

REPORT ON BASIC STUDIES ON HYDRO-ELECTRIC POWER DEVELOPMENT IN THE REPUBLIC OF LIBERIA

THE REPUBLIC OF LIBERIA

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IN THE REPUBLIC OF LIBERIA

NOVEMBER 1975

JAPAN INTERNATIONAL COOPERATION AGENCY

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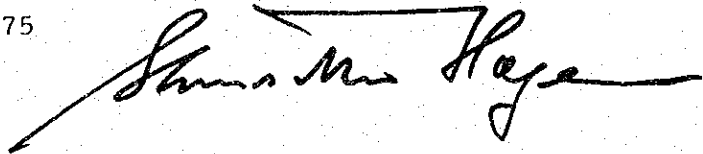
JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

The Government of Japan, at the request of the Government of the Republic of Liberia, decided to undertake a basic study of the possibility of hydroelectric power development in the Republic of Liberia, and entrusted its implementation to the Japan International Cooperation Agency. The Agency organized a survey team consisting of seven experts, headed by Mr. Nobuaki HARADA, Deputy Director of Planning and Design Office, of Electric Power Development Co., Ltd. and dispatched the team to Liberia for a period of 21 days from March 5 to March 25, 1975. The survey team conducted the aerial inspection over the five main rivers, the Mano, the Lofa, the St. Paul, the St. John and the Cestos, based on the data provided by the Government of Liberia. Data were also collected by the team concerning the economic situation in Liberia. We wish that this report will contribute to the promotion of the hydroelectric power development and the economic development in Liberia, and we also hope that this report will promote the friendship between the two countries.

In conclusion, I would like to express our hearty gratitude to the survey team members for their effort to accomplish their task and to those governmental officials of Liberia for their valuable cooperation afforded to our survey team.

November, 1975



Shinsaku HOGEN

President

Japan International Cooperation Agency

国際協力事業団	
受入 月日 '84. 4. 20	517
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LETTER OF TRANSMITTAL

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency

Dear Sir:

Submitted herewith is a report on "Basic Studies on Hydro-Electric Power Development in the Republic of Liberia".

In compliance with a request from the Government of the Republic of Liberia, the Japan International Cooperation Agency (JICA) dispatched a survey team composed of seven specialists in various fields from the Japan International Cooperation Agency, the Ministry of International Trade and Industry, the Electric Power Development Co., Ltd. and Nippon Koei Co., Ltd. to Liberia for a period of 21 days from March 5, 1975 for field investigations.

With the cooperation of the government agencies concerned of the Republic of Liberia, the Survey Team conducted surveys of the economic and electric power situations in the country and was able to collect information and findings such as topographical and hydrological data necessary for their study. Based on such information and data, ten potential sites for hydro power development were selected on drawings. Then, aerial inspections were made on those sites.

Prior to their departure from Monrovia, the Survey Team explained to leading officials of the Liberian Government the tentative results of the field studies conducted so far during their stay in the country.

After the return of the Survey Team to Japan, the Electric Power Development Co., Ltd. continued further studies on hydro-electric power development in Liberia based upon the "Note on Basic Studies on Hydro-Electric Power Development in the Republic of Liberia" and by reference to the data and findings made available to the Survey Team while they were in Monrovia.

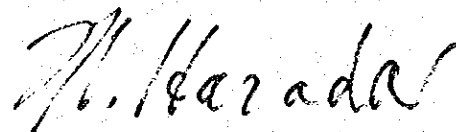
During the course of these studies in Tokyo, the economic situation of the Republic of Liberia was analysed, as were hydrological data, power demand forecast was made, various development alternatives were studied and economic evaluation was also made on these alternatives.

Thus, the report in draft form was forwarded to the Government of the Republic of Liberia in September 1975 through diplomatic channels. I visited Monrovia for a period of seven days from September 27, 1975 in order to explain to key personnel of the Liberian authorities concerned and to exchange frank views with them on the draft report. After my return to Tokyo, the final report has been prepared according to the results of the discussions made in the Republic of Liberia.

As stated in this final Report, it is believed essential that the Government of the Republic of Liberia undertake a feasibility study on the Mano River Development Project or St. John River Development Project as soon as practicable in accordance with the recommendations incorporated in this Report.

In closing, we would like to take this opportunity of extending our heartfelt gratitude to responsible officials of the Foreign Ministry, Ministry of Planning and Economic Affairs, Ministry of Lands and Mines and Public Utilities Authority of the Republic of Liberia as well as the staff of the Embassy of Japan in Liberia for their kind and valuable cooperation in the performance of this study.

Respectfully yours,

A handwritten signature in dark ink, appearing to read 'N. Harada', with a stylized flourish at the end.

Nobuaki Harada, Leader
Japanese Survey Team
for Basic Studies on Hydro-Electric
Power Development in the
Republic of Liberia

November 1975



Scenery of Monrovia Viewed from Ducor Inter-Continental Hotel



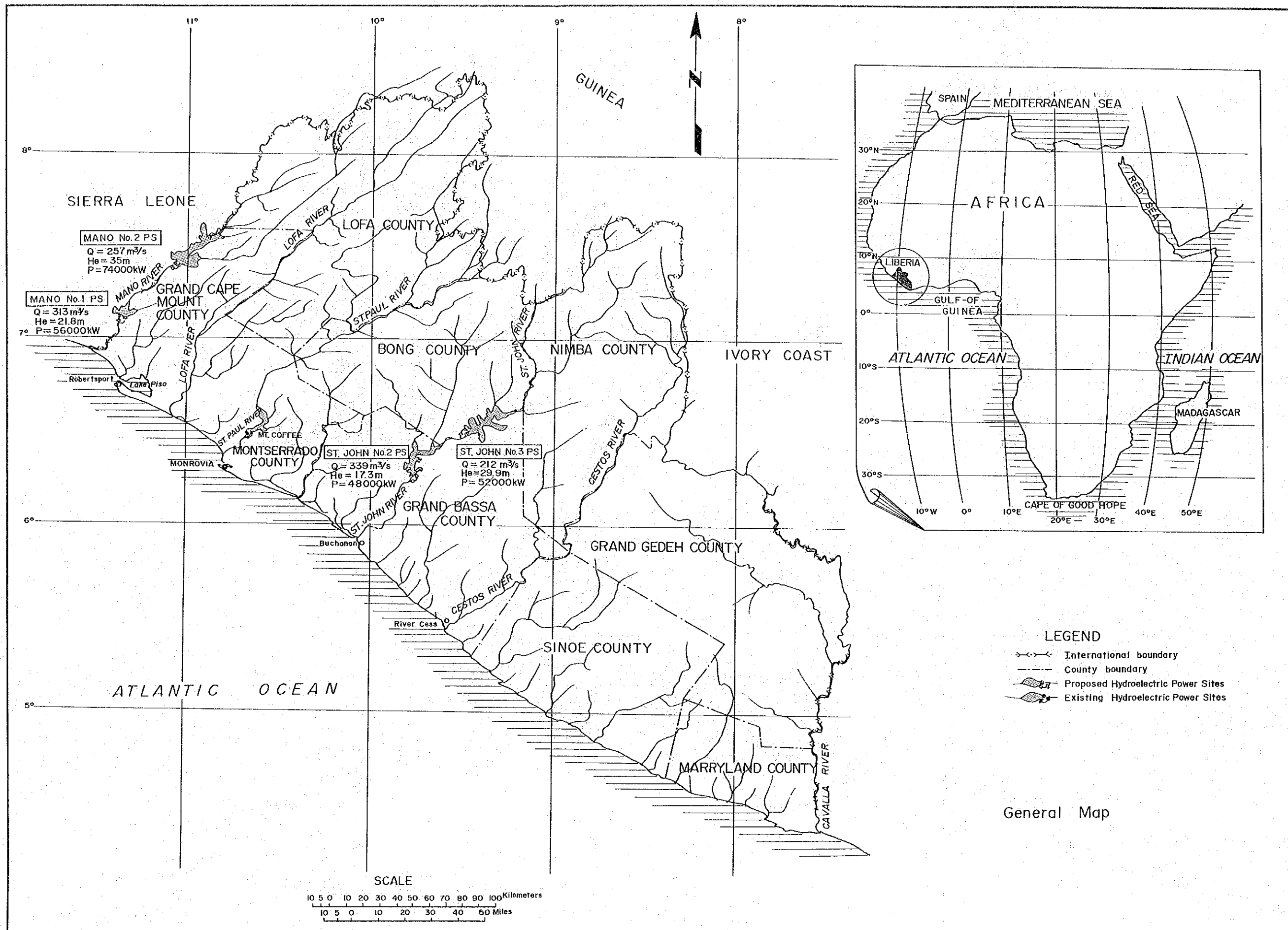
Scenery Observed in the Down-Stream
of the Mano River



Scenery of the St. John River



Distant View of Mt. Coffee Hydro-Electric
Power Station



General Map

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CHAPTER I

INTRODUCTION

1-1 Background of Study

In November 1974 when JICA's project finding team headed by Mr. Genichi Fukuhara, ex-Director of Technical Cooperation Division, Ministry of International Trade and Industry visited the Republic of Liberia, Mr. D. Franklin Neal, Minister of Planning and Economic Affairs alluded to the fact that since the oil crisis of 1973, Liberia which is not an oil-producing country, has been faced with a serious situation in operation of her diesel power stations. On that occasion, a verbal request was made by him in connection with Japanese technical cooperation in the performance of studies on the potentials of hydro-electric power development including the development of the Mano River in the country.

In January 1975, formal application for the performance by a Japanese survey team of the said study was submitted by the Government of the Republic of Liberia to our Government. In compliance with this request, JICA organized a "Survey Team for Basic Studies on Hydro-Electric Power Development in the Republic of Liberia" comprising Nobuaki Harada and six others, which carried out field studies for a period of approximately three weeks from March 5th in the Republic of Liberia. The Survey Team has prepared this Report based on various data made available to the Team in the country and according to the results of field investigations conducted during their stay in the Republic of Liberia.

1-2 Objectives of Study

The objectives of the study in this Report are to undertake a basic study of the possibility of hydroelectric power development in the Republic of Liberia. The major items relevant to the study are as listed hereunder.

- (1) Survey of the general economic conditions in the Republic of Liberia.
- (2) Survey of the present situation of electric power and load forecast.
- (3) Topographic and hydrologic surveys of major rivers and streams.
- (4) Selection of probable hydro power project sites on major rivers and streams.

1-3 Team Composition

The composition of the Survey Team was as follows:

Leader	Nobuaki Harada	Planning & Design Office, Hydro-Electric Engineering Department, Electric Power Development Co., Ltd.
Member	Yuichi Ogawa	Design Department, Overseas Operations Bureau, Nippon Koei Co., Ltd.
Member	Shogoro Nagao	Foreign Activities Department, Electric Power Development Co., Ltd.
Member	Tetsuya Fukuda	Foreign Activities Department, Electric Power Development Co., Ltd.
Member	Takashi Yoshida	Planning & Design Office, Hydro-Electric Engineering Department, Electric Power Development Co., Ltd.
Member	Shinkichi Fujiwara	Hydro-Electric Power Division, Public Utilities Department, Agency of Natural Resources and Energy, Ministry of International Trade and Industry
Member	Toshio Hida	Natural Resources Division, Mining and Industrial Survey Department, Japan International Cooperation Agency

1-4 Field Investigations

The period during which field investigations were made by the Survey Team was from March 5 to March 25, 1975 inclusive of the period of their travelling. During this period, the Survey Team held discussions with those concerned at the Japanese Embassy in Liberia, the Ministry of Planning and Economic Affairs, the Ministry of Lands and Mines, and the Public Utilities Authority, obtained information on the economy, electric power situation, topography and hydrology, and other information as well as maps and carried out aerial inspections based on the above. An outline of the results of the above was submitted to the Government of the Republic of Liberia as the "Note on Basic Study on Hydro-Electric Power Development in the Republic of Liberia".

Details of the survey are as indicated in the schedule below.

Survey Schedule

Date	Day	Remarks
3.5	Wed	Lv. Tokyo, Ar. London (BA 991)
3.6	Thu	Lv. London, Ar. Monrovia (London - Amsterdam KL 124, Amsterdam - Monrovia KL 585)
3.7	Fri	Courtesy Call at Japanese Embassy in Liberia. Visits to Ministry of Planning and Economic Affairs, Ministry of Lands and Mines, Public Utilities Authority for discussions and data collection.
3.8	Sat	Data assessment and analysis
3.9	Sun	- do -
3.10	Mon	Conference at Public Utilities Authority (All the team members)
3.11	Tue	Conference at Public Utilities Authority (Harada, Nagao, Yoshida and Hida). Hydrologic data collection at Hydro Service Section, Ministry of Lands and Mines (Ogawa and Fujiwara). Data collection at Ministry of Planning and Economic Affairs, University of Liberia, Bank of Liberia (Fukuda).
3.12	Wed	Data analysis at Public Utilities Authority (All the team members)
3.13	Thu	Aerial inspection of Mano, Lofa, St. Paul Rivers (Harada, Ogawa, Nagao and Yoshida). Visit to LAMCO Joint Venture Operation Co. for data collection (Fukuda). Data collection at Hydro Service Section, Ministry of Lands and Mines (Fujiwara). Visit to Japanese Embassy for liaison (Hida).

Date	Day	Remarks
3.14	Fri	<p>(Morning)</p> <p>Discussions of investigation results at Public Utilities Authority (Harada, Ogawa, Nagao, Fukuda, Yoshida and Fujiwara).</p> <p>Visit to Japanese Embassy for liaison (Hida).</p> <p>Visit to Ministry of Planning and Economic Affairs for data collection and discussion (Fukuda).</p> <p>(Afternoon)</p> <p>Visits to Bushrod Power Station and Mount Coffee Power Station (Harada, Ogawa, Nagao, Fukuda, Yoshida and Fujiwara).</p> <p>Visit to Japanese Embassy (Hida).</p>
3.15	Sat	Data analysis (All the team members).
3.16	Sun	- do - (All the team members).
3.17	Mon	<p>Visit to LAMCO Pellet Plant at Buchanan (Nagao and Fukuda).</p> <p>Data assortment (Harada, Ogawa, Yoshida, Fujiwara and Hida).</p>
3.18	Tue	Aerial inspection of St. John, Cestos Rivers (Harada, Yoshida and Fujiwara).
3.19	Wed	<p>Discussions with Japanese Embassy (Harada and Fukuda).</p> <p>Surveys of Guinea border area, extreme upstream area of St. Paul River (Ogawa, Nagao, Yoshida, Fujiwara and Hida).</p>
3.20	Thu	<p>(Japanese side)</p> <p>Nakamura, Councillor of Japanese Embassy and all the team members, explanations of progress and tentative results of field studies</p>

Date	Day	Remarks
		(Liberian side) Representatives of Ministry of Planning and Economic Affairs and Public Utilities Authority.
3.21	Fri	(Morning) Visit to Japanese Embassy. Report to Japanese Ambassador to Liberia results of briefing session on survey outline held on March 20 (All the team members) (Afternoon) Courtesy call on Deputy Minister, Ministry of Planning and Economic Affairs (All the team members).
3.22	Sat	Preparations for departure.
3.23	Sun	Lv. Monrovia, Ar. Amsterdam (KL 586).
3.24	Mon	Lv. Amsterdam (JAL 404)
3.25	Tue	Ar. Tokyo

CHAPTER II

CONCLUSIONS AND RECOMMENDATIONS

2-1 Conclusions

2-1-1 Electric Power Demand

(1) The electric power demand of entire Liberia except for the demand from concessions, in effect, the demand to be met by the Public Utilities Authority (PUA) is forecast to grow at an annual rate of 7%. The great part (approximately 95%) of this electric power demand is in the service area of the Monrovia Power System centered around Monrovia which is interconnected by 69 kV transmission lines, and the peak demand which was approximately 60 MW as of 1974 will be approximately 85 MW five years later in 1979 and approximately 118 MW ten years later in 1984.

(2) The installed generating capacity owned by PUA in the Monrovia Power System as of 1974 was approximately 150 MW, but since the dependable power of Mount Coffee Hydroelectric Power Station drops markedly during the dry season, the dependable power of the power system is recorded at approximately 100 MW. Therefore, since there will be a shortage in supply capability in 1981, it will be necessary for new power sources to be developed to fill up this shortage.

Fortunately, there are many rivers with large discharges in Liberia, and in order to effectively utilize this valuable national resource, it is desirable and will be possible to construct hydroelectric power stations.

(3) Meanwhile, the method of supplying electric power to meet the power demand of the Wologisi Mine (peak demand: 175 MW) scheduled to start production in 1981 has not yet become definite. However, it is conceivable for at least the demand at the port site to reach at least approximately 90 MW which will be composed of the load of a pellet plant. This load is expected to be interconnected with the Monrovia Power System.

It is therefore possible for the hydroelectric power stations to be developed in the Monrovia Power System of PUA to supply both the PUA demand and the demand at the port site for the Wologisi Mining Project.

2-1-2. Hydroelectric Development Program

- (1) Of ten hydroelectric sites selected by the Survey Team, those which will have benefit-cost ratios of 1 or more when developed independently are the Mano River No. 2 and St. John River No. 3 and No. 2 sites. The damsites of these locations will allow construction of dams which would be relatively high for Liberia, while in addition, reservoir capacities can be made large, and the annual inflows will be relatively high.
- (2) The optimum scales for the Mano River No. 2 site and the St. John River No. 3 site are 74MW and 52MW, respectively.
- (3) In case of development of the No. 1 site on the Mano River utilizing the water regulated by the reservoir of the No. 2 site, the economics of the No. 1 site will be improved and its installed capacity will be 56MW, so that combined with the No. 2 site, it will be possible to develop a total capacity of 130MW.
- (4) On the St. John River, in case of development of the No. 2 site utilizing the water regulated by the reservoir of the No. 3 site, the economics of the No. 2 site will be improved and its development scale will become 48MW, so that combined with the No. 3 site, it will be possible to develop a total capacity of 100MW.
- (5) Hydroelectric development of the Mano River would be most advantageous from an economic stand-point, but since this river is an international river running along the border with Sierra Leone,

there will be a necessity for international arrangements to be made with Sierra Leone.

On the other hand, hydroelectric development on the St. John River will be slightly inferior to that on the Mano River in the economic aspect, but if the exploitation of the latter should be greatly delayed for the reason given above, the St. John would be the objective of development.

2-2 Recommendations

(1) As a result of the field investigations made by the Survey Team, sites which are economically and technically promising were discovered on the Mano and St. John Rivers. However, these investigations were conducted based on topographical maps on a scale of 1: 50,000 and relevant basic data as well as the results of the aerial inspections so as to examine possibilities of future hydro-electric power development.

(2) Consequently, in order to expedite hydro-electric power development in the future, it will be essential that a feasibility study be performed on Mano River Development or St. John Development including a further study on the Monrovia Power System along with its relations with the Wologisi Mining Project, and preliminary designs and estimates of construction costs of dams and power plants based on detailed topographical surveys.

(3) For the performance of the feasibility study, it will be essential that aerial photogrammetric maps on a scale of 1: 10,000 with a contour line interval of 5 meters be prepared as soon as possible on the proposed project areas including the reservoir areas on the Mano River or the St. John River.

CHAPTER III

SOCIO-ECONOMIC BACKGROUND

The development of electric power which lays the foundation of the national economy requires huge social overhead capital. Consequently, the development plan should be formulated upon full understanding of the present state of that country's society and economy and the natural conditions which govern the economy as well as on an accurate outlook of the future growth of the society and economy.

3-1 General Conditions

(1) Natural Conditions

The physical features of the Republic of Liberia situated from 4°30' to 8°30' north latitude and 7°50' to 11°50' west longitude and having an area of approximately 112,000km² may be divided into four zones consisting of a coastal plain area parallel to the coast-line, a belt of low rolling hills continuing from the coastal plains, followed by a belt of mountain ranges and plateaux which occupy more than half of the inland area, and last the northern highlands (Guinea Highlands), while rivers such as the Mano, Lofa, St. Paul, St. John, Castos and Cavalla run through these zones from north to south to enter the Atlantic Ocean.

The climate is a tropical high rainfall climate divided into a dry season from November to April and a rainy season between May and October. Annual precipitation is recorded to be more than 4,500 mm in the coastal plains and 1,700 to 2,000mm in the inland area. Therefore, in addition to being favored with relatively abundant river discharges, for a country on the West Coast of Africa, there are suitable sites for building relatively high dams and much is expected of future hydroelectric power development.

(2) Resources

Development of energy resources such as petroleum and natural gas or of mineral resources often provides an impetus for take-off of the economy of a developing country. In this respect, the Republic of Liberia does not have fuel energy resources such as petroleum,

natural gas and coal. However, it has one of the largest reserves of iron ore in the world, while forest resources are also abundant. Therefore, the future economic growth of the country may be said to depend on effective development of the natural resources it is favored with and the accompanying promotion of various manufacturing industries, added to which as a precondition, the development of hydroelectric power resources, the only energy resources available.

(3) Economic Structure

The characteristics of the economic structure can be extracted and summarized as follows:

- (a) Dual Structure of Economy Consisting of Subsistence Agriculture Sector and Foreign Enterprises Managing Concessions (Mainly Iron Ore Mines and Rubber Plantations).

Subsistence agriculture was the mainstay of the national economy of the Republic of Liberia for approximately 100 years since its foundation in 1847, but from about the middle of the 1940s, the activities of foreign enterprises (concessionaires) in iron ore and rubber plantations, particularly the former, have become prominent so that together with the indigenous subsistence agriculture a dual structure of the economy has resulted.

- (b) Undeveloped Infrastructure

As is common in developing countries, consolidation of the infrastructure such as highways, railroads, communication facilities, etc., is inadequate.

Since infrastructure sectors are the preconditions for economic distribution and improvement in the living standards of the society, they will be required to be hereafter rapidly built up.

(c) High Degree of Dependence on Foreign Trade and Monoproduct Export

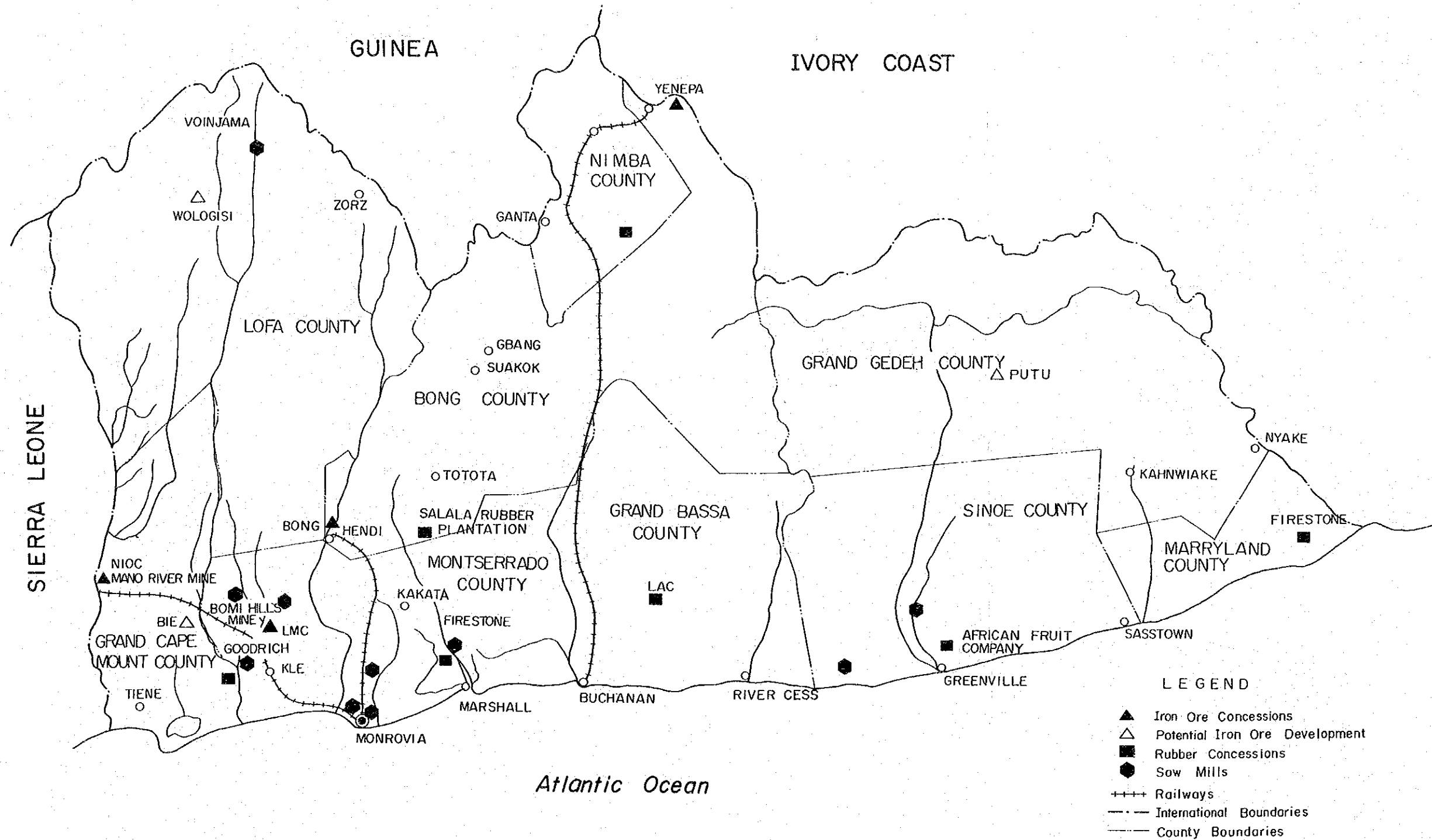
The dependence on foreign trade in the national economy is fairly high with foreign trade comprising 10% of GNP. The main portion of export is iron ore which in 1973 made up more than 70% of total exports (other items: rubber, logs, etc.). Therefore, it may be pointed out that the foreign trade balance is governed by the economic conditions of the industrially developed countries and the demand for iron ore in those countries.

(d) Free Investment Environment

The Liberian Government has held to an "Open Door Policy" towards foreign capital, and is aiming at large infusions of foreign capital by allowing free transfer of capital and profits and guaranteeing non-nationalization of assets of foreign enterprises. Furthermore, with the exception of auxiliary coinage less than one dollar, the U.S. dollar is the currency of the country and there are no statutory restrictions on foreign exchange whatsoever.

The locations of concession enterprises (iron ore development, rubber plantations, others) which have come into the country and are actively operating in view of the above investment environment are as indicated in Fig. 3-1.

Figure.3-1 LOCATION OF CONCESSIONS



3-2 Economic Infrastructure

(1) Roads

The total length of roads in the entire country was approx. 6,700 km as of 1970 of which there were about 470 km of paved roads. The influence of roads on economic development is great, but road construction in Liberia at present is at a low level compared with neighboring countries. Incidentally, the state of road construction per 1,000 people, compared with neighboring countries is as follows:

<u>Country</u>	<u>km/1,000 persons</u>
Ivory Coast	7.1
Senegal	4.1
Ghana	3.9
Guinea	3.3
Sierra Leone	3.3
Liberia	1.9
Nigeria	1.4

(Source: Basic Economic Report - IBRD)

In addition, roads are not only deficient in quantity, but also, even trunk highways are mostly poor roads which have not been built well, and there are many portions which turn to mud in the rainy season and are extremely dusty in the dry season. Improvement and expansion of the road network will hereafter be required.

(2) Railroads

There are three railroad lines as described below and the total length in 1974 was 480km. All of these railroads were built and are owned and operated by the concessionaires, Liberia Mining Co. (LMC), National Iron Ore Co. (NIOC), Bong Mining Co. (BMC) and Liberian-American-Swedish Minerals Co. (LAMCO) for transportation of iron ore from mines to ports and are not for general passenger service.

<u>Sector</u>	<u>User Enterprise</u>
Salala - Monrovia Port	BMC
Fono - Monrovia Port	NIOC-LMC
Saniquellie - Buchanan Port	LAMCO

From 1964 to 1972, rail transportation increased from 12 million tons to 22 million tons. Enlarged rail transportation capacity will be necessary as iron ore production is increased in the future.

(3) Ports

The major seaports are Monrovia, Buchanan, Greenville and Cape Palmas (Harper) and these also are loading ports for foreign trade. The quantity of cargo handled at these ports increased from 16.1 million tons in 1965 to 23 million tons in 1971. It is regarded necessary for new ports to be built as port traffic becomes heavier accompanying future increases in iron ore and lumber exports.

Production of pellets from Wologisi Mine iron ore which has a relation to electric power demand as described later and their shipment are planned to be carried out near Robertsport in the northwestern part of the country.

(4) Airports

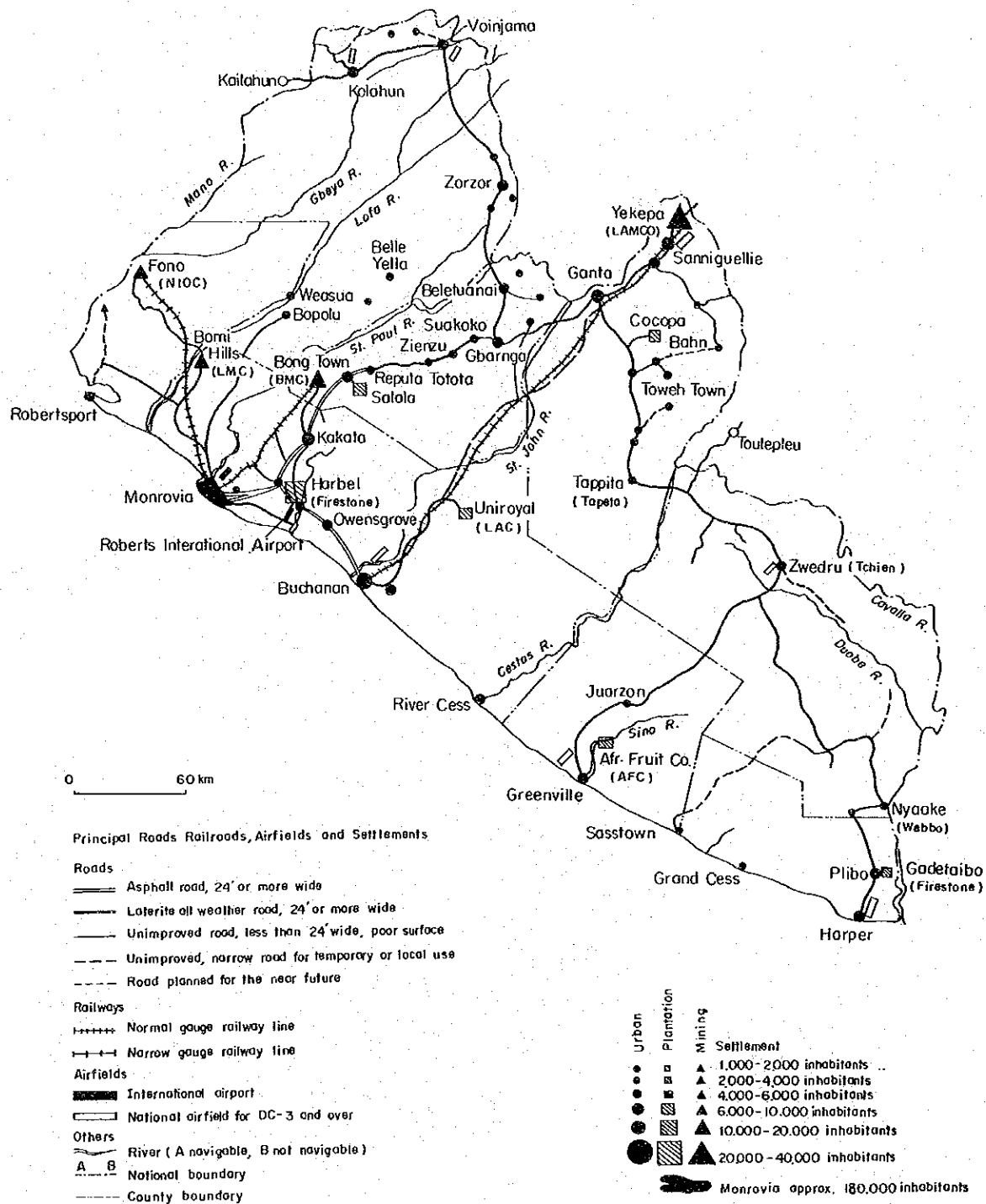
The two major airports are Roberts International Airport and Spriggs Payne Airport presently served by 14 international airlines. Of the two, the former is chiefly used for large jet aircraft, while the latter, besides being used for domestic air traffic, also serves as an international airport for F-28 aircraft flights to and from neighboring countries such as Ghana and Nigeria. In addition to the above, there are also air taxi flights to and from Spriggs Payne Airport.

The government-owned Liberian National Airways operates as an airline of Liberian nationality.

The road network and locations of railroad lines, seaports and airports are illustrated in Fig. 3-2.

Figure. 3-2

Outline of Transportation Facilities in Liberia



(5) Telecommunication Facilities

Basic facilities for a national telecommunication network were completed to an extent in 1965 with investment of 8.5 million dollars, and for construction and consolidation of related facilities, the Government has further formulated a 20-year expansion plan which is presently being carried out. In 1973, a loan from USAID was negotiated for 8 million dollars to expand and update the telecommunication network. The present state of the telecommunication facilities are described below.

(a) For international communications, telex channels connecting with Guinea, Gambia and other neighboring countries, and with New York, and overseas radio telephone channels are successively being expanded.

(b) As a domestic telephone system there is a central telephone exchange in Monrovia with branch exchanges at Sinkor, Buchanan, Harper and elsewhere, and as of 1973, the number of telephone lines was 3,360. Besides cable telephones, negotiations have recently been going on for a microwave expansion project to be implemented with Japanese cooperation. The outline of this project is said to be 44 systems of 6-HGz band wireless apparatus (600 channels), 60 systems of 400-MHz band wireless apparatus (24 channels) and carrier terminal apparatus (276 channels).

(6) Postal Systems

There were only 18 post offices besides a number of postal agents throughout the country in 1973. There are no special domestic mail services such as registered mail and special delivery. Because of this, foreign concessions have special contracts with airports to receive mail from overseas headquarters and others directly from the airports.

3-3 Population and Cities

(1) National Population and Growth Rate

A national census was carried out in 1962 and the total population in that year was recorded as being 1,016,000. After that, sampling surveys have been made by the Ministry of Planning and Economic Affairs according to which it is estimated that the population was 1,592,000 in 1972 and 1,640,000 in 1973. The trend in national population during the recent several years is as indicated below.

Table 3-1 National Population

(Unit: Thousand Persons)

Year	1962	1965	1966	1967	1968	1969
Population	1,016	1,301	1,344	1,388	1,433	1,481

1970	1971	1972	1973
1,523	1,573	1,592	1,640

(Source: United Nations Africa Yearbook)

According to this table, the annual average growth rate during the 5 years from 1967 to 1972 was 2.8%, but in any case, this is only an estimate based on samplings and cannot be considered to be accurate. In this regard, population experts of international institutions have estimated the national population of Liberia to be growing at an annual rate of about 3%.

(2) Urban Population and Growth Rate

In the load forecast which constitutes a basis for formulation of an electric power development plan, the outlook on the population trends in power supply areas comprise an important factor. In the case of the Republic of Liberia, it is thought that there is little likelihood for some time to come for power supply to be made to other than urban areas, and therefore, the state of growth in urban population must be watched.

The major cities are the capital of Monrovia with approximately 11% (180,000) of the national population, followed by Buchanan, Kakata, Bong Town, Gauta, Saniquellie, Greenville and Harper, but those other than Monrovia are small cities with populations of less than 50,000. Besides the above, there are smaller communities scattered along the principal highways. The density of the population in Liberia is presently very low, being only something like approximately 90 per square kilometer in the whole country, including the cities. Large parts of Liberia are completely unpopulated, particularly in Lofa and Grand Gedeh Counties and also in parts of Sinoe. The population is concentrated mainly on a band running from Monrovia to the north end of Nimba County on the Guinea border, with a further concentration of people in the north of Lofa County and in Maryland County. The details of the population density is as given in Fig. 3-3.

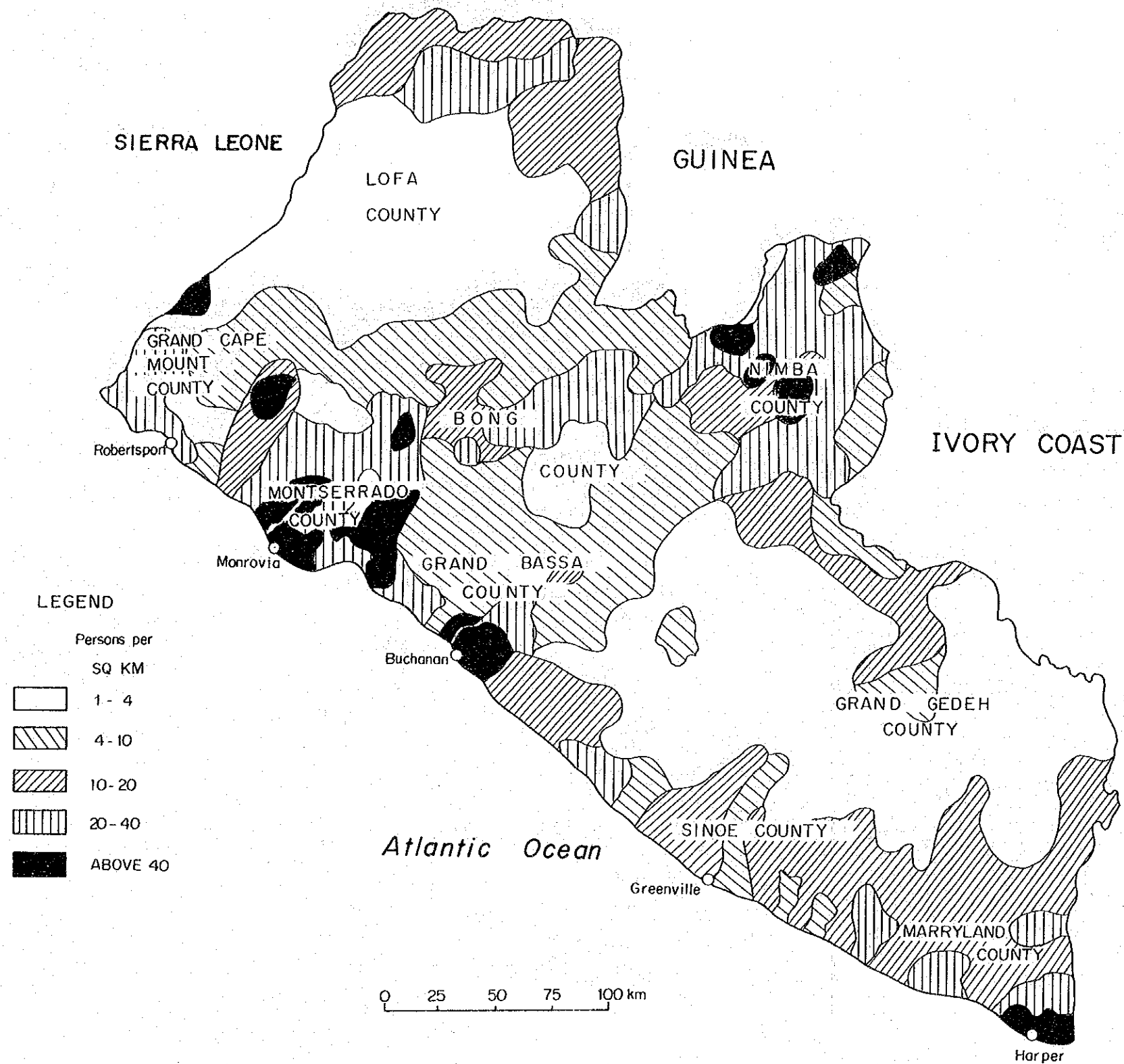
The present distribution of the national population is considered to be 27.6% (approximately 450,000) of the whole in urban areas with the remaining 72.4% in rural areas.

Migration of the rural population to the cities to seek employment as the distributive economy develops is a phenomenon seen in common throughout the world, but data clarifying the trend of increase in the urban population of Liberia were not available. However, judging from actual examples of various developing countries at about the same stages of growth, it is thought safe to estimate that the population growth rate of urban areas of Liberia is approximately double that of the national average, in effect, around 6%.

The distribution of principal cities along trunk highways and other major roads is as indicated in Fig. 3-2.

Figure. 3-3

LIBERIA DENSITY OF POPULATION



3-4 Major Industries

(1) Agriculture

Agriculture may be broadly divided into a subsistence agriculture sector and a cash crop sector for export of rubber, coffee, cocoa and palm kernels.

(a) Production of rice, cassava, sweet potato, vegetables and fruits in subsistence agriculture relies on a primitive "bush rotation" system with 350,000 persons or approximately 22% of the total population engaged in this agriculture. However, because of low productivity, the contribution to GNP by this primitive agriculture is only about 10%.

(b) The most important cash crop is natural rubber cultivated on plantations. The present annual production is more than 80,000 tons, grown on the coastal plains, and all of it is for export. This production quantity is the largest of the African countries (44% of whole). The area of rubber cultivation in 1972 was 118,000 ha of which 48% was managed by Firestone Plantations, African Fruit Co., B.F. Goodrich and other foreign concessionaires, with the remaining 52% being small farms operated by Liberians.

The second cash crop is coffee with annual production of around 4,500 to 5,000 tons. The annual production of cocoa is about 1,800 tons and that of palm kernels approximately 16,600 tons, and although the quantities are small, replanting projects are in progress for both and future production increases are being looked forward to.

(2) Forestry

The contribution of forestry to GNP is about 2.3%. Exports of forestry products amounted to 8.2 million dollars in 1972 comprising 3.3% of total exports. In contrast, it is estimated that exports in 1973 amounted to 15 million dollars for an increase of

approximately double in one year. This is due to the abundant forest resources of the eastern part of the country beginning to be developed accompanying road construction of recent years, and much is expected of increase in exports of forestry products in the future to follow exports of iron ore and rubber. Foreign concessions also make up the major part of the forestry sector and as of the end of 1973 the number of these enterprises was said to be 32.

(3) Mining

The principal mineral resources are iron ore, diamonds and gold, of which iron ore is most important, making up 95% of the total production amount in the mining industry.

Iron ore development in this country was started in earnest in 1946 after World War II and production has increased steadily each year until in 1972 it had reached 22.2 million tons annually and at present the Republic of Liberia is the eighth largest iron ore producer in the world.

The importance of iron ore production in the Liberian economy can be seen from the aspects of the rate of contribution to GNP, the amount exported and public revenues. In effect, the contribution to GNP in 1972 of the iron ore production sector was approximately 30% while the export amount was 182 million dollars comprising two thirds of total exports for the year. Furthermore, the iron ore royalties in the recent several years have been 15 million dollars annually, or approximately 20% of total public revenues.

With regard to the aspect of employment, the number of employees in the iron ore production sector was approximately 11,000 according to statistics of 1971 which made up roughly 10% of the total employment of approximately 110,000 in that year.

The iron ore development enterprises presently in operation are the four concessions of LAMCO, BMC, NIOC and LMC and the ratios of production of the firms are 48% for LAMCO, 24% for BMC, 16% for NIOC and 12% for LMC. The production situations of the various companies are described below.

(a) LAMCO (Liberian-American-Swedish Minerals Co.)

The capital structure is 50% ownership by the Liberian Government with the remaining 50% under American and Swedish ownership. Production was begun in 1961. The mine area is in the Nimba Mountain Range 450 km northeast of Monrovia and high-grade iron ore of concentration of 65% is being mined. The production in 1968 to 1972 was 11 million tons annually, but it is considered there would have been an increase to 12 million tons in 1974. The iron ore extracted at Nimba Mine is transported by private railroad to the port of Buchanan for export, where a part is pelletized (annual production : approximately 2 million tons) before shipping.

(b) BMC (Bong Mining Co.)

The firm is a consortium of West German and Italian capital and production was started in 1965. The mine area is in the vicinity of Bong Town 80 km north of Monrovia and iron ore of concentration of 38.7% is being mined. The production in 1972 was 6.1 million tons annually and in the same year a pellet plant of annual production capacity of 2 million tons was completed and went into operation.

(c) NIOC (National Iron Ore Co.)

The capital structure is 50% ownership by the Liberian Government with the remaining 50% owned by LMC and shareholders in general in the U.S.A. and Liberia. Start of operation was in 1961 with the concession at the Mano Mine along the Mano River. Present production is 3.7 million tons annually.

(d) LMC (Liberian Mining Co.)

LMC is a firm established with American capital in 1946 and its concession is at Bomi Hill 40 km northwest of Monrovia. The iron ore mined is transported to the port of Monrovia by private railroad from where it is shipped, but the ore has now become almost completely depleted and it is said the mine is scheduled to be closed in 1975.

The locations of iron ore mines presently in operation or being planned, and the deposits of other mineral resources are as indicated in Fig. 3-4.

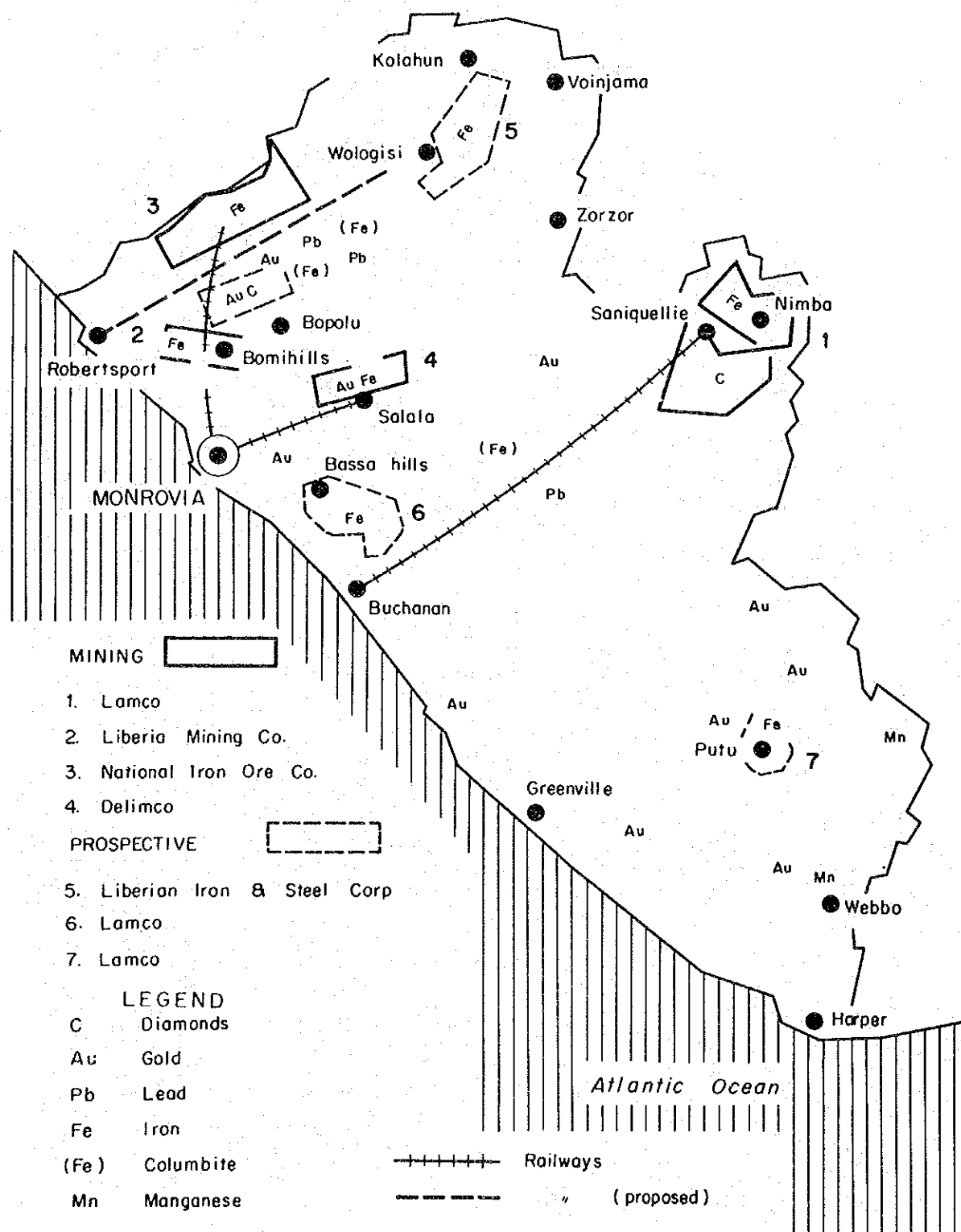
(4) Manufacturing Industries

Industrialization is gradually proceeding through establishment of private industries with introduction of foreign capital in response to the "Open Door Policy" of the Government. The rate of contribution to GNP in 1970 was only about 5% in 1970, but rose in one jump to approximately 14% in 1971.

Factories of comparatively large scale are a petroleum refinery with daily production of 10,000 barrels which started operation at the end of 1968 and a cement clinker grinding mill with an annual production capacity of 125,000 tons. Almost all others are medium-to small-sized plants. For example, the number of employees in manufacturing in 1970 was approximately 6,000 persons of which about 60% were employees of medium-to small-scale factories with not more than 20 employees.

Because of this stage of development, 22% of the entire manufacturing industrial products are made up of consumer products such as beer, soft drinks, furniture and interior decorations, while the remaining 78% are composed of intermediate consumer products such as petroleum products and concrete products. There is hardly any production of durable goods to be of consequence.

Figure. 3-4
LIBERIA: Mineral Resources



3-5 International Balance of Payments

(1) Foreign Trade

The main item of export is iron ore with other goods being rubber, lumber, industrial diamonds, coffee, cocoa and palm kernels. Total exports in 1973 amounted to 324 million dollars of which iron ore accounted for 196.7 million dollars (61%) and rubber for 42 million dollars (13%). From 1965 to 1972, iron ore had comprised 70 to 75% of the whole. During that period the amount of rubber exports initially were 20% of the whole, but this gradually declined and at present is at most 12 to 13%. In contrast, exports of lumber which began around 1968 have gradually risen to reach 3.4% of total exports at present and this is looked forward to as being a promising export item for the future.

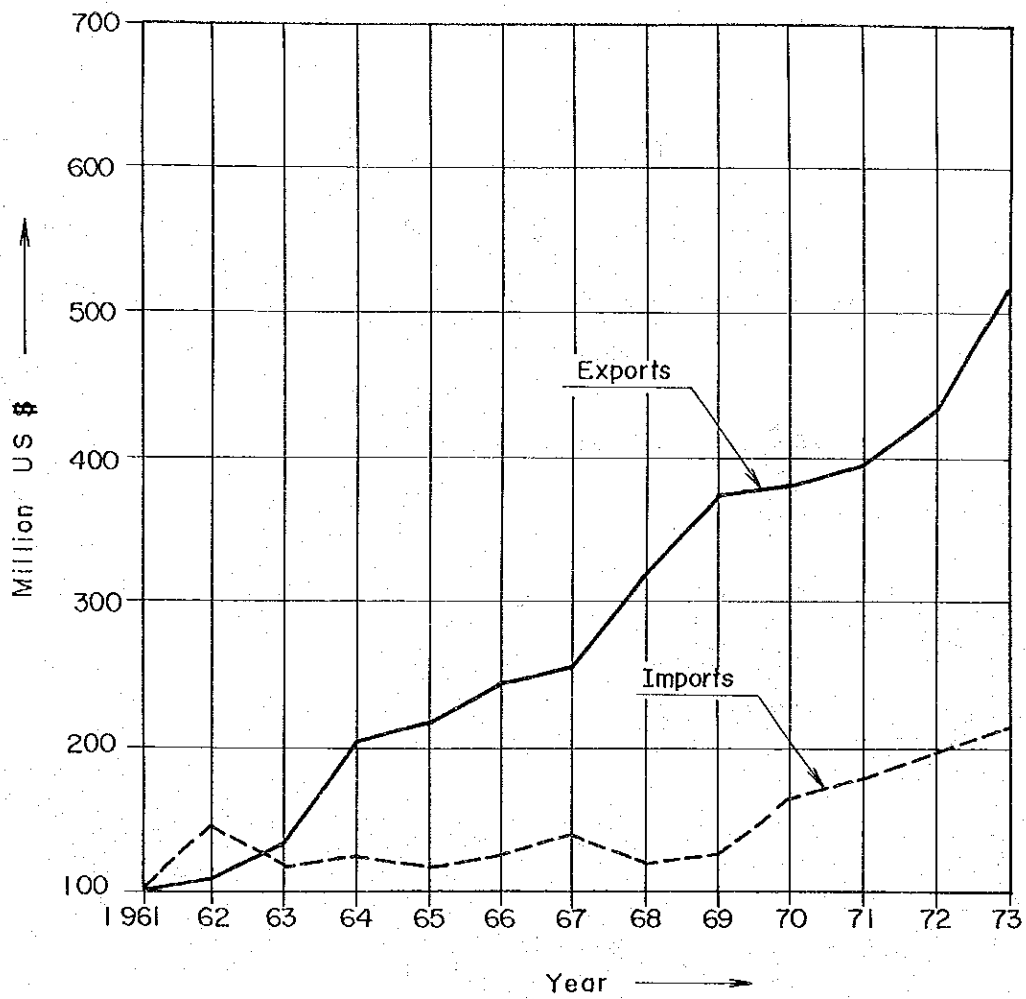
Meanwhile, imports totaled 193.5 million dollars in 1973 of which machinery and transport equipment comprised 36%, raw materials and manufactured goods classified by material 20%, food and live animals 16% and others 28%.

In both export and import, the U.S.A. is the leading trading partner followed by West Germany, the Netherlands, Japan and the United Kingdom. The record in foreign trade may be illustrated as shown in Fig. 3-5, and the balance of export and import has always been in the black.

(2) International Balance of Payments

A comprehensive compilation of the international balance of payments has not been made from the past. In effect, the method adopted is to estimate the international balance of payments for a given year from the foreign trade balance and the foreign assets accounts of financial institutions.

Figure 3-5 Actual Records of Liberian Trade



The international balance of payments for fiscal 1973 is recorded to have been in the black from the previously mentioned foreign trade balance of 130.5 million dollars (324 million dollars exports less 193.5 million dollars imports, or 130.5 million dollars) and the plus of 7.8 million dollars in foreign assets accounts for a total of 138.3 million dollars.

3-6 Gross National Product (GNP)

(1) GNP

The GNP expressed in terms of current prices has increased from 361 million dollars in 1967 to 483.9 million dollars in 1972. This is an annual growth rate of 6%. Converted to per capita amounts, this amounts to an increase from \$260/capita in 1967 to \$304/capita in 1972.

(2) Consumer Prices and Real Growth Rate in GNP

Meanwhile, the consumer price index (1964 = 100) rose from 110.4 in 1967 to 131.0 in 1972 indicating an annual average rate of increase of 3.5% during the period. This was an extremely slow rate of rise, but with the oil crisis of 1973 as a turning point, commodity prices rose sharply to approximately 20% over 1972. Consequently, if the period of 1967 to 1973 were to be taken, the annual average rate of rise in consumer prices during the period would be around 5.9%.

Based on the above, as shown in the table below, with the nominal GNP corrected with the consumer price index as the deflator, the real growth in GNP during 1967 to 1972 was an annual rate of 2.5% while for 1967 to 1973 the real growth rate was almost zero.

On the other hand, the population growth rate during the period was 2.8% (popularly said to be 3%) so that the per capita real growth rate under the normal economic conditions during 1967 to 1972 had been diminishing annually at a rate of 0.3%. This would be an indication that distortions in income distribution under economic growth have been shifted to some sector of the economy.

Table 3-2 Real GNP

(1964 = 100)

Year	Nominal GNP	Deflator (1964=100)	Real GNP	Population	GNP/capita	
					Nominal	Real
	(\$x10 ⁶)		(\$x10 ⁶)	(1,000)	(\$)	
1967	361.0	110.4	327.0	1,388	260	236
1968	378.5	114.3	331.1	1,433	264	231
1969	396.6	125.3	316.5	1,481	268	214
1970	417.5	126.0	331.3	1,523	274	217
1971	448.1	126.1	355.3	1,573	285	226
1972	483.9	131.0	369.4	1,592	304	232
1973	521.0	156.6	332.7	1,640	318	203
Annual Av. Growth Rate (1967 - 1972)	6.0%	3.5%	2.5%	2.8%	3%	-0.3%

(3) Structure of GNP by Sector

The breakdowns of GNP by industry for 1970 and 1971 and the gross national expenditures seen from the aspect of consumption are indicated in the following table :

Table 3-3 GNP and Gross National Expenditure

Item	(Amount) (\$ x 10 ⁶)		Distribution (%)	
	1970	1971	1970	1971
I. <u>GNP</u>				
Agriculture, forestry, fishing	83.5	56.9	20.0	12.7
Mining	125.3	109.4	30.0	24.4
Manufacturing	21.8	60.9	5.2	13.6
Construction	19.0	26.2	4.6	5.8
Commerce	67.1	80.1	16.1	17.9
Hotels, restaurants	6.7	4.8	1.6	1.1
Transportation, communications	26.8	18.7	6.4	4.2
Finance, real estate	4.4	7.9	1.0	1.8
Public services	51.6	55.3	12.4	12.3
Other services	11.3	27.9	2.7	6.2
Total	417.5	448.1	100	100
II. <u>Gross National Expenditure</u>				
Personal consumption expenditure	203.9	214.1	48.8	47.8
Government current expenditure	45.3	52.1	10.9	11.6
Domestic capital formation (net)	80.5	101.3	19.3	22.6
Inventory increase	23.8	18.9	5.7	4.2
Net exports	64.0	61.7	15.3	13.8
Total	417.5	448.1	100	100

(Source: U.N. African Economic Survey)

CHAPTER IV
PROSPECT FOR ECONOMIC DEVELOPMENT

In regard to the outlook for development schemes or projects which would require electric power in the Republic of Liberia, what must particularly be noted would be the manufacturing industry and the mining industry including iron ore development. Subsistence agriculture that is a component of the dualist economy has few relations with the monetary economy, and there is little connection with electric power demand. Accordingly, a broad prospect for economic development related to only the mining and manufacturing industries will be discussed in this Chapter.

4-1 General Conditions

(1) Governmental Implementing Agencies

Mine development requiring large amounts of capital investment is carried out under concession of foreign enterprises with the Government or of joint ventures between the Government and foreign interests. Moreover, the Liberian Government adopts the policy of granduallly fostering medium and small scale manufacturing industries in line with its encouragement policy and it is thought that these principles will be continued in the future.

The competant governmental organization responsible for industrial development is the Ministry of Commerce, Industry and Transportation. The agencies described below could be enumerated as those for implementing industrial development promotion under and/or in cooperation with the Government.

(a) Liberian Development Corporation (LDC)

The LDC was established by an Act of Legislature in 1961 for materialization of industrial policies. Its primary functions are to finance government equity participation in business development enterprises and financing, giving assistance when various government agencies carry out industrial development based on the Liberian Investment Incentive Code and further providing technical assistance to LBIDI described on the next Page.

(b) Liberian Bank for Industrial Development and Investment
(LBIDI)

This is a financial institution of the Government established in 1961 with its principal activity to provide financing for founding factories, expanding industrial facilities or modernizing equipment of private enterprises.

(2) Forecast of Development

Detailed information on the features of projects and target growth rates of budgets and GNP were not available in connection with "economic development plans in the future". However, it is thought possible to make a forecast to some extent of future development based on the industrialization scheme promoted by the Government in the past and recommendations on development strategies made by international institutions together with other factors.

Firstly, with respect to formation of domestic capital for development, as shown in Table 3-3 supra, the gross domestic capital formation including inventories is 100 to 120 million dollars annually for a capital formation rate of 25 to 27%. Therefore, it may be said that the condition is that of sound economic growth, but the amount of capital is insufficient. For this reason, as shown in the table below, the weight of foreign aid funds occupied in the Government's development budget is considerable.

Table 4-1 Government Development Budget (1974)

(Unit: million dollars)

	Government Capital	Foreign Capital	Total
Economic development	9.7	10.3	20
Social services	3.8	9.4	13.2
Administration and planning	1.1	2.5	3.6
Total	14.6	22.2	36.8

Therefore, in view of the before-mentioned matters, it is considered permissible to arrive at the following broad conclusions regarding the outlook for economic development:

- (a) Ordinary small enterprises will continue to develop "slowly but steadily" reflecting the sound capital formation.
- (b) Assistance in the form of foreign capital will be required in large quantity for the Government's development projects and the free investment environment will facilitate inflow of this assistance.
- (c) Large-scale development projects would not be materialized without foreign capital, but there are numerous promising projects (mining, forestry, etc.) and development can be expected. Also, there is much room left for the effective impact of these large projects upon the total economy through an appropriate industrial policy.

4-2 Promising Industrial Projects and Outlooks

The industrial projects which would substantiate the development forecast are described below.

(1) Industrialization Projects in Progress

(a) Monrovia Industrial Park Project

An industrial park project in an area of 450 ha is in progress at Gardnersville approximately 10km outside of Monrovia. This project is to attract various types of factories in small-scale industries, light industries and heavy industries and to build necessary administrative facilities, houses for employees, warehouses, transportation facilities and other infrastructures.

A fair portion of the infrastructures has already been completed by the Government and surveys for detailed planning have also been finished. Enterprises presently

located in this park are only the three firms; West Africa Shoes and Industries, Ltd. (WASRIL), Metalloplastica (a plastic plant) and the Liberian Refinery Company. If construction of other factories and enterprises are made successively in the future, the park will become an important electric power load center.

(b) Monrovia Free Port Project

This is a project to build a supplementary environment for industrialization and the chief aim is to attract factories to the free port area. Attraction of industry has not been realized according to plan as yet, but the progress should be watched from a long-range point of view.

(2) Future Industrialization Plans

In Liberia, where the land area is relatively limited, the population is small and the level of GNP is low, there is little room for promoting import substitution industries which mainly produce capital goods. In this sense, in the recommendations of the World Bank and other international organizations, it has been pointed out that considerable efforts should be exerted to production of goods which can cope with fluctuations in international markets. In this respect, the industry types which appear particularly promising are the following:

(a) Wood Based Products

There is presently a large demand in European countries for wood products made of tropical woods and it is expected that this trend will continue in the future. The exports of forest products from Liberia up to now have been 98% in the form of logs. However, it would be far more advantageous to export processed wood products with higher value added after expanding the range of manufacturing to sawwood, plywood, veneer and further to furniture and other processed goods,

and the demand for wood products in developed countries is greater than for logs. It is therefore considered that much can be expected of future development of the wood product industry of Liberia which has abundant forest resources.

(b) Semi-Processed Rubber Products

Exports of rubber have, in the past, been made in the form of crude natural rubber, but similarly to the case of wood products, it would be more advantageous for the rubber to be made into various products of higher value added. In this respect, industries using rubber could be promising.

(c) Processed Foodstuffs

Edible oils and fats, fruit juices, sugar and fruits (canned), cocoa products, etc. are among items imported by Liberia and the imports in 1971 amounted to approximately 3.6 million dollars. These items can be produced domestically (the domestic production in the same year was 1.4 million dollars), and promotion of foodstuffs processing to save on imports is also hopeful.

4-3 Future Mine Development Projects and Outlook

As described in Chapter V, concessionaires developing iron ore mines at present are meeting electric power requirements in mining and processing ore with their self-generating facilities. Their total installed capacity is slightly below the scale of generating facilities owned by PUA. However, for mines to be newly developed in the future, there is a possibility for PUA to be looked to for power supply. In such case, power demand to arise from these mines may constitute an important portion of the total demand, and therefore, mine development plans will be of the greatest importance in electric power development planning. The more important aspect of mining projects in the country are described on the following Page.

(a) Wologisi Mine Development Project

The location of the mine is in the northwestern part of Liberia approximately 180 km from Robertsport and the mineable ore deposit is estimated to be approximately 600 million tons.

Since LISCO obtained the mining rights in 1967, it has been engaged in prospecting. A Japanese group, AMAX, UAC and Liberian investors have participated in the project with capital and production is planned to be started in 1981. A feasibility study is presently being made on this project by Bechtel Corporation of Canada, and it is said the possibility for the project to be carried out is extremely high.

Details of production plans have not yet been decided, but it is said that annual production will be 10 million tons and a pellet plant is expected to be built in the vicinity of Robertsport.

(b) Tokadah Mine Development Project

The mine is in the concession area of LAMCO and the proved reserves are said to be 160 million tons. LAMCO started preparation works for development in 1971 and it is said the initial production planned is for 1.5 million tons in crude ore.

(c) Bie Mine Development Project

The mine is located between the Bomi Hill Mine and Mano Mine now being operated and the reserves are estimated to be between 450 and 1,360 million tons. Since the existing railroad runs by a point only 12 km to the west of the Bie Mine, it will be convenient for development and it is expected to take the place of the Bomi Hill Mine after the latter closes in 1975.

(d) Guinea Nimba Mine Development Project

The mine is at a location approximately 28 km from the Nimba Mine of LAMCO. The iron ore is of high grade with a concentration of 68% and the reserves are estimated to be 1,000 to 1,500 million tons.

Negotiations are presently going on between the Governments of Liberia and Guinea in regard to development of this mine.

(e) Putu Mine Development Project

The mine is at a location 300 km northwest of Monrovia and the mineable ore of concentration of 35% is estimated to be approximately 500 million tons.

It is expected that the E&B firm of West Germany and a Japanese group will undertake development of the mine.

The Mine is scheduled to start production some time between 1982 and 1985. It is reported that 8 million tons of pellets will be produced.

(f) Others

Besides the above, ore prospecting is going on at the Gangra, Beeton and Yuelliton Mines in the concession area of LAMCO, and it is estimated that the reserves of iron ore are approximately 900 million tons.

CHAPTER V

ELECTRIC POWER SITUATION

5-1 Outline of Electric Power Industry

Electric power in Liberia is being supplied by power facilities owned by the Public Utilities Authority (PUA) and privately-owned facilities of various enterprises.

The installed power generating capacity of all Liberia totals approximately 300 MW as indicated in Table 5-1, of which the installed capacity under PUA is approximately 160 MW (53% of whole). Almost all of the capacity belongs to the Monrovia Power System. The remaining approximately 140 MW is the capacity of private generating facilities operated by enterprises.

Although energy consumption in the area of the Monrovia Power System showed an annual increase rate of more than 30% in 1967/68, such rate has, in recent years, tapered down to be less than 10%.

As of 1973, the energy demand of entire Liberia was estimated to have been around 660 million KWh, and to meet this demand, power was supplied by the generating facilities owned by PUA and those by enterprises at a ratio of approximately 6:4.

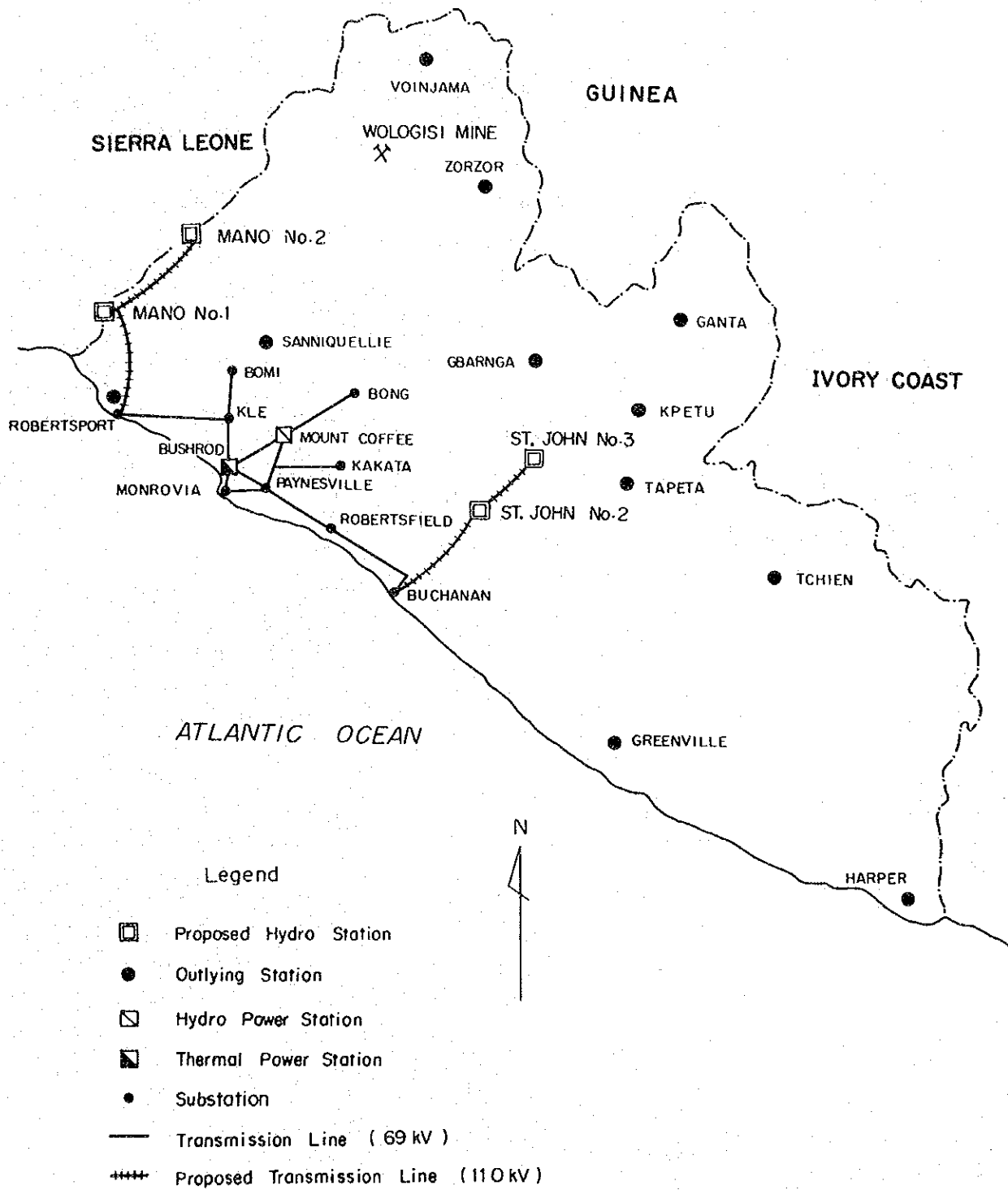
The power systems of PUA, as shown in Fig. 5-1, consist of the Monrovia Power System centered around the capital of Monrovia and numerous and small independent systems.

Various enterprises have their own generating facilities. Most of power demand belonging to PUA is concentrated in the Monrovia Power System while there are other independent small scale systems in Liberia since it is uneconomical to interconnect tiny power plants scattered in the interior of the country.

Table 5-1 Energy Production and Installed Capacity in Liberia (1973)

	P U A		Private	Total
	Monrovia System	Outlying Station		
Energy Production (MWh)	347,200	22,300	252,700	622,200
(%)	55.8	3.6	40.6	
Installed Capacity (MW)	149.5	11.7	143.2	304.4
(%)	49.1	3.9	47.0	

Figure 5-1 PUA POWER SYSTEM



5-2 Process of Growth in Power Supply

(1) Infancy Period of Power Supply

The history of electric power supply in Liberia is old and even before World War I there were privately-owned generating facilities along the coast in the Montserrado County. In 1926, the Firestone Plantations Co. (the largest natural rubber plantation company in Liberia) completed the first local power supply system in Liberia.

Approximately 15 years later, in 1942, the first hydroelectric power station in Liberia was constructed at Harbel on the Farmington River to meet new demands at an airbase at Robertsfield and at military bases. This power station is still in operation today with 4 generators having a total capacity of 4 MW for annual energy production of 1.6×10^6 KWh.

After World War II, numerous small-capacity diesel generating facilities were installed in larger cities. According to a survey made in 1958, there were 325 units of generators at that time with approximately one half of them installed at five principal cities along the coast (61 units in Monrovia, 42 units in Cape Palmas, 25 units in Buchanan, 15 units in Greenville, 13 units in Robertsport). The total installed capacity was 26 MW, the breakdown of which was 15.7 MW in privately-owned facilities for the Firestone and LAMCO enterprises, 7.3 MW for the capital of Monrovia and 3 MW for other outlying districts.

(2) Development by Government

The Liberian Government made a decision in 1958 that electric power development which had been carried out by concessions should thereafter be undertaken by the Government and thus established Monrovia Power Authority.

It was decided (a) that a large number of small-scale public power stations should be built, and (b) that for Liberia which does not have coal or petroleum resources, a survey should be initiated

on the hydroelectric potentials of the major rivers which could be thought of as the only economical energy source, and that taking into consideration the possibility of supplying electric power to Monrovia and its surrounding area, development of Mount Coffee on the St. Paul River would be given emphasis. (Construction of private generating facilities by concessions is, however, still continuing.) As a result, 13 MW of diesel generating equipment was installed from 1961 to 1963 at Bushrod Power Station which is presently a central thermal power plant of the Monrovia Power System, while in 1966, the First Stage (34 MW) of Mount Coffee was completed.

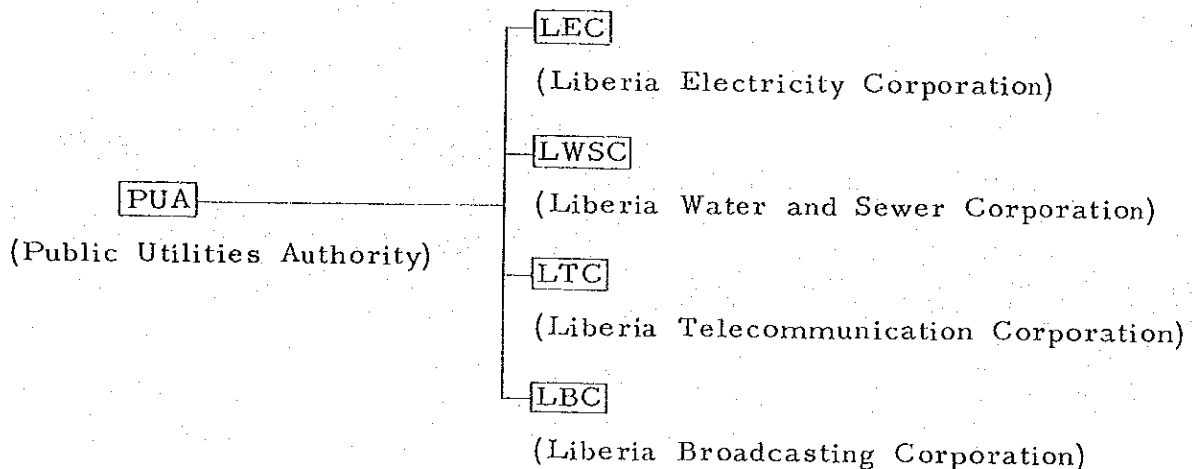
In 1962, PUA which is the outgrowth of the Monrovia Power Authority was created as an independent organization by an Act of the National Legislature in order to promote administration of the Liberian power industry under the integrated policy of the Government of Liberia.

In the period from 1969 to 1973, gas turbine generators with an installed capacity of 68 MW were added at Bushrod Thermal Power Station, while expansion of 34 MW was made at Mount Coffee Power Station at its second stage. The total installed capacity of PUA's generating facilities has come to be doubled during the last decade.

5-3 Electric Power Administration Organization

The electric power administration of Liberia is under the jurisdiction of PUA.

The respective agencies forming PUA are as illustrated below.



PUA is a governmental implementing organization responsible for public utilities which was created upon integration of Monrovia Power Authority by an Act of the National Legislature passed and approved on June 1, 1962. Since its establishment, PUA has achieved remarkable growth for the past ten years. At present, PUA deals with water supply and sewerage, telecommunication and broadcasting in addition to electric power for which PUA was held responsible at the initial stage.

The Board of Directors of PUA is composed of nine directors and the Chairman is of cabinet rank.

5-4 Present State of Electric Power Facilities

5-4-1 Power Generating Facilities

The power generating facilities in all of Liberia as of 1973 totalled 304.4MW as shown in Table 5-1. Of this total, the generating facilities controlled by PUA amounted to 161.2MW (53% of the whole) while the private generating facilities owned by enterprises amounted to 143.2MW (47% of the whole). Of the generating facilities of PUA, 149.5MW belongs to the Monrovia Power System. The breakdown is given in Table 5-2.

To elaborate, the generating facilities of the Monrovia Power System are composed of Mount Coffee Hydroelectric Power Station with a capacity of 68MW (17MW x 4 units) and Bushrod Thermal Power Station (6 units diesel, 13MW, 4 units gas turbine, 68.5MW). Mount Coffee Hydroelectric Power Station is of daily-regulated type with a regulating pond capacity of $11 \times 10^6 \text{ m}^3$.

The electric power generating facilities of independent systems of PUA not belonging to the Monrovia Power System are indicated in Table 5-3.

The power generating facilities privately owned by enterprises total 143.2MW as previously mentioned, the principal ones being the 48MW of LAMCO (12MW at Nimba site, 36MW at Bachanan Port site), the 68MW of the Bong Mine, and the 7MW of Firestone Plantations Company (including 4MW of hydro).

Except for the Firestone-owned hydroelectric power plant with an installed capacity of 4MW, all of these power plants are diesel generating installations.

Table 5-2 Installed Capacity of Existing Power Plants Owned by PUA

Power Station	Type of Unit		Output (MW)	Date of Installation	Total Installed Capacity (MW)
Mount Coffee	Hydro Unit	1	17	1966	68
	"	2	17	1966	
	"	3	17	1973	
	"	4	17	1973	
Bushrod	Diesel Unit	1	1.5	1961	13
	"	2	2	1961	
	"	3	2	1961	
	"	4	2.5	1963	
	"	5	2.5	1963	
	"	6	2.5	1963	
Bushrod	Gas Turbine Unit	1	15.5	1969	68.45
	"	2	14.75	1970	
	"	3	19.1	1973	
	"	4	19.1	1973	
					149.45

Table 5-3 Actual Energy and Installed Capacity in Outlying Areas (1972)

	Energy (MWh)	Installed Capacity (KW)
Robertsport	480	271
Greenville	950	271
Harper	3,520	2,100
Sanniquellie	360	500
Gbarnga	3,020	2,020
Tchien	370	450
Voinjama	2,400	1,000
Ganta	4,800	2,100
Topeta	1,800	1,000
Keptu	2,800	1,000
Zorzor	1,800	1,000
Total	22,300	11,712

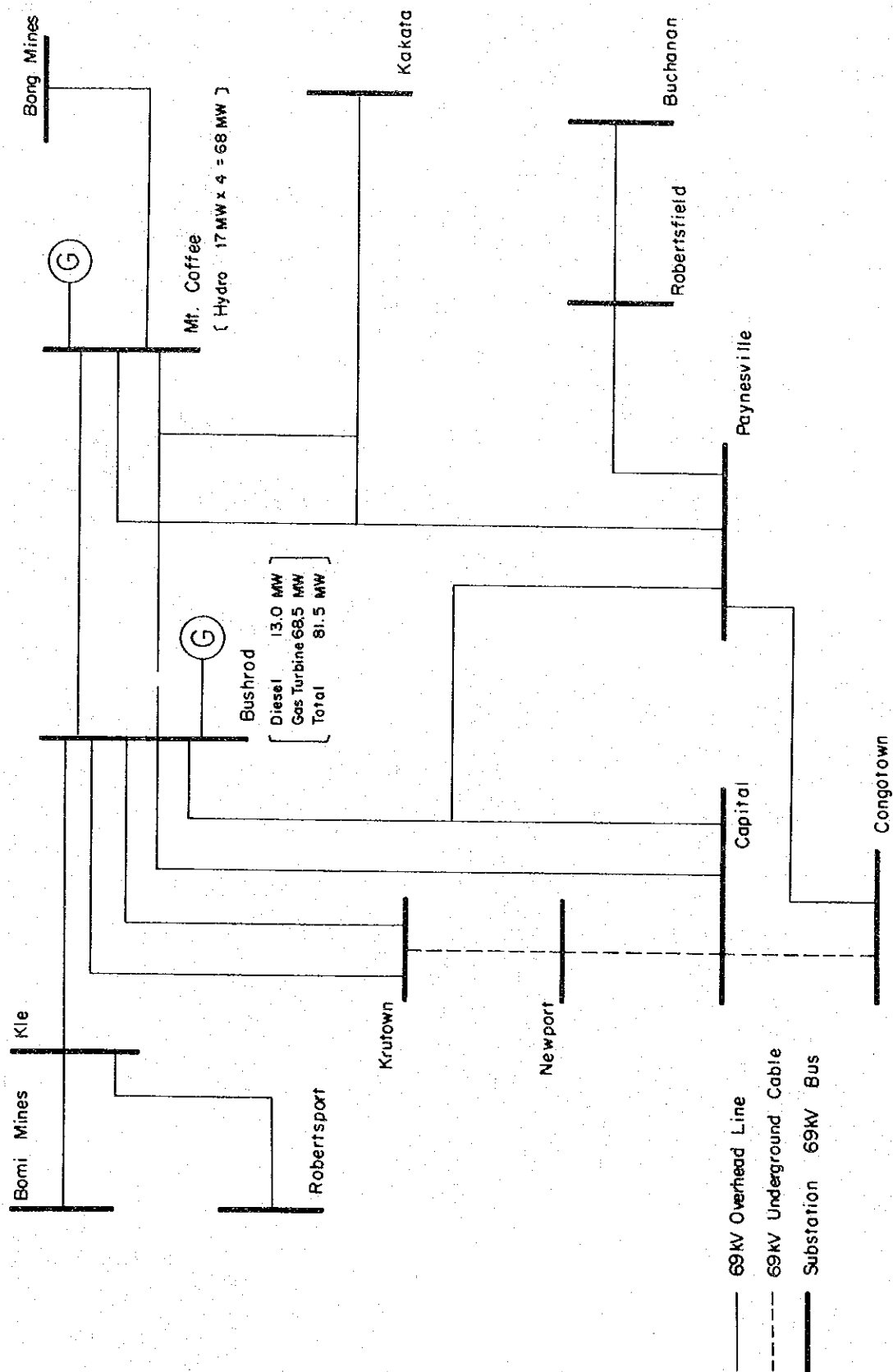
5-4-2 Power Transmission and Transforming Facilities of Monrovia

As shown in Fig. 5-2, the Monrovia Power System stretched from Monrovia exists in an area of 112km by 220km from Kakata in the north-eastern part of Liberia.

The system voltage is 69 KV, while the transmission capacity of each circuit is 350A, 42 MVA. A part of the circuits in Monrovia has become insufficient in capacity due to increased demand, and the system is being operated in loop form.

The substations at Bomi Mine, Bong Mine and Buchanan are linked to the Monrovia Power System, but since the loads of these concessions are met by privately-owned generating facilities, no power supply is normally made by PUA.

Figure 5-2 69KV TRANSMISSION SYSTEM (Monrovia System)



5-5 Electricity Charges of Monrovia Power System

The new rate structure of PUA effective as of May 1974 is the following:

(1) Residential and Commercial

One rate will apply to all residential customers and to small commercial customers:

The first	400 Kilowatt Hours	8¢ per Kilowatt Hour	with a minimum bill of \$3.20
Next	1100	"	7¢ per Kilowatt Hour
Over	1500	"	6 1/2¢ "

(2) Primary Power Rates

Primary Power for delivery to large commercial and Industrial Customers:

Alternate I

If customer owns transformer(s) and all material beyond the meter:

First	2000 Kilowatt Hours	7¢ per Kilowatt Hour
Over	2000	" 5 1/2¢ "

Alternate II

If customer owns transformer(s):

Demand charge (Monthly)	\$4.00 per Kilowatt
Energy charge	5 1/2¢ per Kilowatt Hour

5-6 Past and Present of Electric Power Demand (Monrovia Power System)

The annual energy consumptions, peak demands and load factors of the Monrovia Power System from 1965 to 1974 are as shown in Table 5-4, Fig. 5-3 and Fig. 5-4.

Both annual energy consumption and peak demand have shown steady growths during the past 10 years. Particularly, during the period of several years following the completion of Mount Coffee Hydroelectric Power

Station in 1966, high growth rates of more than 20% were indicated.

However, the growth rate has been blunted in these several years and has been under 10%. This is mainly attributable to the changed economic situations following the "oil crisis" in 1973. Meanwhile, the load factor, except for that in 1967 and 1968, has been at a constant level of just under 70%.

Table 5-4 Actual Data of Energy Consumption in Monrovia Power System

	Energy Consumption		Peak Demand		Load Factor (%)
	(10 ⁶ KWh)	Increase (%)	(10 ³ KW)	Increase (%)	
1965	96.7	14.7	16.2	13.7	68.1
1966	111.8	15.6	18.5	15.0	68.7
1967	146.9	31.3	29.0	56.5	57.7
1968	181.3	23.4	32.4	11.7	63.7
1969	214.3	18.3	36.0	11.1	68.0
1970	257.3	20.1	43.3	20.3	67.8
1971	295.8	15.0	49.0	13.2	68.9
1972	323.7	9.4	54.0	10.2	68.1
1973	347.2	7.3	56.9	9.3	68.0
1974	366.0	5.4	60.0	5.6	69.6

Figure 5-3

Annual Energy Production and Increase 1962~1973

(PUA'S Monrovia System)

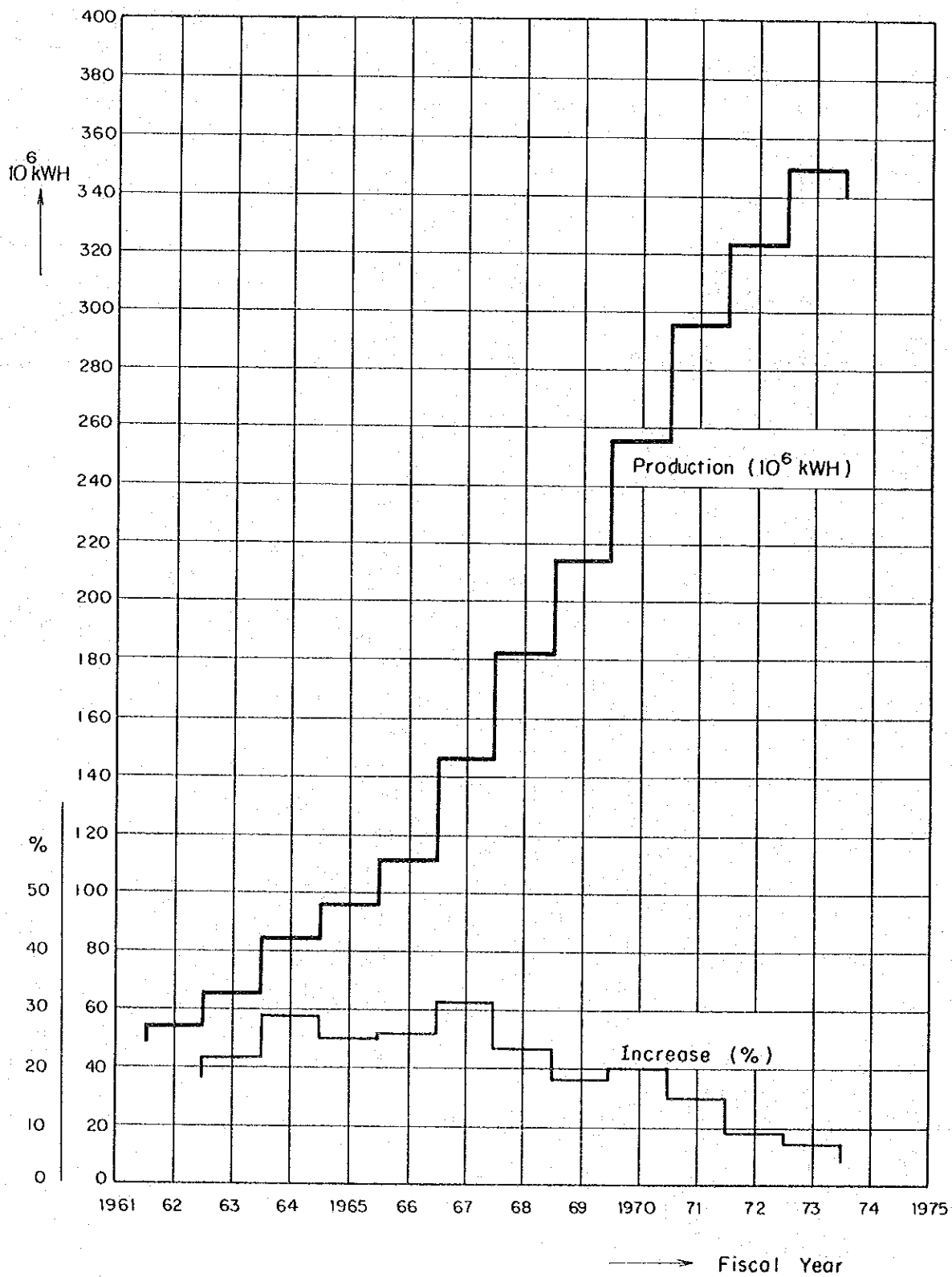
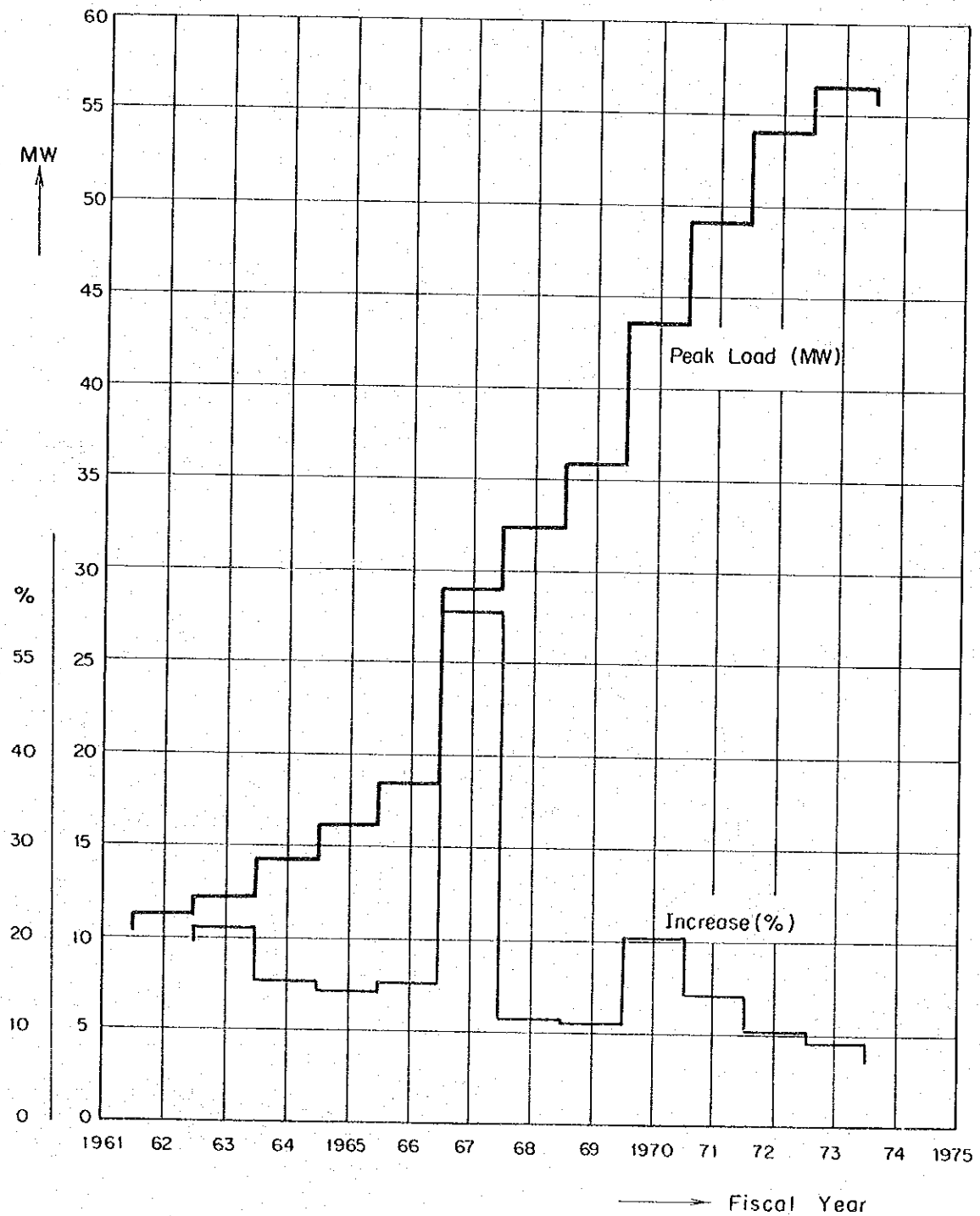


Figure 5-4

Annual Peak Load and Increase 1962~1973
(PUA'S Monrovia System)



5-7 Future Power Demand

5-7-1 Monrovia Power System of PUA

Load forecasts are generally made under (1) the microscopic methodology and (2) the macroscopic methodology.

Under the microscopic methodology stated in (1), analysis of the composition of demand and cumulative aggregate of the demands by factor are performed. The macroscopic methodology is to use the historical trend of power demand or extend the trend of correlation with relevant economic indices.

In making forecast on the future load of the Monrovia Power System, since no basic data on future demand were available, the macroscopic methodology given in (2) was employed. In this case the following three of

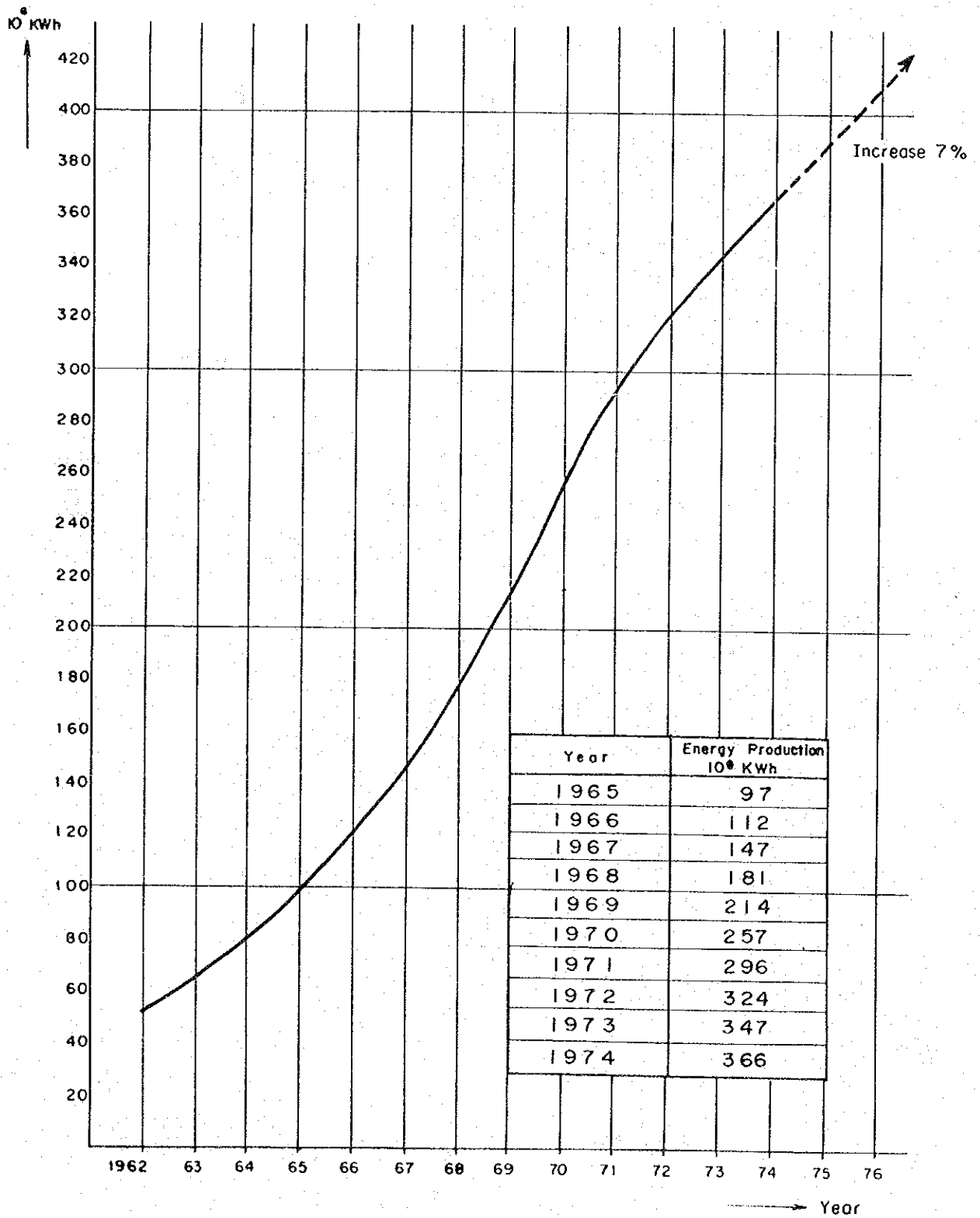
- (a) time series trend of electric power demand itself,
 - (b) time series trend of per capita energy production,
and
 - (c) correlation between KWh/GNP and per capita energy production
- were applied, and the forecast was made in overall consideration of the above.

Further, in projecting the demand of the Monrovia Power System in the future, interconnections with the various concessions would be a matter of consideration, but the privately-owned generating facilities have been amortized over many years, and since therefore it would be costly in terms of electricity charges to interconnect with the Monrovia Power System, it was considered in this Report that there would be no interconnections between the Monrovia Power System and the existing facilities owned by concessions.

(a) Time Series Trend of Electric Power Demand

The time series trend of electric power energy production of entire Liberia in 1962 and subsequent years, not including concessions, is shown in Fig. 5-5. As indicated in this Figure, there was a pronounced growth in the past, especially the growth of more than 20% from around the year of 1966 when Mount Coffee Power Station was constructed.

Figure 5-5 Energy Production



However, in the past several years, the growth rate has been slowed, and has remained at a rate of under 10%.

From the time series trend, it is judged that there will be a growth rate of about 7%.

(b) Time Series Trend of Per-capita Energy Production

The time series trend of per-capita energy production is indicated in Fig. 5-6.

Since the energy productions of the various concessions were unknown, considerations were given to only energy production under PUA in this Report. Therefore, the resulting figures are smaller than the actual, but even if they were doubled (for the reason that the total installed generating capacity of the concessions is about the same as that under PUA), it would have been approximately 500 KWh, which is judged to be very small in comparison with the world level.

In view of the trend in per-capita production up to this time, the growth rate in the future is estimated at around 6%.

(c) Correlation between KWh/GNP and Per-capita Energy Production

The correlations between energy consumption per dollar of gross national product and per-capita energy production of approximately 70 countries in the world in 1970 are shown in Fig. 5-7.

In the overall average for the world, there is roughly 1.68 KWh of energy used to produce value of one dollar in GNP. As regards the average for per-capita energy production, it is approximately 1,500 KWh. The figures for Liberia are far below the averages of both cases. It can be expected that in the future such figures of Liberia would approach to the above overall averages for the world.

The correlations between per-capita energy production and KWh/GNP in Liberia during the period between 1965 and 1973 are as plotted in Fig. 5-7. The annual growth rate of energy production

Figure 5-6 Per Capita Energy Production

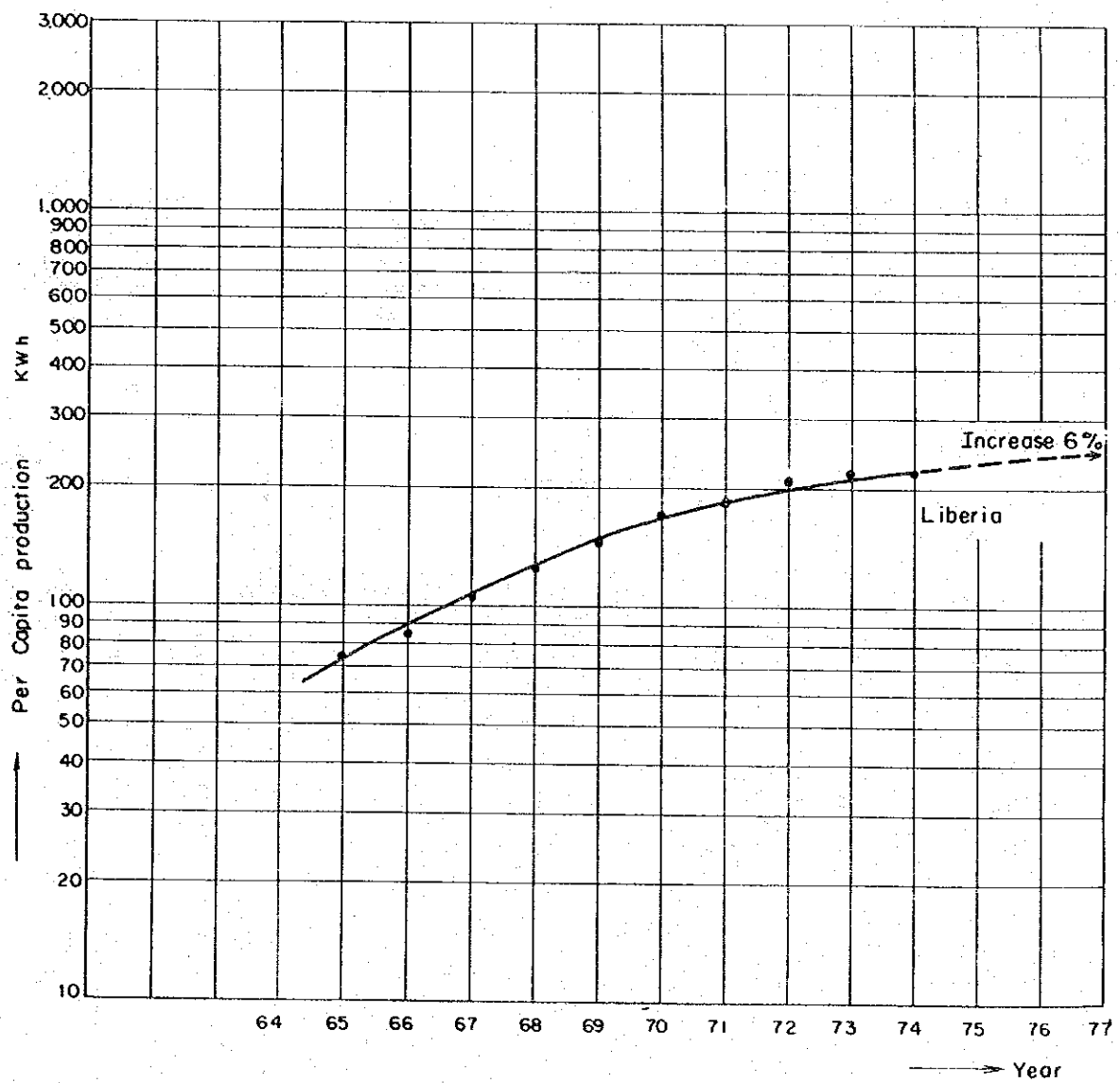
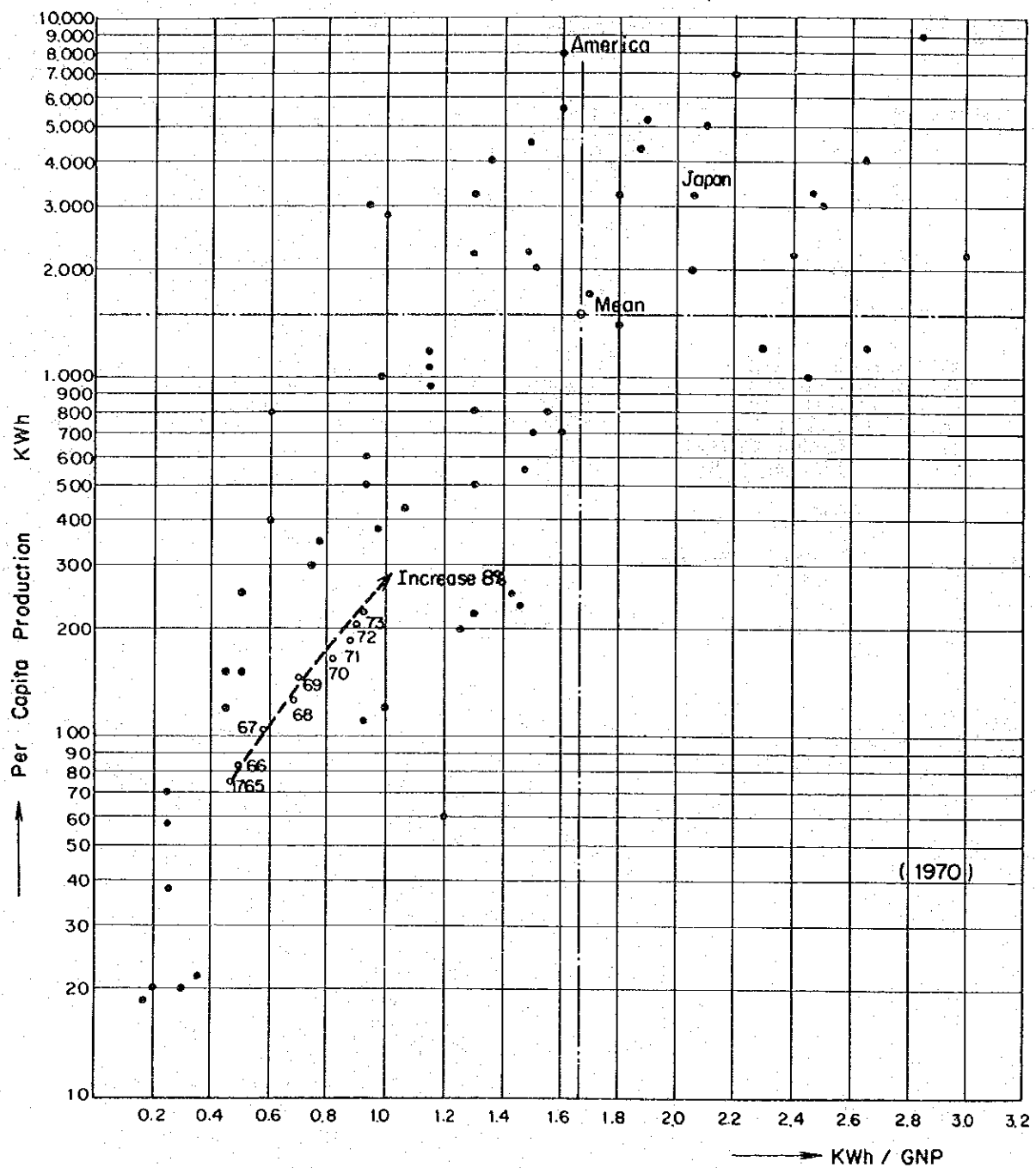


Figure 5-7 KWh / GNP – Per Capita Energy Production
(Liberia)



is estimated to reach around 8% in the future on the condition that the growth rates of GNP and the population in 1974 and subsequent years are to be some 6% and 3%, respectively.

(d) Future Power Demand

On estimating the growth rate in future years taking the above three methodologies; a, b and c into overall consideration, since the Monrovia Power System of PUA makes up almost all (approximately 95%) of PUA's total load throughout Liberia, the growth rate for the Monrovia Power System can be regarded as that of PUA for entire Liberia.

In effect, five years hence in 1980, it is estimated that the power demand will be 90 MW and the energy demand 550×10^6 KWh, while 10 years hence in 1985, the power demand will be 127 MW and the energy demand 772×10^6 KWh.

5-7-2 Power Demand of Wologisi Mine

The Wologisi Mine, located in the northwestern part of Liberia, is scheduled to start production in 1981.

According to one scheme, the iron ore mined is to be dressed at the site and sent through slurry pipes to a port site near Lake Piso (approximately 20 km from Robertsport) approximately 230 km from the Mine site. At this port site, the dressed ore is to be pelletized.

The electric power to be required at the Wologisi Mine according to persons involved in the mine development will be a total of about 175 MW with the load at the port site centered around the pellet plant being around 90 MW and the load at the mine site centered around the concentration plant about 85 MW. The results of a feasibility study on the Wologisi Mine are scheduled to become known in October 1975 at which time the power demand in connection with the mine will be clarified.

Because of the above background, annual energy to be required for the pellet plant at the port site is estimated at 670×10^6 KWh on the

assumption that the installed capacity for the said plant is to be approximately 90 MW at a load factor of around 85%. If approximately 85 MW at the same load factor is necessitated for other facilities at the Mine site, an annual energy production of 630×10^6 KWh will be required for such facilities. Therefore, the value of annual energy requirement for the Mine will total about $1,300 \times 10^6$ KWh.

5-7-3 Consolidated Monrovia Power System (including Wologisi Load)

With the preconditions of growth rate of power demand in the existing Monrovia Power System at 7% as described in 5-7-1, and the required power demand of the Wologisi Mine as described in 5-7-2 (peak demand; 175 MW, annual energy requirement; $1,300 \times 10^6$ KWh) by connection with the Monrovia Power System from 1981 onward.

As shown in Table 5-5, the power demand of the Monrovia Power System is estimated to be 90 MW in 1980, 272 MW in 1981 when the Wologisi Mine starts production, and 311 MW in 1986 after 5 more years have elapsed.

Table 5-5 Load Forecast in Monrovia Power System

	Without Wologisi		With Wologisi	
	Energy Consumption (10 ⁶ KWh)	Peak Load (10 ³ KW)	Energy Consumption (10 ⁶ KWh)	Peak Load (10 ³ KW)
1975	392	64	392	64
1976	419	69	419	69
1977	448	74	448	74
1978	479	79	479	79
1979	514	85	514	85
1980	550	90	550	90
1981	589	97	1,889	272
1982	630	104	1,930	279
1983	674	111	1,974	286
1984	721	118	2,021	293
1985	772	127	2,072	302
1986	826	136	2,126	311
1987	884	145	2,184	320
1988	946	155	2,246	330
1989	1,012	167	2,312	342

* Load for Wologisi Energy Consumption 1,300 x 10⁶ KWh
 Peak Load 175 MW

5-8 Load Forecast for Monrovia Power System

Although the present installed capacity of the Monrovia Power System totals 150 MW, the dependable power available in the said System is only 99 MW comprising the output of the thermal power station obtained after deduction of its station service load and the extremely decreased output of Mount Coffee Power Station during the dry season.

When the future increase in power demand described in 5-7 and the necessary reserve supply capability of 10% are taken into account, it is feared that there will be a shortage of power supply in 1981. This shortage will reach approximately 40 MW in 1985. The details are as shown in Table 5-6.

Meanwhile, the power demand of the Wologisi Mine which is planned to commence production in 1981 is supposed to be 175 MW. In case the power demand of the pellet plant (approximately 90 MW) scheduled to be built near Robertsport is met by the Monrovia Power System, the shortage of power capability in the said System is estimated at 107 MW (including the required reserve capacity) in 1981. Consequently, it is considered necessary that new power facilities with an installed capacity of around 100 MW be constructed in the area of the Monrovia Power System not later than 1981. The details are as shown in Table 5-6.

Furthermore, if the demand at the Wologisi Mine site (approximately 85 MW) is also met by the Monrovia Power System, the shortage in supply capability of the System will be about 200 MW in 1981 and reach about 230 MW ten years hence in 1985. The details are indicated in Fig. 5-8.

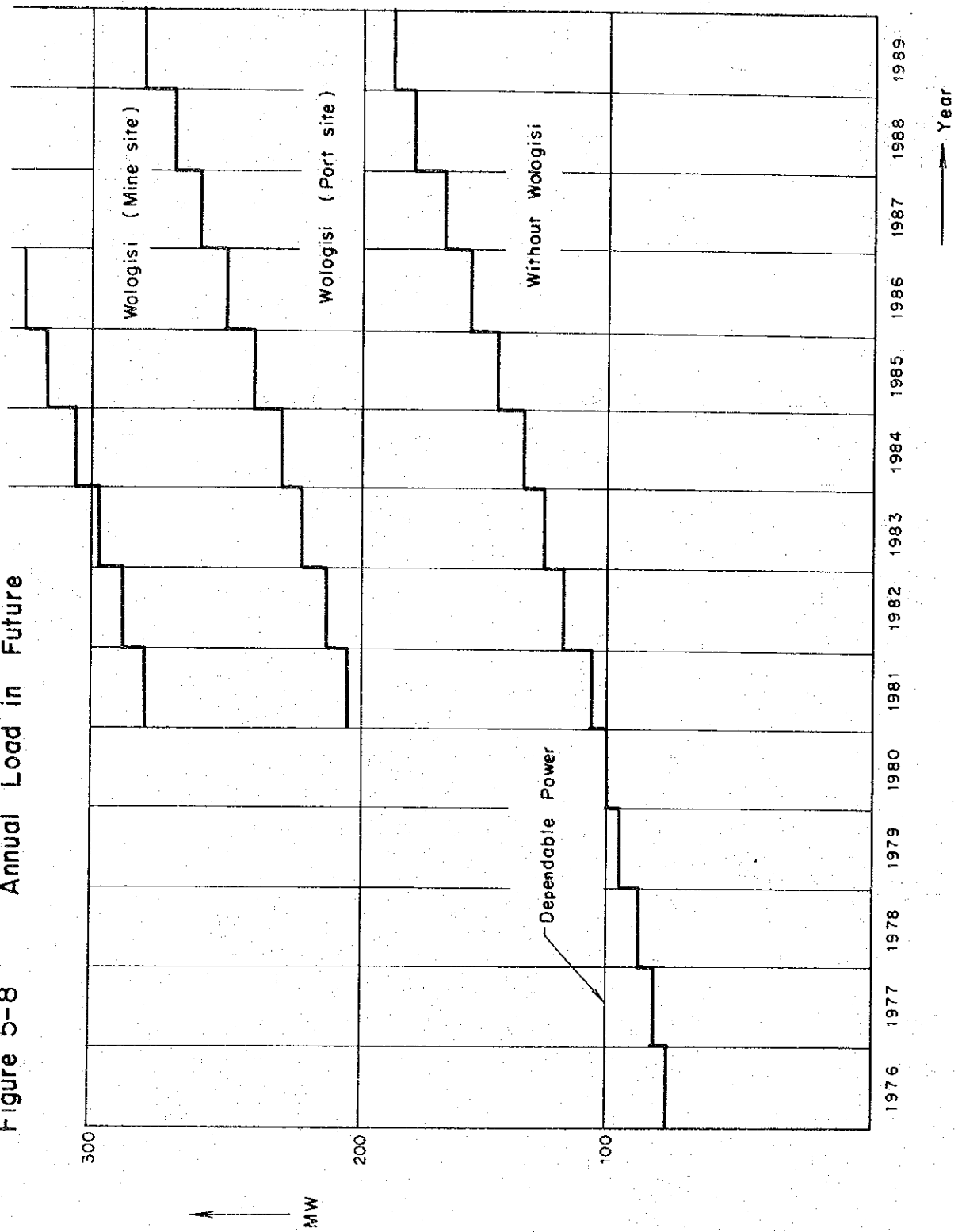
Table 5-6 KW Balance in Future (Monrovia Power System)

(MW)					
Year	Peak Load (a)	Dependable Power (b)	b-a (c)	Required Reserve (d)	d-c *1
1976	69	99	30	7	-
1977	74	99	25	7	-
1978	79	99	20	8	-
1979	85	99	14	9	-
1980	90	99	9	9	-
1981	*2 97(187)	99	*2 2(-88)	*2 10(19)	*2 8(107)
1982	104(194)	99	-5(-95)	10(19)	15(114)
1983	111(201)	99	-12(-102)	11(20)	23(122)
1984	118(208)	99	-19(-109)	12(21)	31(130)
1985	127(217)	99	-28(-118)	13(22)	41(140)
1986	136(226)	99	-37(-127)	14(23)	51(150)
1987	145(236)	99	-46(-137)	15(24)	61(161)
1988	155(245)	99	-56(-146)	16(25)	72(171)
1989	167(257)	99	-68(-157)	17(26)	85(183)

*1 Dependable Power to be added to Monrovia Power System

*2 Peak Load including Load at Port Site of Wologisi Project

Figure 5-8 Annual Load in Future



5-9 Characteristics of Supply Capability Required in Future

5-9-1 Daily Load Curve of Monrovia Power System in Future

The following conditions were considered in regard to the daily load curve of the Monrovia Power System in the future:

- (1) The years for which forecasts are to be made are to be 1981 when the Wologisi Mine starts production and 1986, five years later.
- (2) The load forecast was made in respect of two cases; "With Wologisi Mine" and "Without Wologisi Mine".
- (3) The daily load factor of the Monrovia Power System in the future is to be estimated as 75%, and 95% for Wologisi.
- (4) The operating patterns of the hydro and thermal facilities of the Monrovia Power System will vary greatly during the dry and rainy seasons. In effect, Mount Coffee Hydroelectric Power Station (68MW) will be in operation for the base load in the rainy season while Bushrod Thermal Power Station will provide the regulating power for peak load. In the dry season, the operating pattern will be the reverse of the rainy season. In this Report, in the sense of proceeding with a study based on hydroelectric sites for power development in the future, the month of the lowest water; March, is to be taken as the representative month.
Fig. 5-9 shows the monthly fluctuations in the output of Mount Coffee Hydroelectric Power Station in 1961.
- (5) Of the parts of the daily load curve to be borne by hydro and thermal, it is to be considered that Bushrod Thermal

Power Station, 62 MW (the largest unit capacity of 19 MW to be reserve capacity), will be in operation for the base load, and Mount Coffee Hydroelectric Power Station will provide the regulating power for peak load with regulating energy of 293 MWh ($12.2 \text{ MW} \times 24 \text{ hours}$). The remainder would be the part which will await new electric power development.

The daily load curves of the Monrovia Power System in the future forecast according to the above will be as shown in Fig. 5-10 to 5-12 for 1981 and Figs. 5-13 to 5-15 for 1986.

5-9-2 Required Peak Duration Time

As shown in Fig. 5-12, it was considered that the peak portion of load would be supplied by the existing hydroelectric power station in order to effectively utilize the regulating power of Mount Coffee Hydroelectric Power Station. Therefore, the operation curve which would be expected of a hydroelectric power station to be developed hereafter would be of flat type of long peak duration time (18 hours).

The above does not take Wologisi into consideration, but as indicated in Figs. 5-15, even when the power demand of Wologisi is taken into account, the necessary peak duration time will also be 18 hours.

Figure 5-9 Mean Power (Monthly) of St Paul River at Mount Coffee.

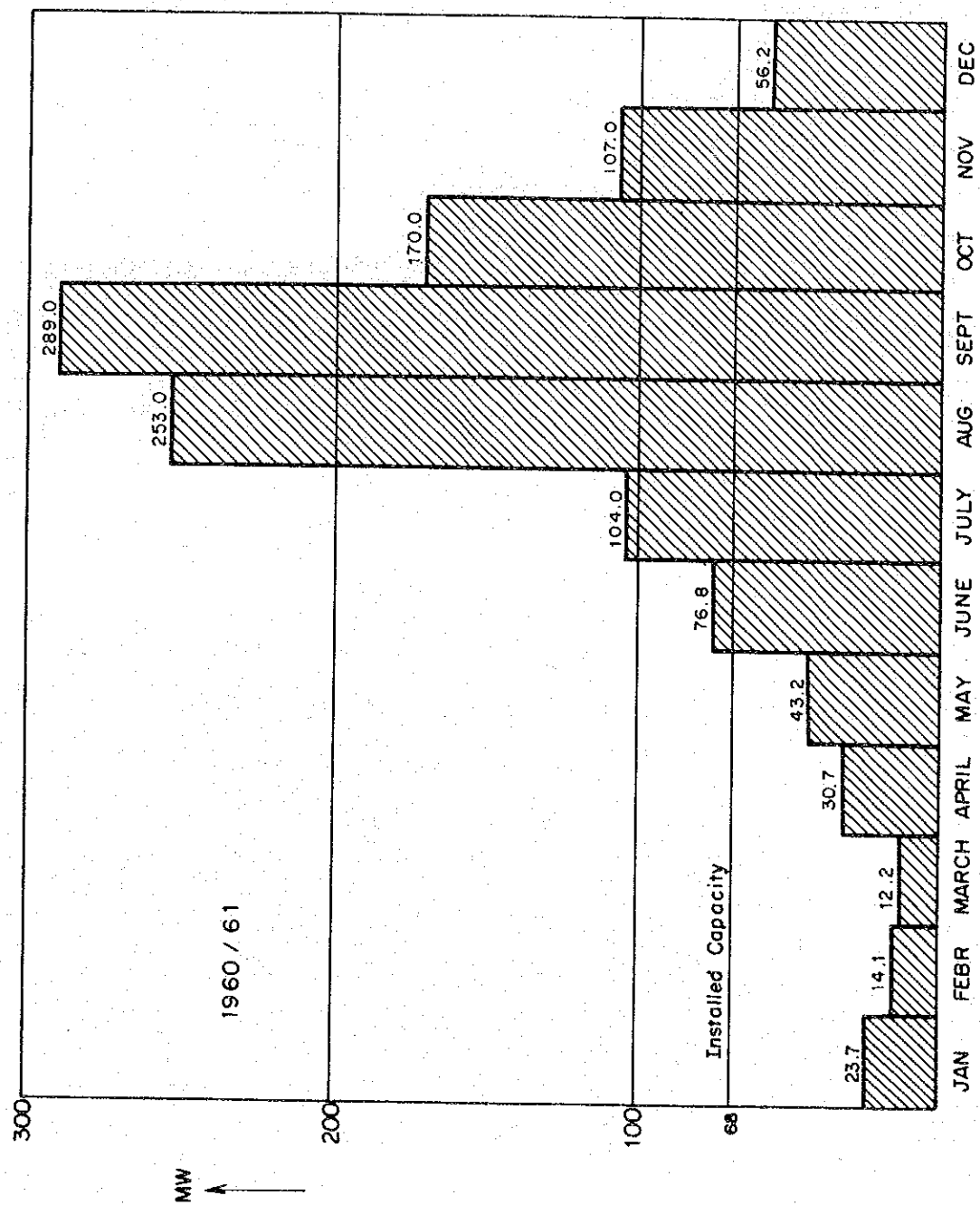


Figure 5-10 Daily Load Pattern in 1981
(Wologisi , Monrovia , Respectively)

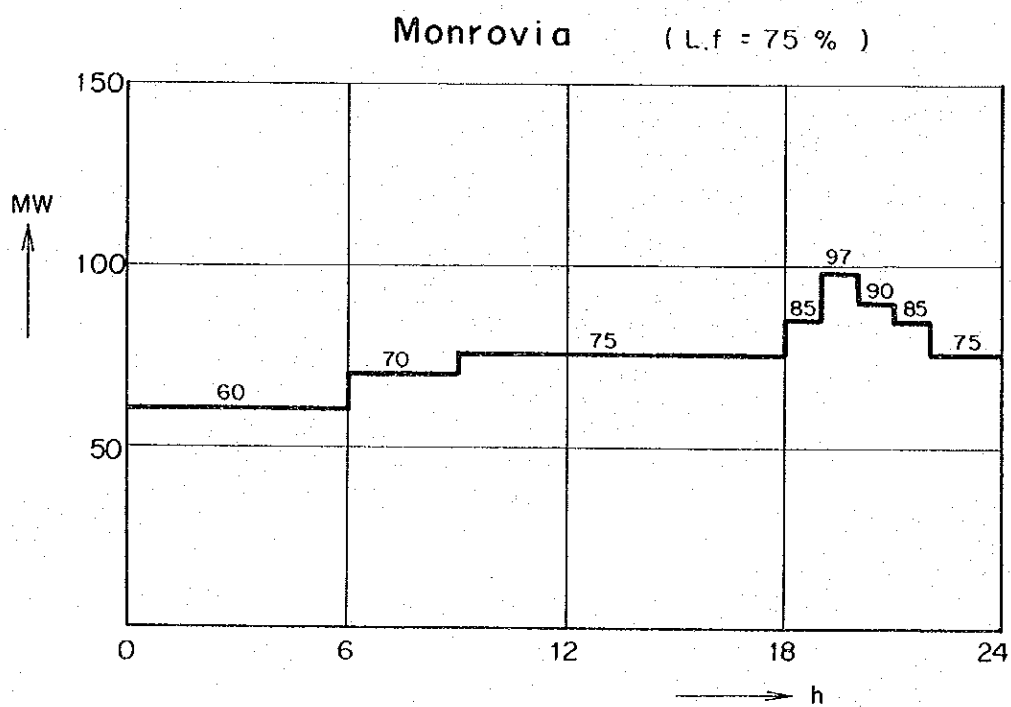
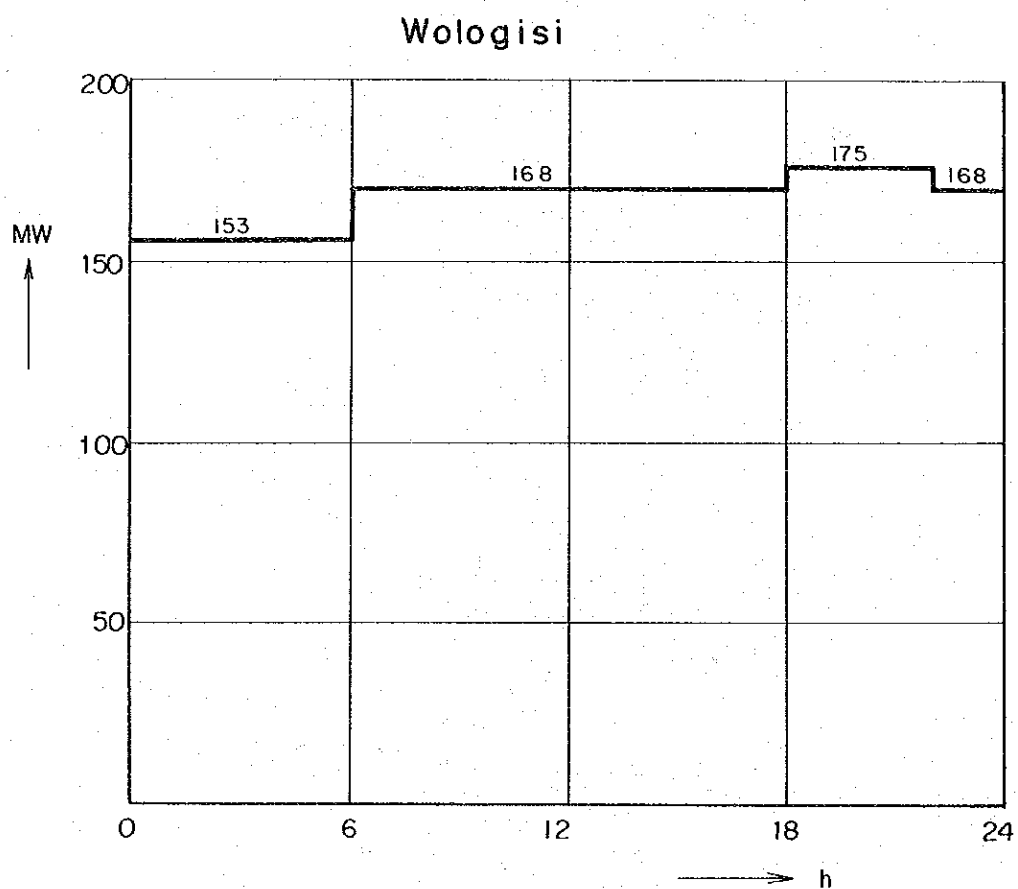


Figure 5-11 Daily Load Pattern in 1981
(Wologisi + Monrovia)

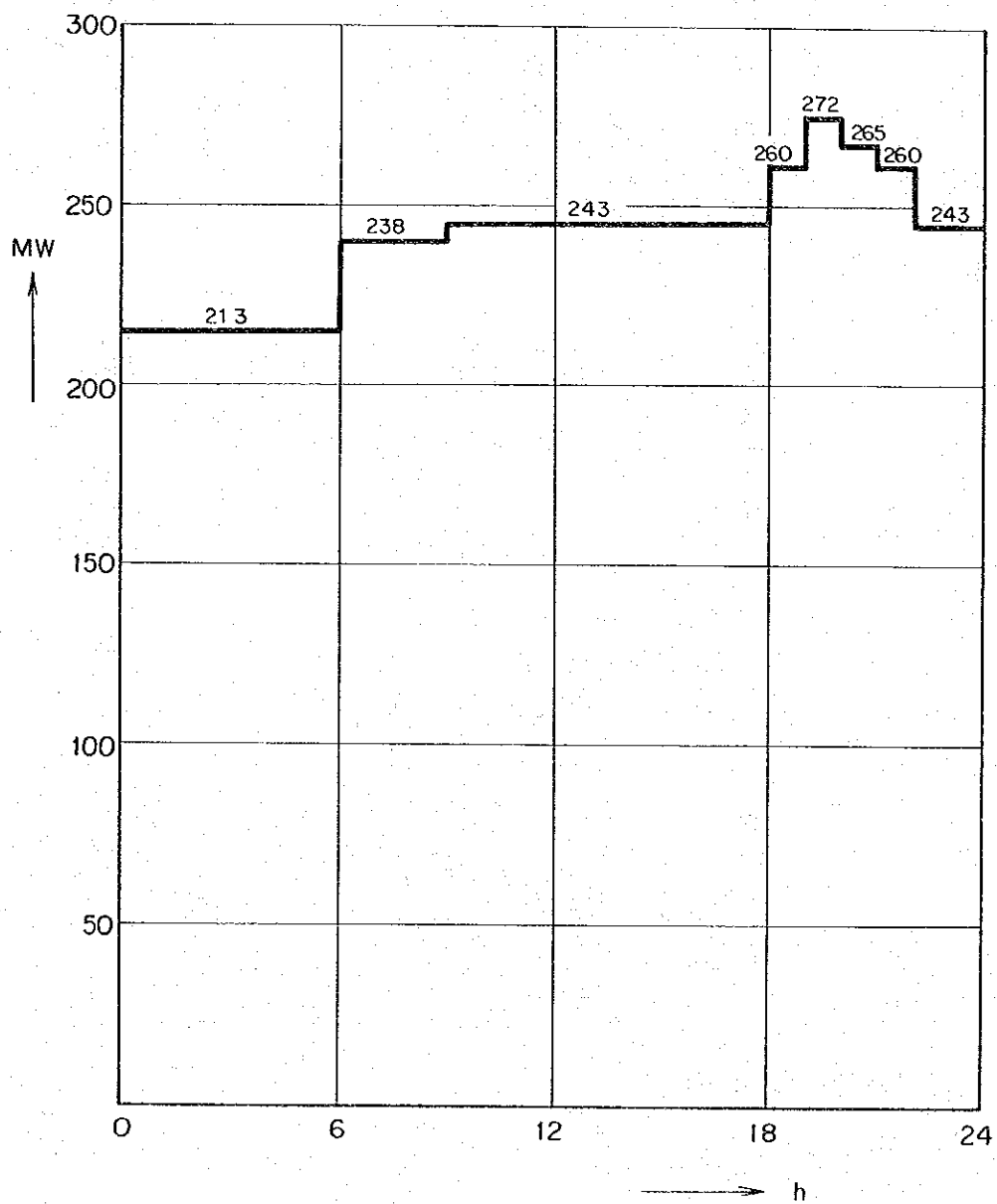


Figure 5-12 Daily Load Duration Curve
(Dry Season in 1981)

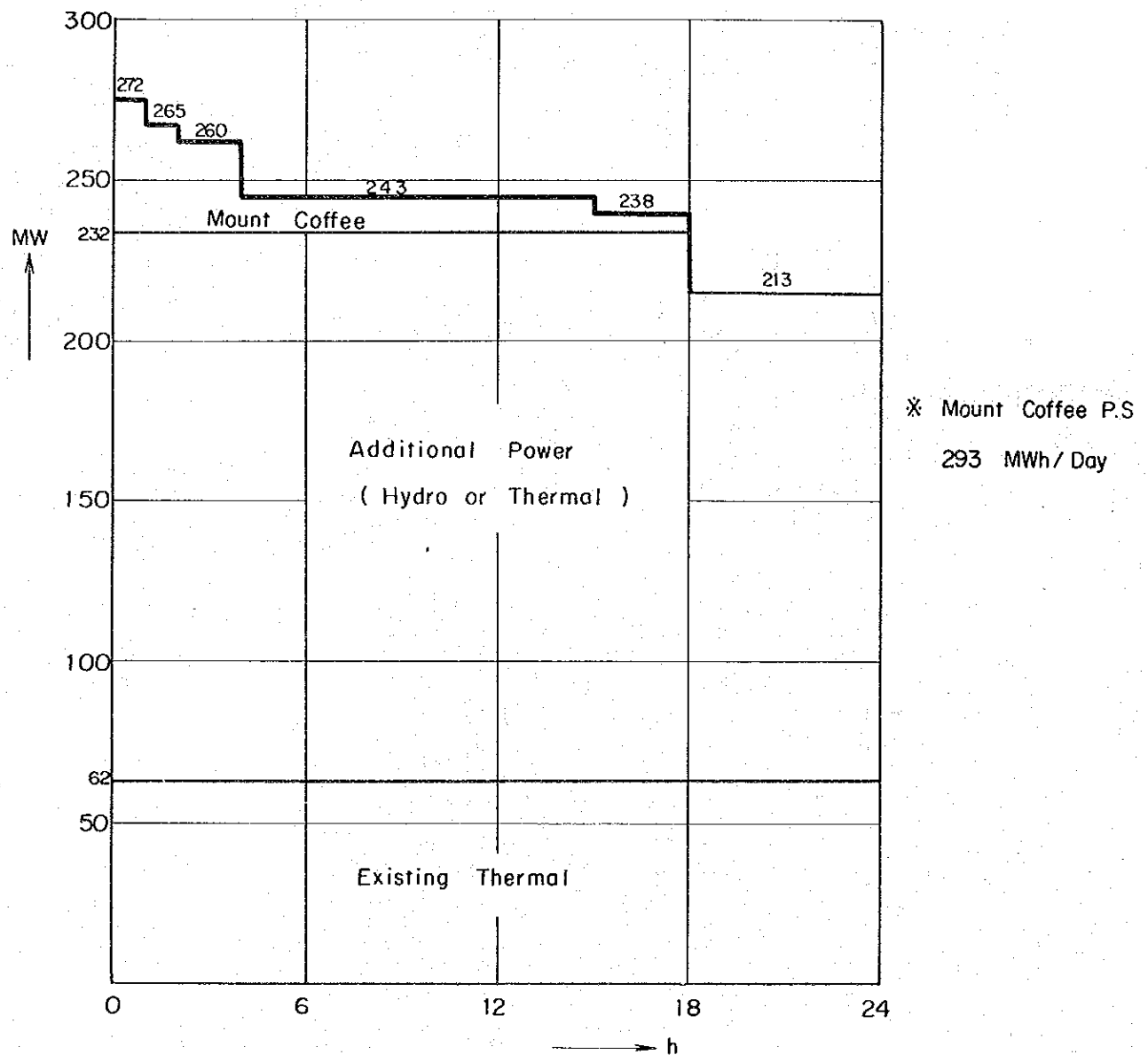


Figure 5-13 Daily Load Pattern in 1986
(Wologisi , Monrovia Respectively)

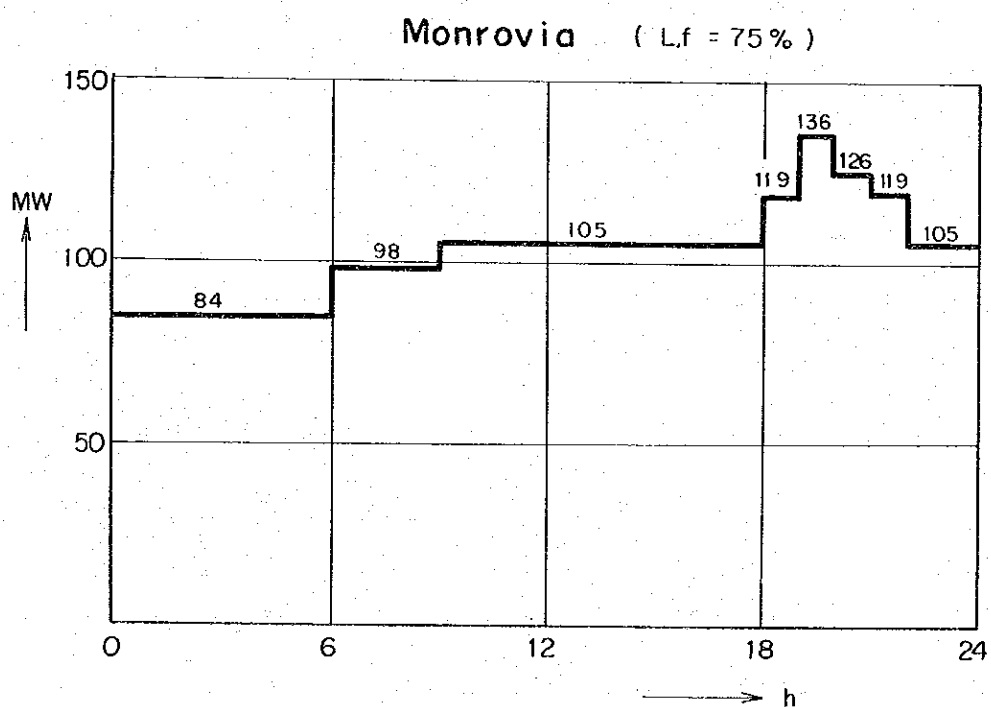
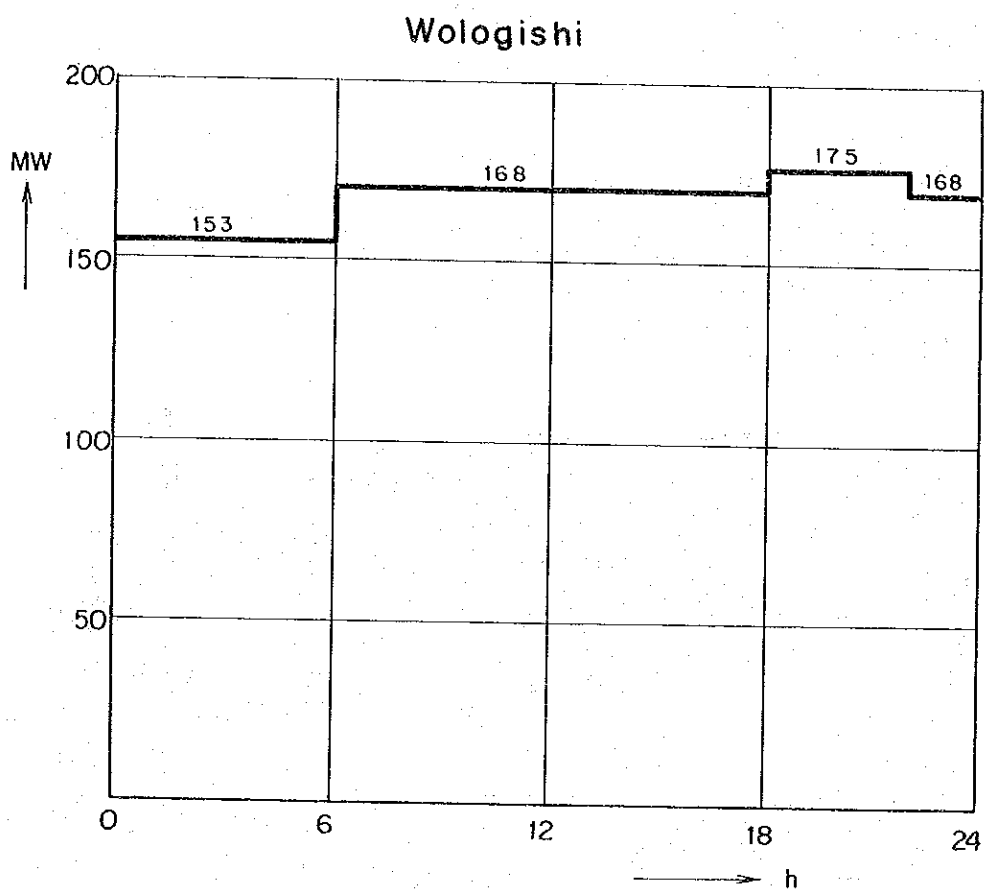


Figure 5-14 Daily Load Pattern in 1986
(Wologisi + Monrovia)

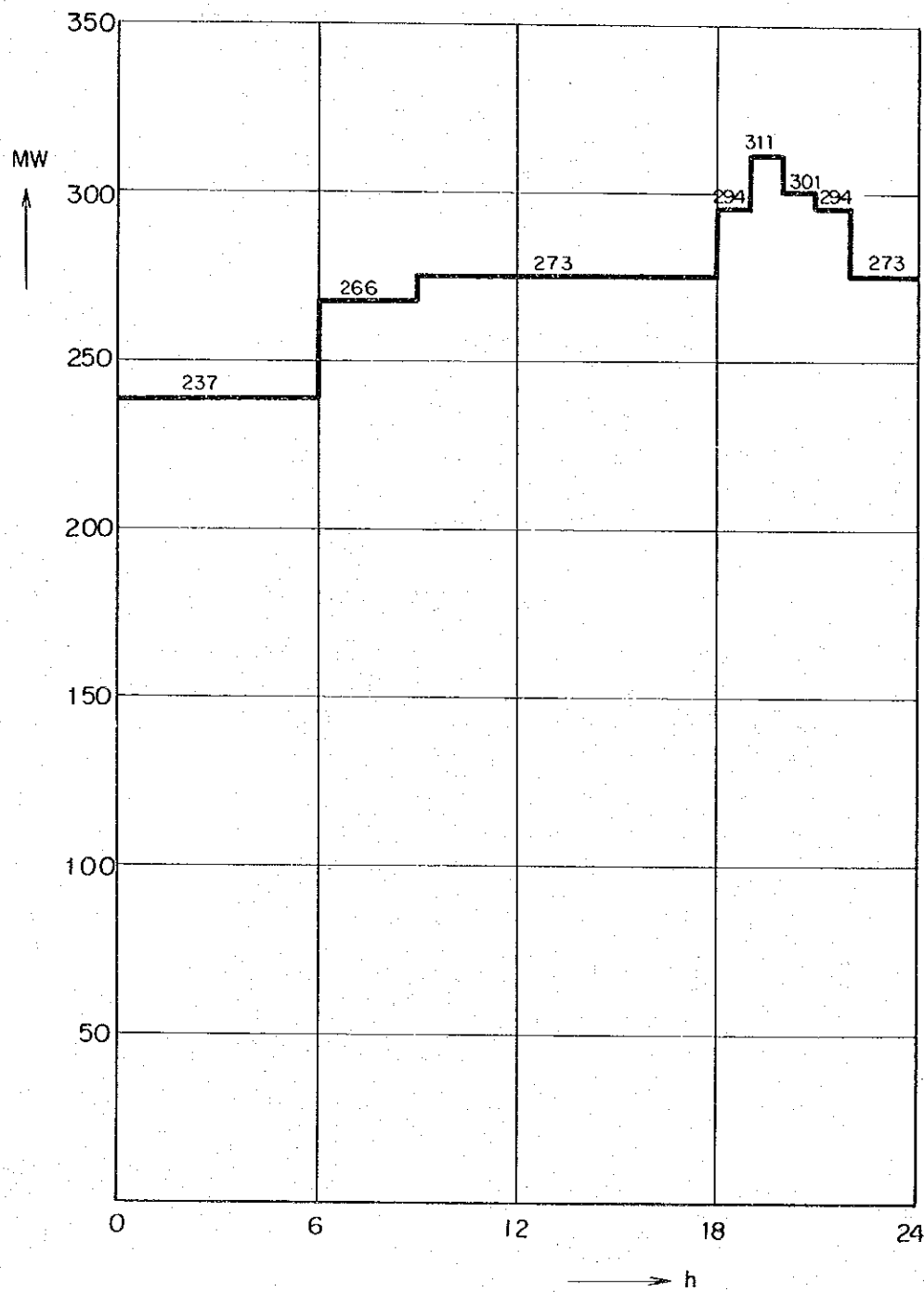


Figure 5-15 Daily Load Duration Curve
(Dry Season in 1986)

