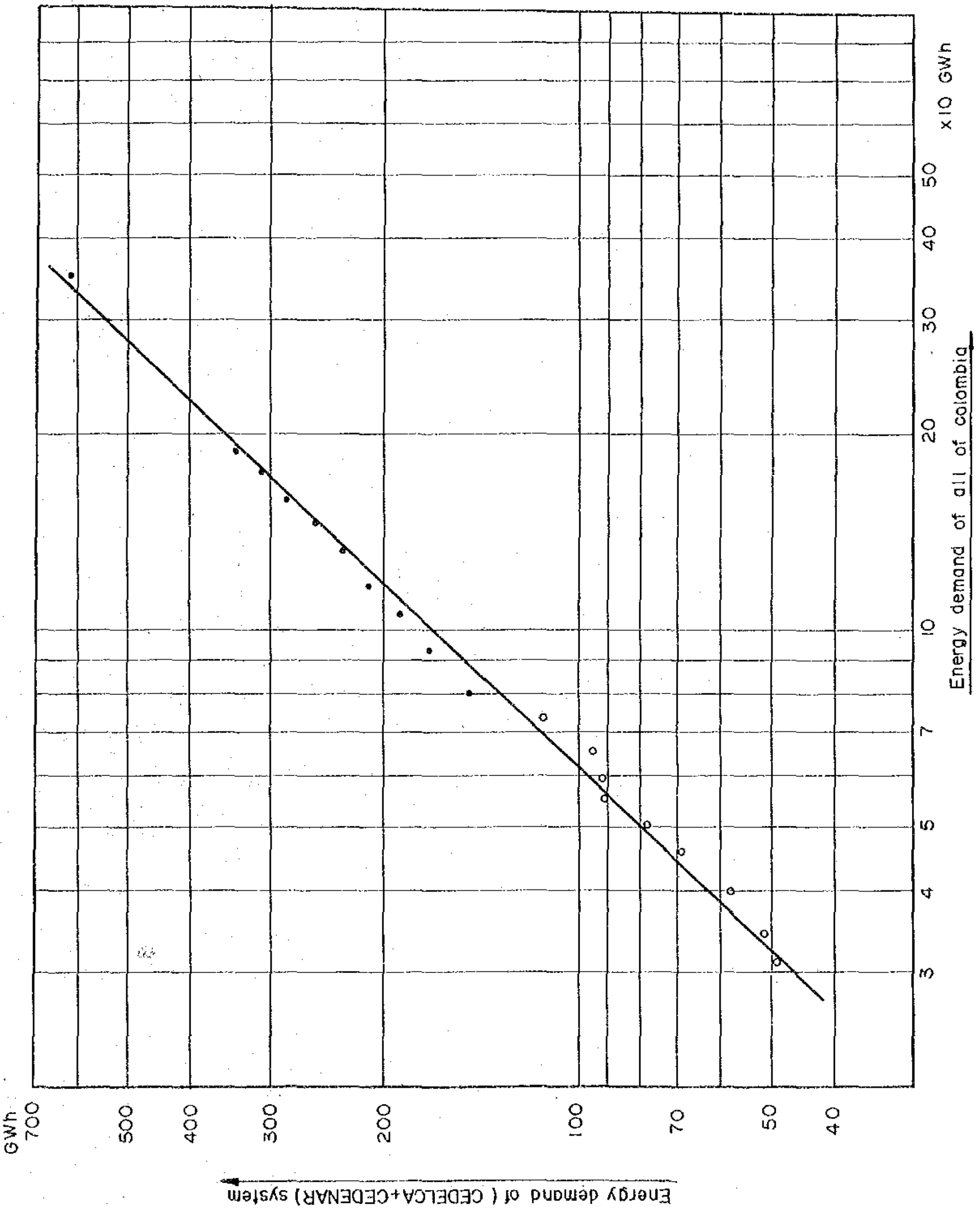


Fig. 3-5 Correlation for Energy Demand between National Wide of Colombia and (CEDELCA + CEDENAR) System



In effect, the growths in electric power of the two show the country as a whole to have a slightly greater rate, but as indicated by the elasticity of 0.98, they are almost the same.

The load forecast for all Colombia from 1970 to the year 2000 according to the date of Planeación is as given in Table 3-9.

When the forecast for the entire country and that for the CEDELCA + CEDENAR System are compared, a generally identical trend is indicated as shown in Table 3-10. In other words, it may be said the load forecast for the total CEDELCA + CEDENAR System is reasonable.

Incidentally, when the load forecasts for 1976, 1980 and 1985 are checked employing the previously determined elasticity, the results are as given below.

	Forecasted (GWh)	Calculated (GWh)
1976	279.2	281
1980	397.3	407
1985	612.7	612

As a result of checking of the forecast with the relationships between population and demand and between the country as a whole and the projected service area, the load forecast for the CEDELCA + CEDENAR System given in Table 3-5 may be said to be reasonable.

It should be noted that the load forecasts described above were made at generating end. Primarily, load forecasts should be made based on loads at demand end taking into account losses to arrive at forecasts for loads at generating end.

Furthermore, as previously discussed, (1) from the fact that the forecast of CEDELCA and CEDENAR used as references were for generating end ana (2) for the reason that although data on losses were not available the forecast for CEDELCA was estimated taking into account investment for future power distribution facilities, it was judged suitable for forecasts at generating end to be used andtherefore, the load forecast for this Report is made directly for genrating end.

Table 3-9 National Wide Load Forecast and Installed Capacity of Colombia

Year	Energy Demand (GWh)	Growth Rate of Energy (%)	Load Factor (%)	Peak Demand (MW)	Growth Rate of MW (%)	Scheduled Additional Capacity (MW)	Total Installed Capacity (MW)	Reserved Capacity
1970	8,000		55.7	1,640		498	2,998	40.1
1971	9,300	16.3	58.0	1,830	11.5	69	2,449	33.8
1972	10,400	11.8	59.0	2,010	9.8	184	2,633	26.9
1973	11,600	11.6	60.0	2,210	9.9	50	2,683	17.6
1974	13,200	13.7	61.0	2,470	11.7	472	3,155	24.4
1975	14,500	9.8	61.0	2,710	9.7	100	3,255	17.0
1976	15,800	8.9	61.5	2,930	8.1	500	3,755	25.3
1977	17,300	9.4	62.0	3,180	9.2	0	3,755	15.5
1978	18,900	9.2	62.5	3,450	8.4	280	4,035	14.5
1979	20,700	9.5	63.0	3,750	9.6	500	4,535	18.7
1980	22,600	9.1	63.5	4,060	8.2	365	4,900	19.5
1981	24,700	8.2	64.0	4,400	9.1	400	5,300	19.3
1982	26,900	8.9	64.5	4,760	8.1	200	5,500	14.5
1985	35,000	30.0	66.0	6,000	26.0	1,500	7,000	15.0
1990	53,000	51.0	67.0	9,100	52.0	3,500	10,500	14.0
2000	110,000	108.0	70.0	18,000	98.0	10,000	20,500	13.0

Table 3-10 Relation between Energy Demand of National Wide Colombia and (CEDELCA + CEDENAR) System

Year	National Wide of Colombia				(CEDELCA + CEDENAR)			
	Energy	Ratio		Growth Rate	Energy	Ratio		Growth Rate
	GWh			%	GWh			%
1971	9,300				170.3			
1976	15,800				279.2			
		76/71	1.70	11.2		76/71	1.64	10.4
1980	22,600				397.3			
		80/76	1.43	9.35		80/76	1.43	9.20
		80/71	2.43	10.35		80/71	2.33	9.85
1985	35,000				612.7			
		85/80	1.55	9.15		85/80	1.54	9.00
		85/71	3.77	9.95		85/71	3.60	9.60

3.3.3 Load Factor

The annual load factors for the CEDELCA and CEDENAR systems from 1961 and after show considerable fluctuations of 41 - 61% and 35 - 61% respectively, but for 1970 and 1971 when the supply capacity was adequate, the combined load factor of the two systems was 58 - 60% and it is judged these figures reflect the actual present conditions. The futre load factor, in consideration of the spread of television sets and washing machines to households in general, would show some decrease in the annual load factor to 56 - 58% and the annual load factor calculated here was 56% for which the peak demand was calculated.

Also, it was assumed that the diversity factor would not be considered between the CEDELCA and CEDENAR systems.

Further, since it could not be expected that industrial demand would increase greatly in the two systems, it was assumed that this anual load factor would not be changed.

3.3.4 Forecast of Daily Load Curve

The typical daily load curves of the two systems in 1971 are as shown in Fig. 3-6. These curves show almost no variations for weekdays throughout the year.

In regard to load curves for 1972 and after as stated in the preceding item on load factors, it is not conceivable that the load structures of the two systems will be greatly changed and as it is forecast that two-thirds of the total demand would be for *residential* purposes, the load curve synthesizing the demands of the two departments for 1974 until 1985 was forecast assuming that more or less the same shape as that of the 1971 load curve would be maintained.

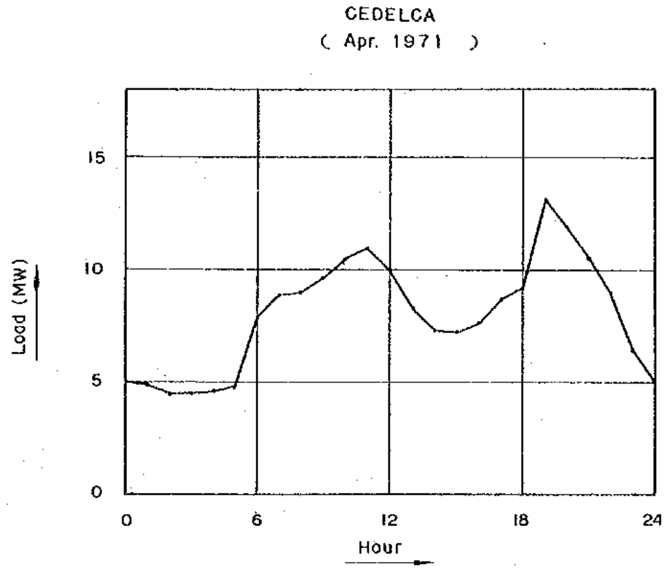
This is indicated in Fig. 3-7.

3.4 Demand and Supply Balance

3.4.1 kW Balance

For both the CEDELCA and CEDENAR systems, the months in which peak demand would appear are not constant and it was assumed as an extremely severe condition that the time of the annual maximum peak demand would coincide with the driest month in studying the kW balance.

Fig. 3-6 Dairly Load Curve in 1971



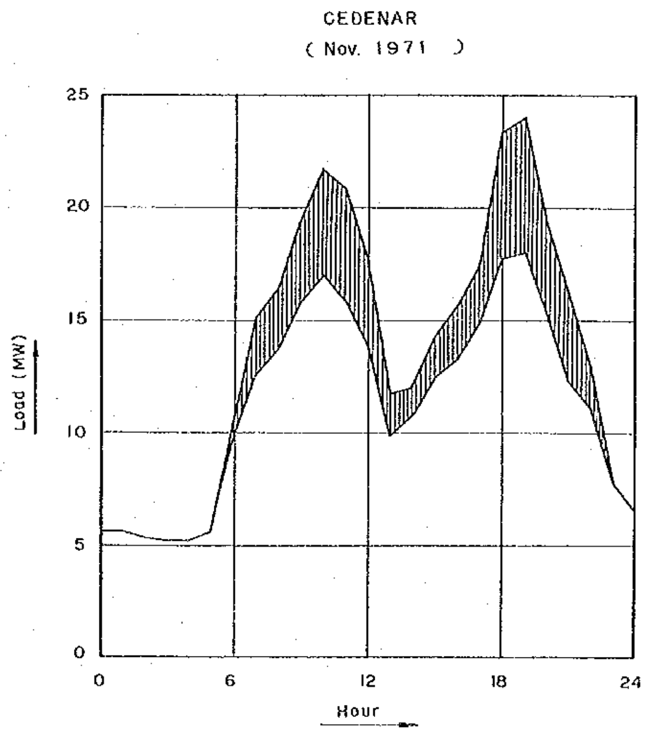
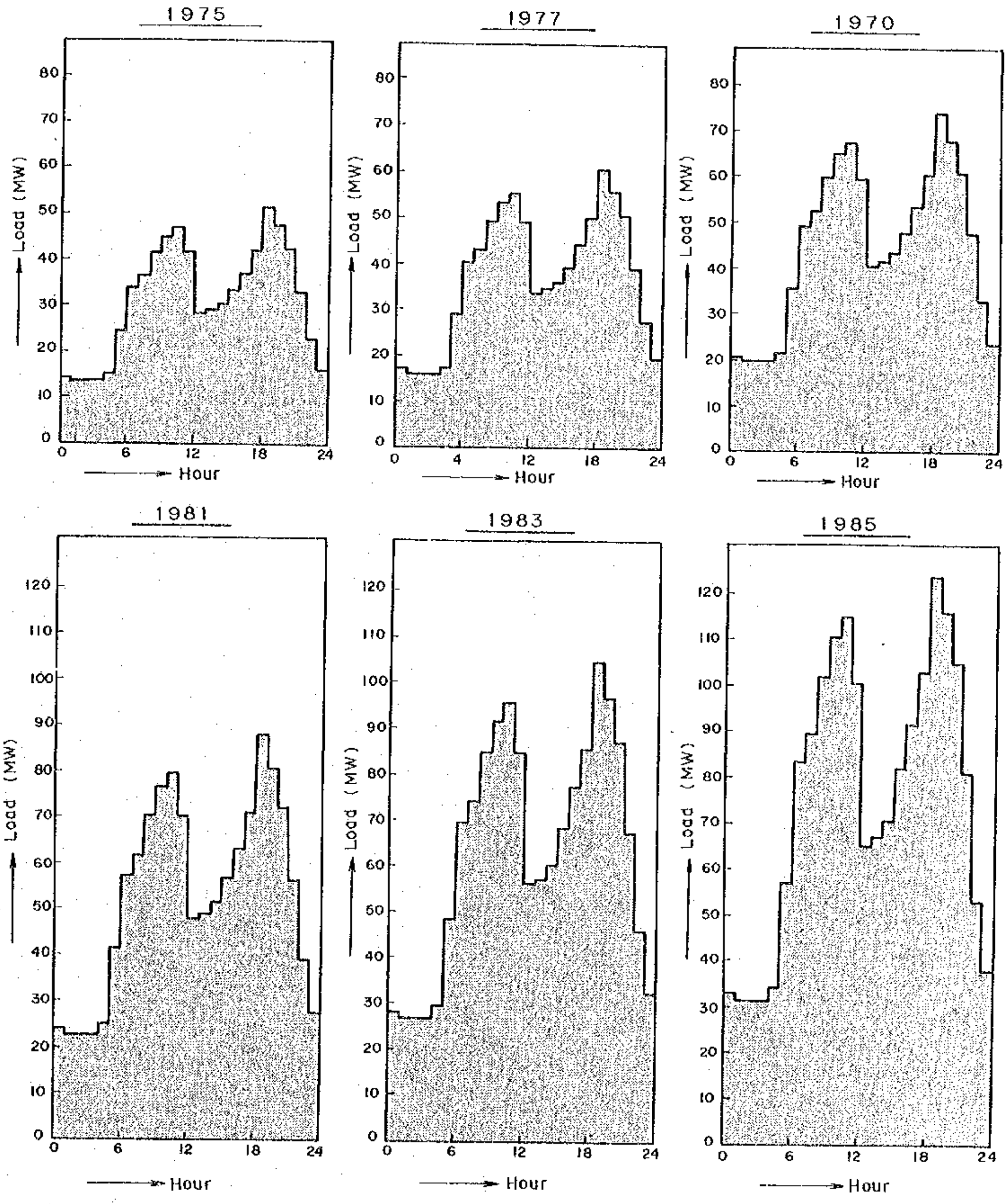


Fig. 3-7 Estimated Load Curve



The period of study was the 12 years from 1974 through 1985. Regarding the low water flow, since 1966 was the driest year according to the hydrologic data of the past 10 years, the study was made adopting the data for 1966.

Preparing the kW balance from this dry season supply capacity and the maximum peak demand of each year, the results are as indicated in Table 3-11 and Figs. 3-8 and 3-9.

According to this, even taking into consideration Florida II Power Station scheduled for commission of operation in September 1973, the CEDELCA + CEDENAR System will indicate a deficiency in kW in 1975 and a necessity will arise for a new power source to compensate for this shortage.

In this kW balance study, it is assumed that the group of existing small hydroelectic power stations would carry the base load and Florida II Power Station and Rio Mayo Power Station the peak load regulating the average droughty water discharge (355-day run-off) by the reservoirs (250 x 10^3 m, 61.7 MWh and 130 x 10^3 m^3, 61.7 MWh respectively) with further shortages to be filled from other power sources.

Regarding these other sources, it is assumed power would be received through the interconnecting transmission line until 1981 while from 1982 and after the supply would be made from Julumito Power Station.

As seen in Table 3-11, even with Julumito Power Station to commence operation from the end of 1981, there will be a shortage in supply capacity although slight in 1984 and it will become necessary to receive power through the interconnecting transmission line.

3.4.2 kWh Balance

In regard to annual energy production, calculations were made from data obtained for the CEDELCA System. For the CEDENAR System, assumption of approximately 90% of installed capacities of run-of-river type power stations as dependable firm kW (the value used for kW balance) was used, while for Rio Mayo Power Station the usable run-off was calculated from the discharge-duration curve of 1966.

The results are given in Table 3-12 and Fig. 3-10.

As seen from these table and figure, there will be a shortage in kW as well as kWh from 1975 and supply from elsewhere will become necessary.

Table 3-11 Demand and Supply Capability in CEDELCA and CEDENAR System

(KW)

			1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Installed Capacity	CEDELCA System													
	Florida I	H	2,210	2,210	2,210	2,210	2,210	2,210	2,210	2,210	2,210	2,210	2,210	2,210
	Florida II	"	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000
	Sajandi	"	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400
	Rio Palo	"	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440
	Other Small P.S	"	3,000	3,000	3,000	3,000	3,000	33,000	3,000	3,000	3,000	3,000	3,000	3,000
	Diesel	D	530	530	-	-	-	-	-	-	-	-	-	-
	Sub-total		33,580	33,580	33,050	33,050	33,050	33,050	33,050	33,050	33,050	33,050	33,050	33,050
	CEDENAR													
	Rio Mayo	H	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000
	Rio Bobo	"	4,370	4,370	4,370	4,370	4,370	4,370	4,370	4,370	4,370	4,370	4,370	4,370
	Rio Sapuya	"	1,860	1,860	1,860	1,860	1,860	1,860	1,860	1,860	1,860	1,860	1,860	1,860
	Other Small P.S.	"	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200
	Pasto	D	3,100	3,100	-	-	-	-	-	-	-	-	-	-
	Sub-total		32,530	32,530	29,430	29,430	29,430	29,430	29,430	29,430	29,430	29,430	29,430	29,430
	Julumito		-	-	-	-	-	-	-	-	53,000	53,000	53,000	53,000
	Total		66,110	66,110	62,480	62,480	62,480	62,480	62,480	62,480	62,480	62,480	62,480	62,480
Supply Power	CEDELCA													
	Flirida I	H	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
	Florida II	"	16,500	18,000	18,700	19,500	20,800	22,200	22,900	23,700	24,000	24,000	24,000	24,000
	Sajandi	"	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
	Rio Palo	"	700	700	700	700	700	700	700	700	700	700	700	700
	Other Small P.S	"	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	Diesel	D	400	400	-	-	-	-	-	-	-	-	-	-
	Sub-Total		21,900	23,400	23,700	24,500	25,800	27,200	27,900	28,700	29,000	29,000	29,000	29,000
	CEDENAR													
	Rio Mayo	H	14,500	14,800	16,500	17,000	17,300	17,700	18,300	18,900	19,600	20,400	21,000	21,000
	Rio Bobo	"	4,200	4,200	4,200	4,200	4,200	4,200	4,200	4,200	4,200	4,200	4,200	4,200
	Rio Sapuya	"	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300
	Other Small P.S	"	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
	Pasto	D	3,100	3,100	-	-	-	-	-	-	-	-	-	-
	Sub-total		25,100	25,400	24,000	24,500	24,800	25,200	25,800	26,400	27,100	27,900	28,500	28,500
	Total		47,000	48,800	47,700	49,000	50,600	52,400	53,700	55,100	56,100	56,900	57,500	57,500
	Maximum Demand		47,000	51,300	55,900	61,000	67,800	73,900	80,600	87,900	95,800	104,400	113,900	124,200
	Transmission Line		0	2,500	2,500	12,000	17,200	21,500	26,900	32,800	0	0	3,400	13,700
	Julumito		-	-	-	-	-	-	-	-	39,700	47,500	53,000	53,000
	Sub-total		0	2,500	2,500	12,000	17,200	21,500	26,900	32,800	39,700	47,500	56,400	66,700
	Total		47,000	51,300	55,900	61,000	67,800	73,900	80,600	87,900	95,800	104,400	113,900	124,200

Table 3-12 Balance of Energy Demand in CEDELCA and CEDENAR System

(MWh)

		1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Available Energy	CEDELCA												
	Florida II	113,500	113,500	113,500	113,500	113,500	113,500	113,500	113,500	113,500	113,500	113,500	113,500
	Florida I and Other P.S	42,500	42,500	42,500	42,500	42,500	42,500	42,500	42,500	42,500	42,500	42,500	42,500
	Diesel	0	0	-	-	-	-	-	-	-	-	-	-
	Sub-total	156,000	156,000	156,000	156,000	156,000	156,000	156,000	156,000	156,000	156,000	156,000	156,000
	CEDENAR												
	Rio Mayo	102,000	102,000	102,000	102,000	102,000	102,000	102,000	102,000	102,000	102,000	102,000	102,000
	Rio Bobo and Other P.S	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000
	Pasto	0	0	-	-	-	-	-	-	-	-	-	-
	Sub-total	166,000	166,000	166,000	166,000	166,000	166,000	166,000	166,000	166,000	166,000	166,000	166,000
	Total	322,000	322,000	322,000	322,000	322,000	322,000	322,000	322,000	322,000	322,000	322,000	322,000
Generated Energy	CEDELCA												
	Florida II	63,600	65,000	73,800	84,800	91,800	101,400	108,100	113,500	113,500	113,500	113,500	113,500
	Florida I and Other P.S	42,500	42,500	42,500	42,500	42,500	42,500	42,500	42,500	42,500	42,500	42,500	42,500
	Sub-total	106,100	107,500	116,300	127,300	134,300	145,900	150,600	156,000	156,000	156,000	156,000	156,000
	CEDENAR												
	Rio Mayo	60,600	66,300	73,400	77,300	77,500	78,200	80,000	83,200	88,200	91,200	99,500	102,000
	Rio Bobo and Other P.S	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000
	Sub-total	124,600	130,300	137,400	141,300	141,500	142,200	144,000	147,200	152,200	155,200	163,500	166,000
	Total	230,700	237,800	253,700	268,600	275,000	286,100	294,600	303,200	308,200	311,200	319,500	322,000
	Annual Energy Demand	230,700	253,400	279,200	307,200	334,800	364,900	397,300	433,700	472,900	515,600	562,100	612,700
	Deficiency	0	15,600	25,500	38,600	59,000	78,800	102,000	130,500	164,700	204,400	242,600	290,700
	Transmission Line	0	15,600	25,500	38,600	59,000	78,800	102,000	130,500	0	0	0	5,300
	Julumito	-	-	-	-	-	-	-	-	164,700	204,400	242,600	285,400

Fig. 3-8 Balance of kW-Demand in CEDELCA and CEDENAR System

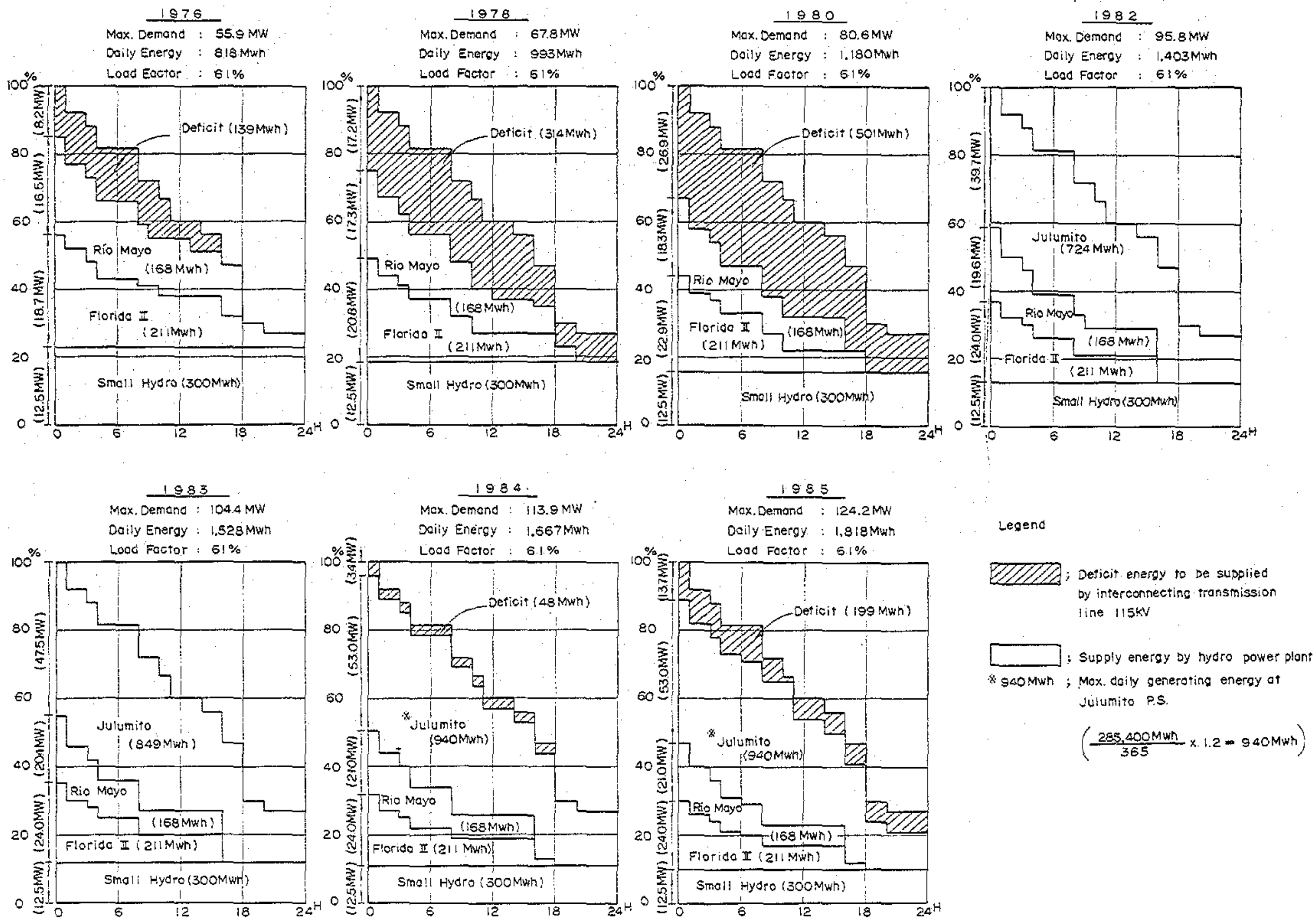


Fig. 3-9 Peak Demand and Supply Capability

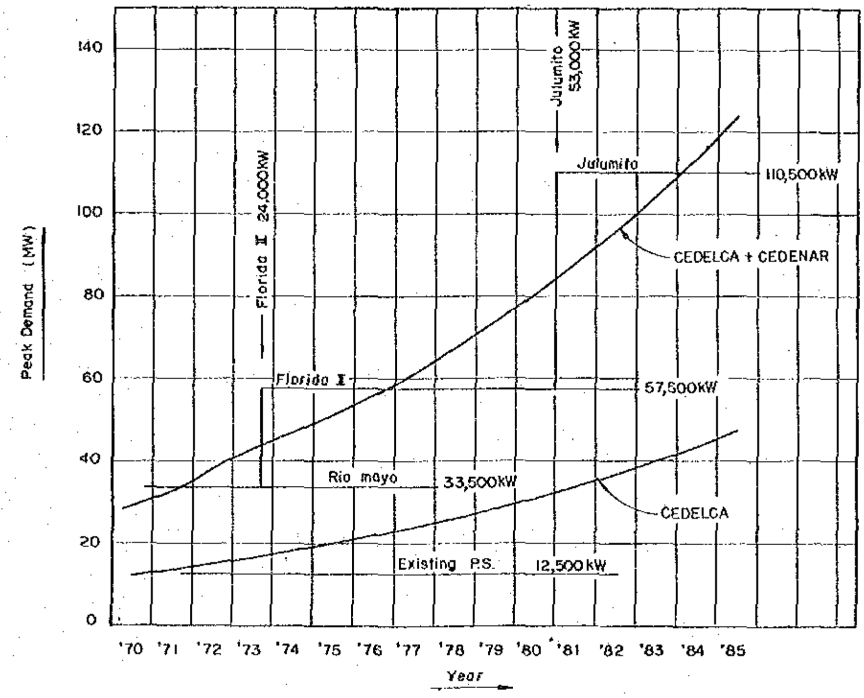
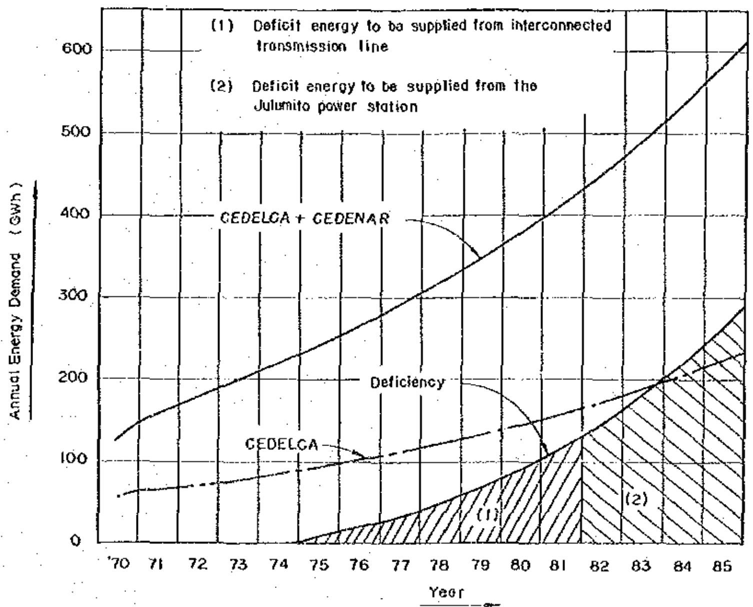


Fig. 3-10 Annual Energy Demand



3.5 Timing of Development

As discussed in the paragraph on kW balance, the CEDELCA + CEDENAR System will be confronted with shortages in kW and kWh from 1975 and a new power source will become necessary. Julumito Power Station should be constructed for start of operation in 1975 primarily, to fill this shortage, but the CEDELCA + CEDENAR System is to be tied to the Central System from September 1972 by an interconnecting transmission line being built by ICEL. Therefore, the timing of Commission of Julumito Power Station must be determined based on a comparison study with the case of purchase of power through this transmission line.

Here, as a measure for determination of the time of commencement of Julumito Power Station, an analysis is made applying the comparison of kWh cost.

The conditions for the study are the following:

(1) The unit price of power purchased from the Central System is taken to be 18.5 cvs/kWh at the outlet of the CVC Pancé Substation.

(2) The rate of kWh loss of the interconnecting transmission line from Pancé Substation to Popayan Substation is taken to be 3%.

(3) The rate of annual cost for the transmission line is to be taken at 12.27% of the construction cost (assuming interest rate per annum 9.15%, serviceable life 50 years, operation and maintenance 2.5%, and administrative expense 0.5%).

(4) The rate of annual cost for Julumito Power Station is to be taken at 10.59% (assuming average interest rate per annum of 7.25% for foreign currency, and 12.0% for local currency, serviceable life of 50 years, operation and maintenance 0.7%, and administrative expense 0.3%).

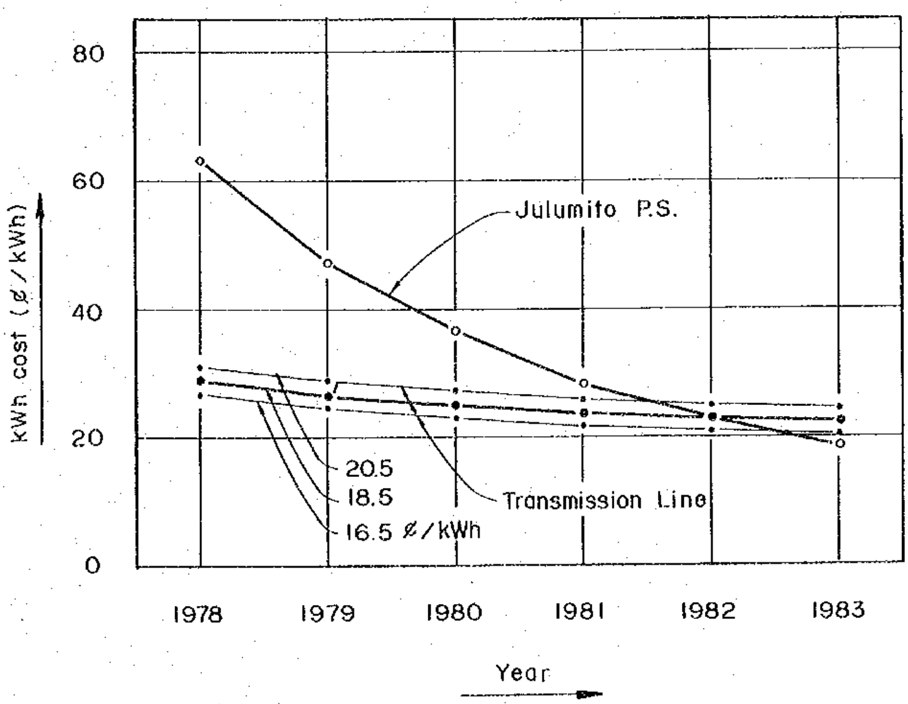
The cost per kWh of supply of the deficient energy through the interconnecting transmission line from 1975 calculated according to the above conditions and the cost per kWh in the case of power supplied from Julumito Power Station are as given in Table 3-13, and when graphically illustrated, as Fig. 3-11.

As is clear from the table and figure, from 1975 until 1981, purchasing power through the interconnecting transmission line is lower in unit price per kWh than generating power at Julumito Power Station. Therefore, it will suffice for the supply of power from Julumito Power

Table 3-13 kWh Cost Comparison

Year	Deficit Energy (MWh)	Supply from Transmission Line CVS/kWh (A)	Supply from Julumito Power Station CVS/kWh (B)	B/A
1975	15,600	52.9	238.0	4.50
1976	25,500	39.7	146.0	3.68
1977	38,600	32.7	96.6	2.95
1978	59,000	28.0	63.2	2.26
1969	78,800	25.9	47.3	1.83
1980	102,000	24.3	36.6	1.50
1981	130,500	23.1	28.6	1.24
1982	164,700	22.3	22.6	1.01
1983	204,400	21.7	18.3	0.84

Fig. 3-11 kWh Cost Comparison

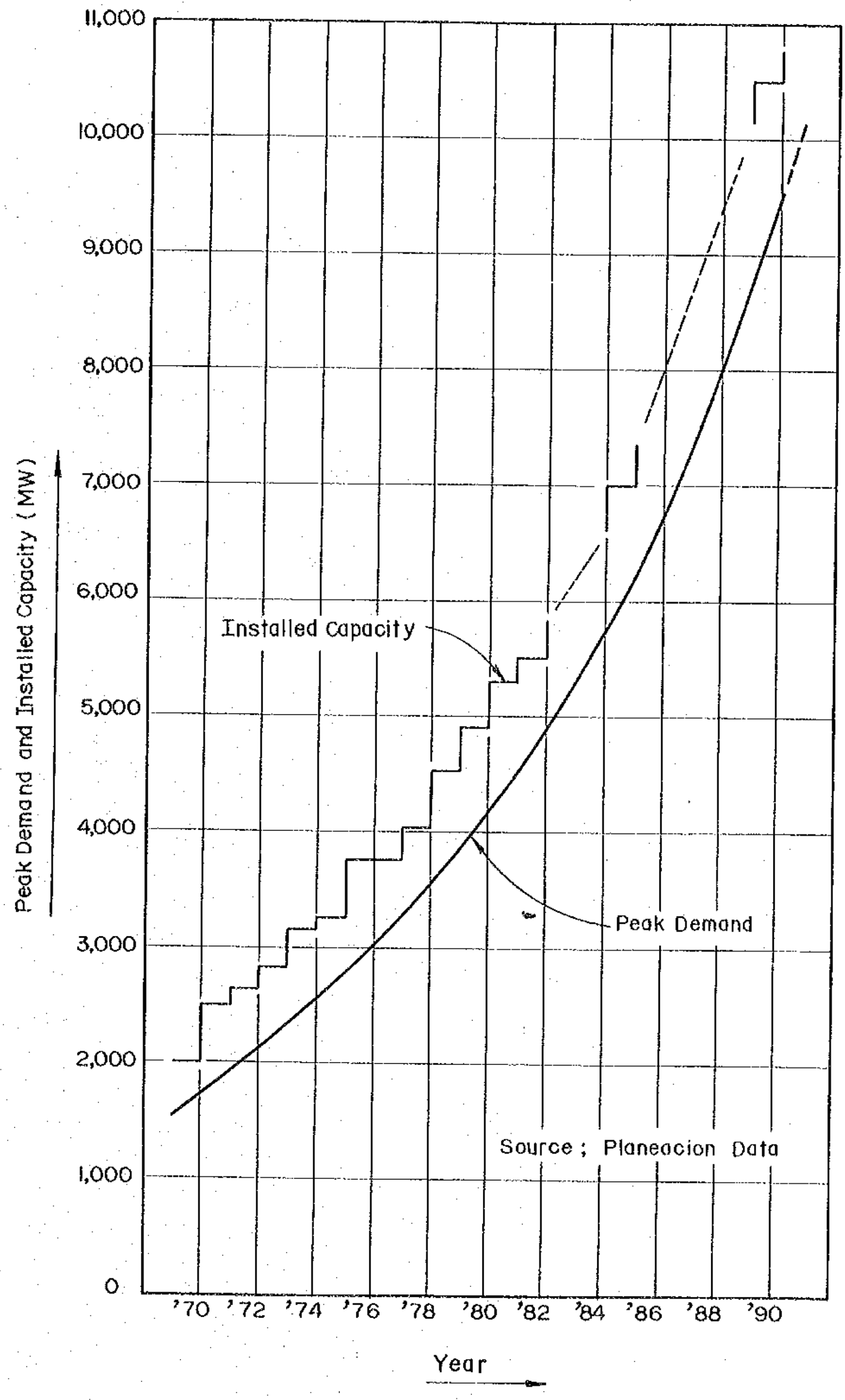


Station to be from 1982 so that start of operation of the power station is to be from the end of 1981.

Further, in the case of purchase of electric power from the Central System from 1975 to 1981, it was necessary to conduct a study on whether or not there would be a surplus in the supply capacity on the side of the Central System, and upon making the study based on data of ICEL and PLANEACTION, it was found that there was ample reserve supply capability in the Central System as shown in Fig. 3-12 and Table 3-9 and that it would be possible for power to be supplied to the CEDELCA + CEDENAR System.

As a reference, the cases of unit prices of 16.5 centavos and 20.5 centavos in purchase from the Central System given in Fig. 3-11 are the results of calculation based on the same conditions as for the case of 18.5 centavos.

Fig. 3-12 Peak Demand and Installed Capacity in Colombia



CENTRALES ELECTRICAS DEL CAUCA S. A. «CEDELCA»

No. 193

Popayán, 25 de febrero de 1.972

Doctor
TOKIE KAWASHIMA
JEFE DE LA MISION DEL
GOBIERNO JAPONES
Ciudad.

Adjunto me permito remitirle un Memorando con algunos comentarios que considero importantes en relación con el estudio de factibilidad del Proyecto Julumito.

Atentamente,

J. AURELIO IRAGORRI HORMAZA

Anexo: 1

c.c. Ingeniero Gonzalo Paz
Ingeniero Juan Caicedo
Ingeniero Elberto Mejía

CENTRALES ELECTRICAS DEL CAUCA S. A. «CEDELCA»

MEMORANDO

No.

ESTUDIO DE FACTIBILIDAD DEL PROYECTO JULUMITO Febrero de 1.972

El presente memorando tiene el propósito de fijar la posición de Centrales Eléctricas del Cauca S.A. -CEDELCA-, con respecto al enfoque que debe darse al estudio de factibilidad técnico-economica del Proyecto de Julumito.

El documento ha sido preparado con destino a la Misión del Gobierno Japonés que adelanta dicho estudio, con el fin de aclarar algunos aspectos de importancia que inciden sobre la orientación general del mismo.

SISTEMA CEDELCA-CEDENAR

El sistema de CEDELCA contará con una capacidad instalada de 33.6 MW, después de la entrada en operación de la Hidroeléctrica Florida II. El sistema CEDENAR tiene una capacidad instalada de 32.9 MW, y no hay en el momento proyecto de incrementar esta capacidad instalada. Para el suministro de las dos áreas se contará además con las líneas de interconexión Popayán-Cali a 115 KV, que deberá entrar en operación en el curso del año 1972 y permitirá transferir hasta 40 MW aproximadamente desde el Sistema Central.

SISTEMA CENTRAL

El llamado "Sistema Central" está compuesto por los sistemas de Empresa de Energía Eléctrica de Bogotá, Empresas Públicas de Medellín, C.V.C. y Central Hidroeléctrica de Caldas, interconectados a través de una red de 220 KV con centro en Manizales. Esta red está en operación y fué construida por la Sociedad "Interconexión Eléctrica S.A.", de la cual son accionistas los sistemas nombrados.

Los socios accionistas de Interconexión Eléctrica S.A. -ISA-, entre los cuales está la C.V.C., han delegado en esa Sociedad la función de planear y construir todas las adiciones de capacidad generadora que sean requeridas por el Sistema Central agregadamente, a partir de la Central de CHIVOR que debe entrar en operación en los años 1975-1976. En opinión de CEDELCA, este esquema institucional del Sistema Central, impone excluir a la C.V.C. como uno de los posibles sistemas beneficiados por la Central de Julumito, para efectos de estudiar la justificación económica de dicha Central.

SUMINISTRO DE ENERGIA AL SISTEMA CEDELCA-CEDENAR

De acuerdo con los estimativos de crecimiento de la demanda en estas dos áreas, la capacidad instalada en ellas (incluyendo Florida II) debe coparse alrededor de los años 1975-1976, a partir de los cuales sería necesario comprar cantidades de energía cada vez mayores del sistema central a través de la C.V.C. De acuerdo con el crecimiento de la demanda esperado, la línea de interconexión a 115 KV con C.V.C. sería insuficiente a partir de 1978-1979. En ese tiempo es necesario que entre en servicio un nuevo proyecto de generación, o una línea de interconexión de mayor capacidad (probablemente a 220 KV).

JUSTIFICACION DEL PROYECTO DE JULUMITO

La justificación económica del Proyecto de Julumito, como fuente de generación para el sistema integrado CEDELCA-CEDENAR debe estudiarse planteando las siguientes alternativas de suministro de energía al área, que deben cubrir un período que se extiende por lo menos hasta 1985:

Primera Alternativa: Construcción de Julumito durante los años 1974, 1975 y 1976. Compras de energía del Sistema Central a partir de 1979-1980 (aproximadamente). Ampliación de la interconexión con la C.V.C. alrededor de 1984.

Segunda Alternativa: Compras de energía del Sistema Central hasta 1978-1979. Construcción de Julumito durante los años 1977-1978-1979. Ampliación de la interconexión con C.V.C. alrededor de 1984.

Tercera Alternativa: Compras de energía del Sistema Central durante todo el período. Ampliación de la Interconexión con C.V.C. alrededor de los años 1978-1979.

Para las tres alternativas, el "cash flow" está constituido no solamente por los desembolsos para inversión en la Central de Julumito y/o la ampliación de la Interconexión con la C.V.C., sino también por los desembolsos para compras de energía.

CONSIDERACIONES ADICIONALES

Al definir las tres alternativas de suministro debe tenerse en cuenta que éstas sean equivalentes no solamente desde el punto de vista de suministro de energía al sistema CEDELCA-CEDENAR durante el período considerado, sino también desde el punto de vista de la capacidad que queda a disposición del sistema integrado al final de dicho período (Así, la ampliación de la interconexión con la C.V.C. que se contempla en la tercera alternativa debe ser mayor que la considerada en las otras alternativas).

Dado que las demandas del sistema CEDELCA-CEDENAR son pequeñas en comparación con la demanda agregada del Sistema Central, puede considerarse que siempre habrá energía disponible en este sistema para entregar al sistema CEDELCA-CEDENAR. Sinembargo consideramos pertinente incluir en la comparación de alternativas alguna referencia a la seguridad del suministro en las diferentes alternativas.