LAO PEOPLE'S DEMOCRATIC REPUBLIC

FEASIBILITY STUDY
ON
XE KATAM SMALL-SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT

FINAL REPORT

MARCH, 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of Lao People's Democratic Republic, the Government of Japan decided to conduct a feasibility study on Xe Katam Small-scale Hydroelectric Power Development Project and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Laos a study team headed by Dr. Hiroshi Hori of Electric Power Development Company, Ltd., 9 times between December 1990 and March 1992.

The team held discussions with the officials concerned of the Government of Laos, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Lao People's Democratic Republic for their close cooperation extended to the team.

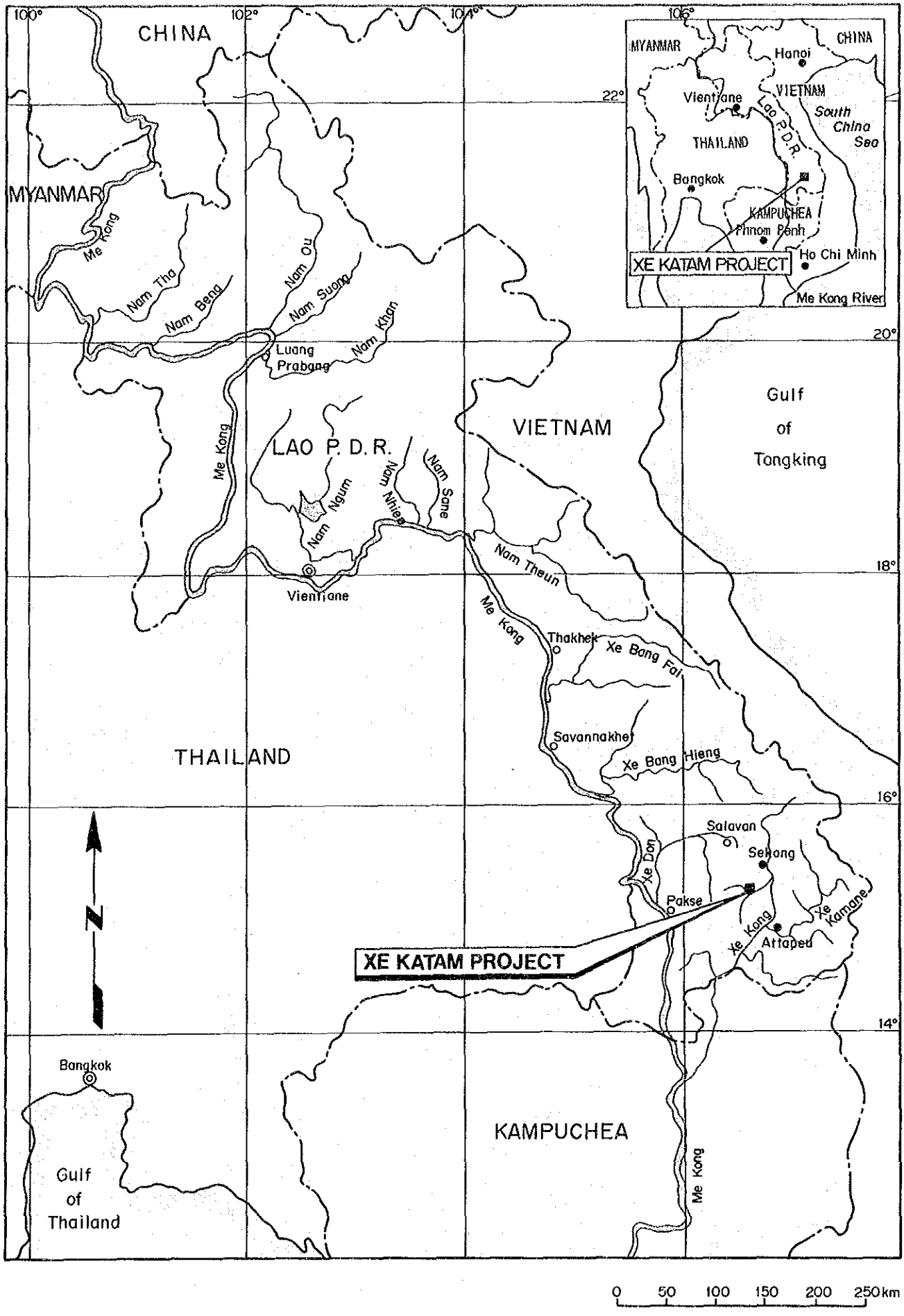
March 1992

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

XE KATAM PROJECT

LOCATION OF PROJECT



SALAVAN

XESET PROJECT

SELABAM
Hydropower
Station

SEKONG

PAKXE

XE KATAM PROJECT

CHONG MEK
(THAILAND)

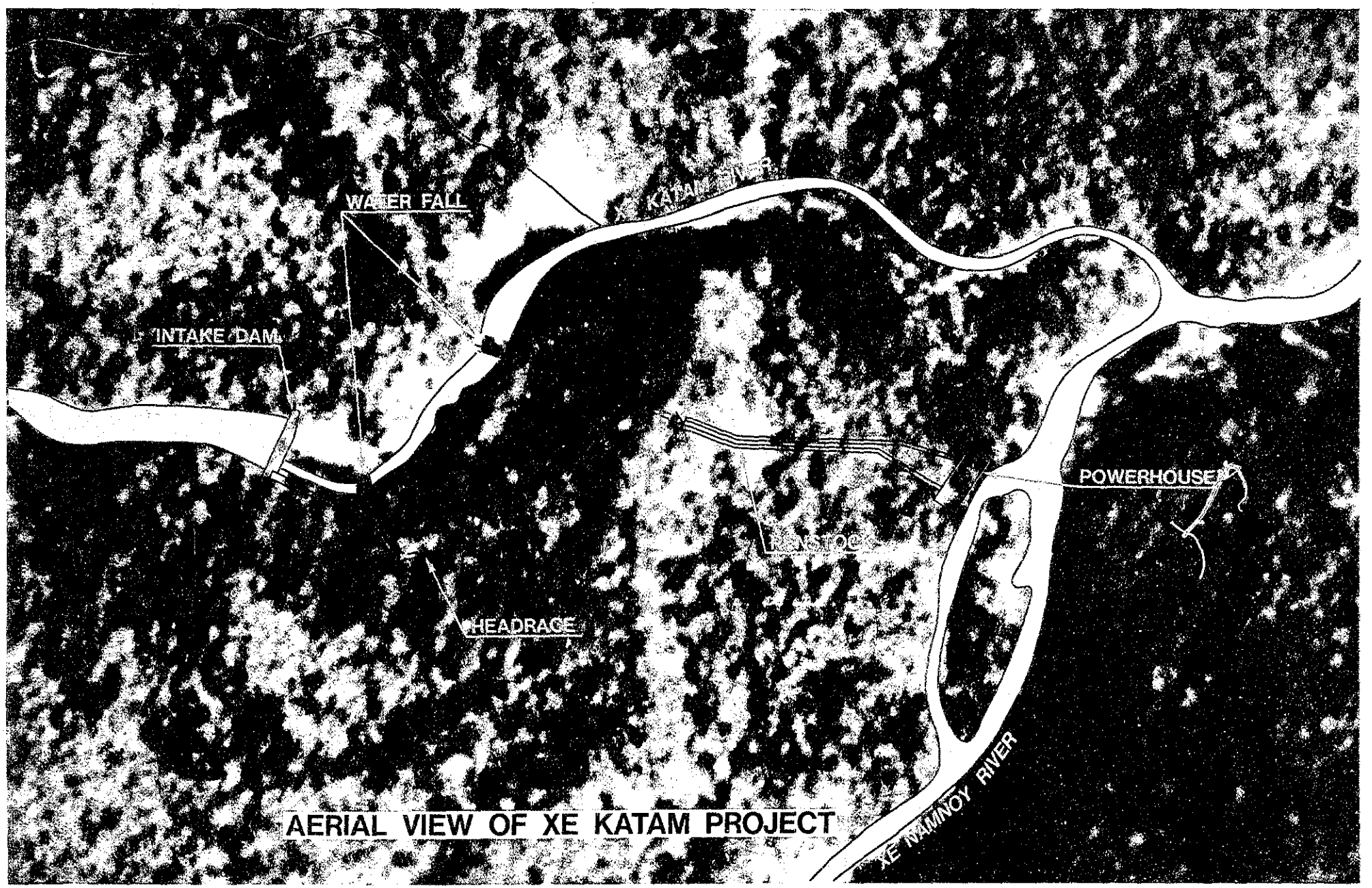
CHAMPASAK

ATTAPEU

CHINA
MYANMAR
VIETNAM
LUANG
PRABANG
LAOS
VIENTIANE
THAILAND
SALAVAN
PAKSE
SEKONG
ATTAPEU
KAMPUCHEA

XE KATAM SMALL-SCALE
HYDROELECTRIC POWER
DEVELOPMENT PROJECT

PROJECT AREA



AERIAL VIEW OF XE KATAM PROJECT

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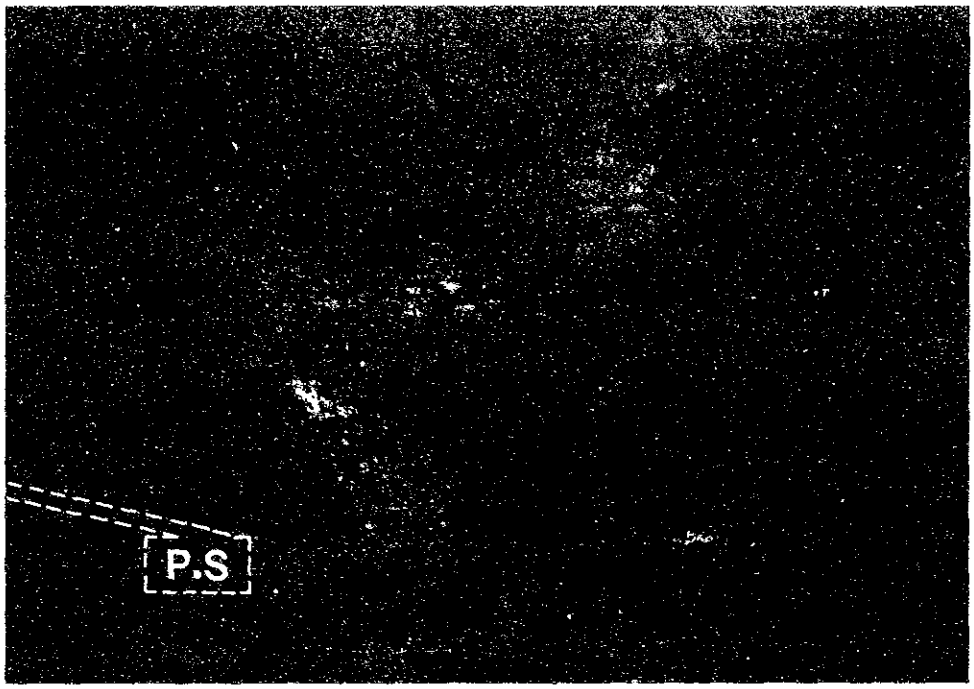
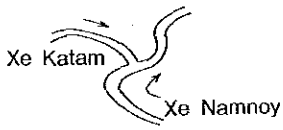


Confluence of Xe Katam and Xe Namnoy River



Penstock and Power House Site
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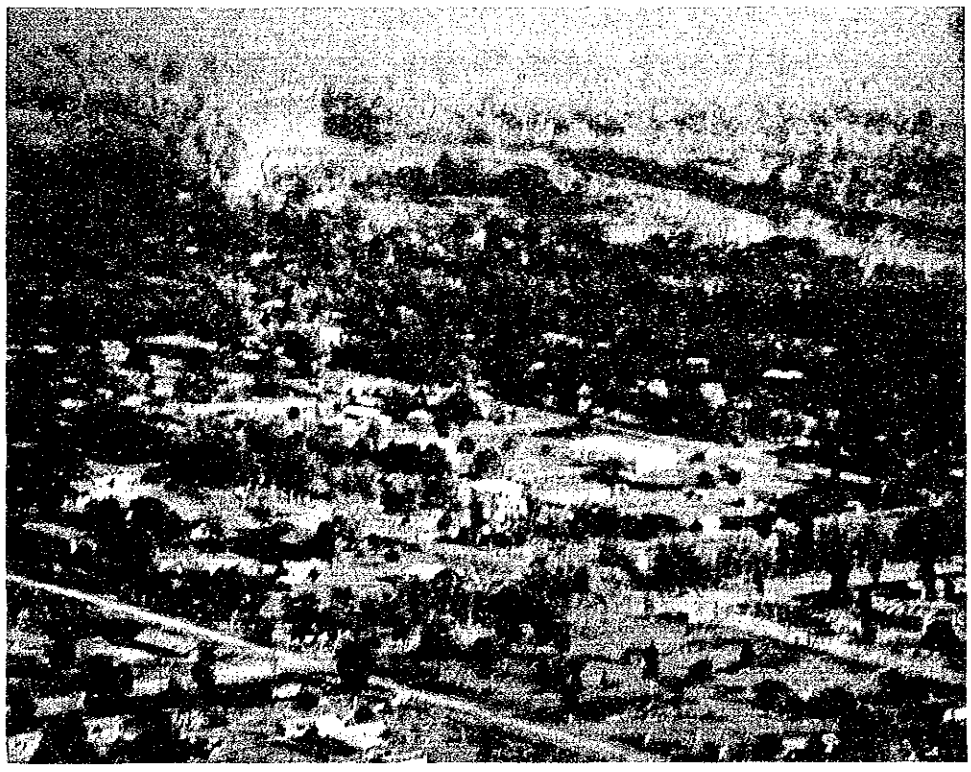
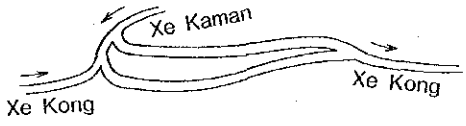
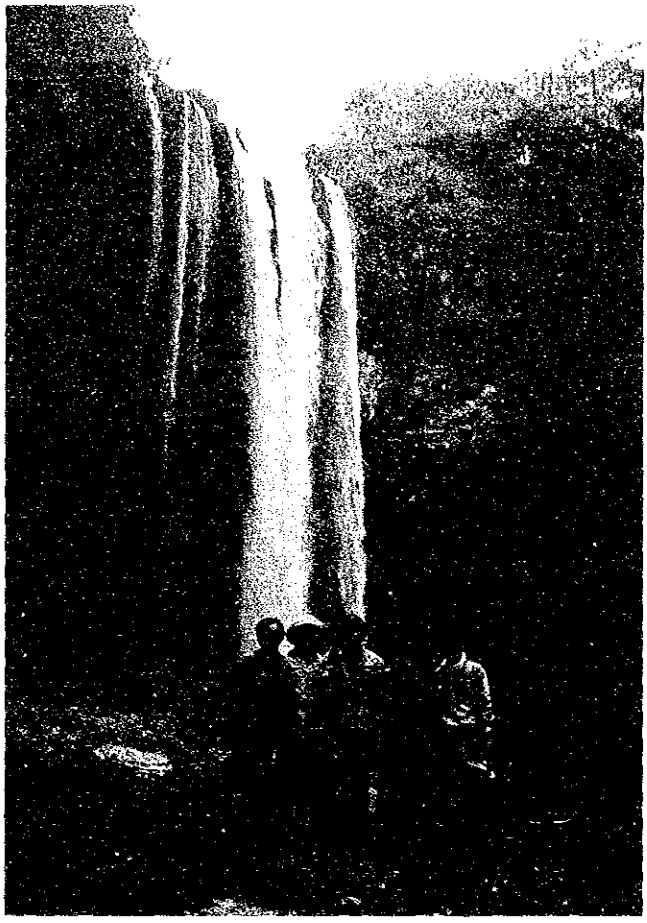
Sekong Town (Aerial Photo)

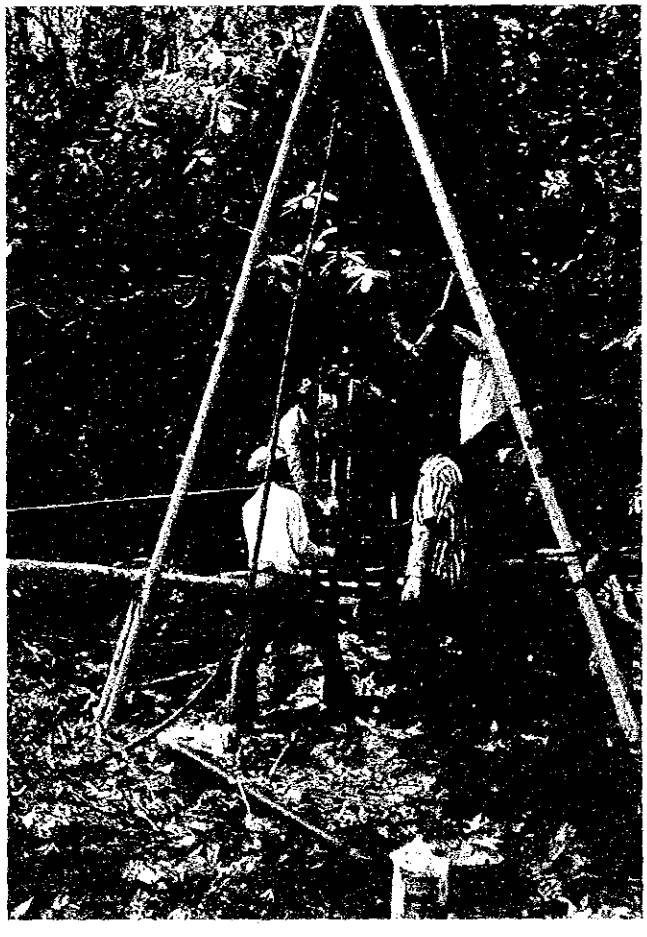


Attapeu Town (Aerial Photo)

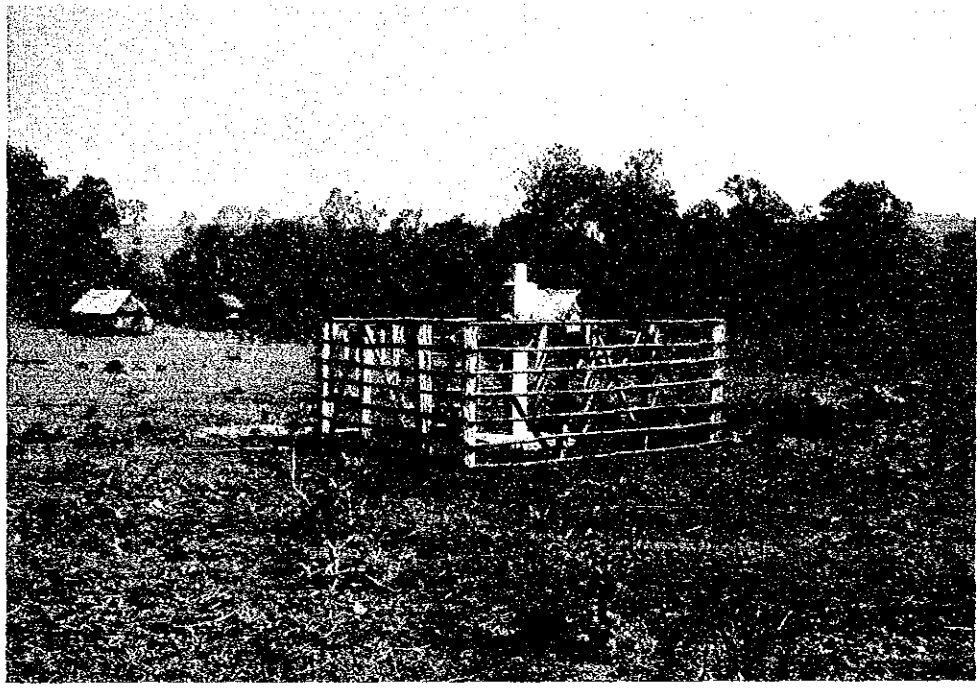




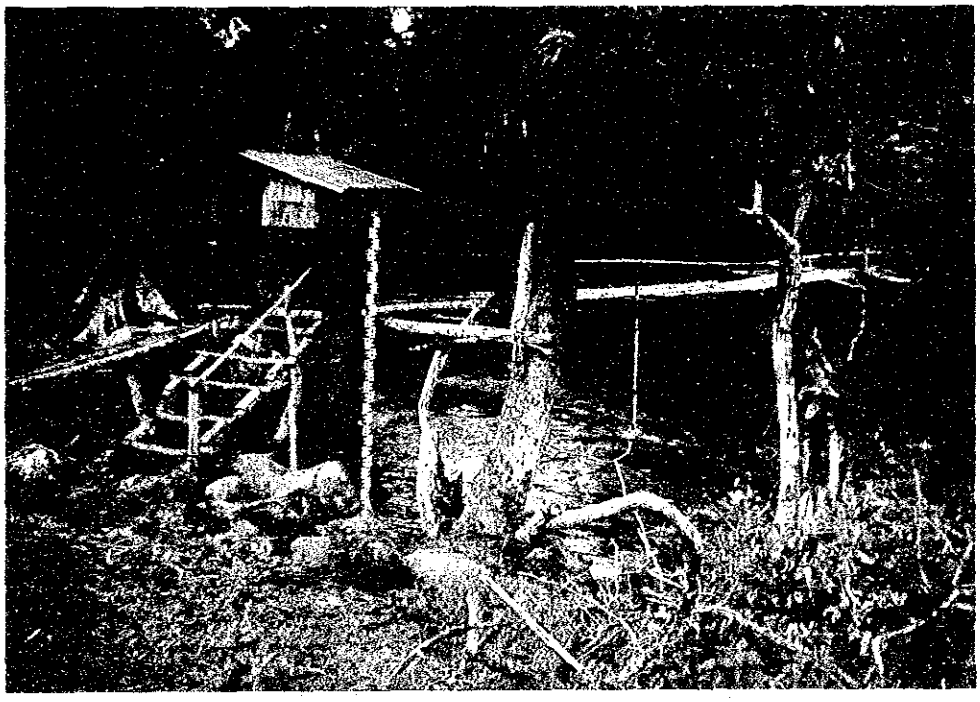
Water Fall located at the downstream of Intake Dam Site



Drilling Work of Geological Investigation (KI-2)



Newly Installed Rainfall Gauge (B. Xe Katam)



Newly Installed Water Level Gauge (B. Nonghin)

Signing of Minutes of Meeting

Left : Mr. Damdouane PHOMDOVANGSY
Director of Cabinet, MIH
Right : Dr. Hiroshi HORI
JICA Team Leader

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UNITS AND ABBREVIATION

(1) Units

mm	:	Millimeter
cm	:	Centimeter
m	:	Meter
km	:	Kilometer
inch	:	Inch (25.4 mm)
mm^2	:	Square millimeter
cm^2	:	Square centimeter
m^2	:	Square meter
km^2	:	Square kilometer
ha	:	Hectare (10,000 m^2)
m^3	:	Cubic meter
MCM	:	Million cubic meter
ℓ	:	Liter
m^3/s	:	Cubic meter per second
m/s	:	Meter per second
km/s	:	Kilometer per second (for elastic wave velocity)
g	:	Gram
mg	:	Milligram
kg	:	Kilogram
ton, t	:	Tonnes
t/m^2	:	Tonnes per square meter
kW	:	Kilowatt (1,000 watt)
MW	:	Megawatt (1,000 kW)
kWh	:	Kilowatt hour
MWh	:	Megawatt hour (1,000 kWh)
GWh	:	Gigawatt hour (1,000 MWh)
kV	:	Kilovolt (1,000 volts)
A	:	Ampere
kVA	:	Kilovolt-Ampere (1,000 VA)
MVA	:	Megavolt-Ampere (1,000 kVA)
rpm	:	Revolutions per minute
Hz	:	Hertz (cycles per second)

°	:	Degree
°C	:	Degree in centigrade
mb	:	Millibar
%	:	Percentage
Lu	:	Lugeon value (rate of water loss from a drillhole)
gal	:	cm/sec^2 (acceleration of earthquake motion)
Kcal	:	Kilocalorie (1,000 calorie)
hr(s), h	:	Hour(s)
yr	:	Year

(2) Glossaries

(i) Terms

Ave	:	Average
Max	:	Maximum
Min	:	Minimum
WL	:	Water Level
NHWL	:	Normal High Water Level
LWL	:	Low Water Level
TWL	:	Tail Water Level
EL	:	Elevation (Altitude)
CA	:	Catchment Area
UHF	:	Ultra High Frequency
VHF	:	Very High Frequency
cct	:	Circuit
a.c.	:	Alternative current
HAL	:	Hard Drawn Aluminum Stranded Conductor
ACSR	:	Aluminum Conductor Steel Reinforced
FRP	:	Fiberglass Reinforced Plastic
ASTM	:	American Standard for Testing and Materials
JIS	:	Japanese Industrial Standard
M_B	:	Body Wave Magnitude
M_S	:	Surface Wave Magnitude
GDP	:	Gross Domestic Product
IRR	:	Internal Rate of Return
EEDR	:	Economic Equalizing Discount Rate
FEDR	:	Financial Equalizing Discount Rate

SDR	:	Social Discount Rate
NPV	:	Net Present Value
OM	:	Operation & Maintenance
B	:	Benefit
C	:	Cost
B-C	:	Net Present Value of Surplus Benefit
B/C	:	Benefit Cost Ratio
FC	:	Foreign Currency
LC	:	Local Currency
CIF	:	Cost, Insurance and Freight
IDC	:	Interest During Construction
FOB	:	Free on Board
SPE	:	Southern Provinces Electrification Project

(ii) Currency

US$, $	:	U.S. dollar
Kip	:	Local Currency of Laos

(iii) Countries and Agencies

Laos	:	Lao Peoples' Democratic Republic
USA	:	United States of America
MIH	:	Ministry of Industry & Handicraft, Laos
JICA	:	Japan International Cooperation Agency
MEPF	:	Ministry of Economy, Planning & Finance, Laos
EDL	:	Electricite du Laos
HEC	:	Hydropower Engineering Consultants
EPDC	:	Electric Power Development Co., Ltd.
IBRD	:	International Bank for Reconstruction & Development
IDA	:	International Development Association
ADB	:	Asian Development Bank
SIDA	:	Swedish International Development Authority
UN	:	United Nations
UNDP	:	United Nations Development Program
EGAT	:	Electricity Generating Authority of Thailand

CONCLUSION AND RECOMMENDATION

CONCLUSION AND RECOMMENDATION

The feasibility study on the Xe Katam Small-scale Hydroelectric Power Development Project was carried out by JICA Team with a purpose to electrify towns of Sekong and Attapeu, both of which have not so far been satisfactorily electrified, by supplying reliable power which will be generated at the proposed power station.

To examine a possibility of hydropower development potentials from a comprehensive viewpoint, the Xe Katam river basin was surveyed in the closest context of the overall Xe Namnoy river basin. In order to do so, the study team formulated plans of various development projects within the Xe Namnoy river basin, and a composite evaluation was made for all possible development projects in regard to the economic and technical aspects. As a result, it was concluded that the proposed Xe Katam project would be quite an appropriate project as a means to satisfy urgent, latent demand of power of the two towns, taking into account of its timing and scale of development as well as its amount of investment.

In general, a small-hydro power project requires relatively high unit cost for power generation, that is, kWh cost. Keeping this in mind, sequence studies were made with full care; first, field reconnaissance was made to cover target areas and, next, fundamental information and data on topography, geology, hydrology, etc., on the whole area, as well as environment was collected. Third, based on the above-mentioned collected data and information, several comparison studies on various development plans were made in the Xe Namnoy and the Xe Katam river basin. As a result, the final plan of development was adopted, taking into consideration of its easiness of construction and also of its benefits to be derived from investment. The development plan thus finally adopted was further examined again in detail on the topography, geology and hydro meteorology. On the plan, the most appropriate design was applied.

Regarding the optimization of scale of development, analysis was made on the future demand of power forecasted in the two towns, and, in order to meet the forecasted demand, it was concluded to set up a power station with the

installed capacity of 2,000 kW at the initial development stage and of 6,000 kW as the final scale of development, in view of social and economic aspects.

For the economic evaluation, a diesel power plant was selected as an alternative power supply scheme to replace this project with a view to meeting future power demand to arise in the towns of Sekong and Attapeu. As a result of the comparison study, it has proved that the proposed hydropower plant would be superior to the said alternative scheme. It is also concluded that the development not to rely upon imported diesel oil would contribute to saving of foreign exchange outlays.

As far as the financial analysis is concerned, it has become apparent that the financial equalizing discount rate of the project would not reach 10% which is the social discount rate prevailingly used as a criterion for project evaluation in Lao P.D.R. unless some specially favoured financial arrangements are made in connection with the invested capitals for 2,000 kW at the first stage. It was thus concluded that some special financial measures should be needed for the sound implementation of the proposed project.

Regarding environmental effects of the proposed project, as the project is of a small-scale run-of-river type, there would not be any resettlement problems to be encountered and also the anticipated natural destruction during its construction as well as its operation would be minor.

In summary, the proposed project was judged as quite adequate as a power development project to be set up near the service area, even though some special financial measures may have to be made for the sound project implementation, because the study made by the Team clarified this project to be by all means viable from all view points including technical, economic, social as well as environmental and other considerations.

Nevertheless, this study had to be carried out within quite a limited period of time and on inadequate conditions, so that it had to be completed without success to collect a satisfactory amount of hydro-meteorological data, which collection require a long-term observation period as a matter of fact, although the utmost efforts were made by the Team throughout the study period

to try to collect such data from neighbouring observation stations as well as hydropower stations and also a limited number of data collected from new precipitation and run-off observation stations which were set up at the proposed area in this year. The river discharge simulation was carried out by means of all run off data collected.

In regard to the power demand survey, it was not necessarily easy to forecast demand due to paucity of historical data in service area. In fact, in the forecasting work, there were certain uncertainties on several factors, which are important for forecasting demands.

It is therefore recommended that the hydro-meteorological data observation be continued up to the next stage, that is, definite design stage, and that further more detailed survey be made for the power demand study which should include future investment plans for the development of mining, industry and agriculture in Sekong and Attapeu areas as well as the trend study on power demand in other neighbouring areas where electrification have already been materialized.

Furthermore, it is to be advised that monitoring of the environmental parameters should always be made even from the period prior to the project's implementation from the viewpoint of conservation of the river basin although there would not be any significant negative environmental effects caused by the Xe Katam project.

In addition, since this project is of a run-of-river type, there is some fear to be partly unable to supply stable power for a certain short period in the driest season after commissioning of this project. It is therefore expected that some transmission line expansion project to interconnect lines between the proposed ones and the adjacent existing ones would be realized in the future.

GENERAL PROJECT FEATURE (1/3)

Items	Description
Project Name	Xe Katam Small-scale Hydroelectric Power Development Project
River	Xe Katam River
Catchment Area	290 km^2
Installed Capacity	2,000 kW (First Stage) 6,000 kW (Final Stage)
Firm Capacity	1,400 kW (First Stage) 1,400 kW (Final Stage)
Available Annual Energy	16,613 MWh (First Stage) 40,299 MWh (Final Stage)
Intake Dam Intake Water Level Available Drawdown Gross Storage Capacity Effective Storage Capacity Type Dam Height Crest Length Sand Flush Gate Design Flood (100 year return period)	 El.. 469.0 m 1.0 m 30,000 m^3 10,000 m^3 Overflow type concrete gravity dam 8.6 m 77 m 5.0 m width x 4.0 m height 840 m^3/s
Intake	Side intake type with right-angled to the dam axis 6.0 m ~ 5.0 m width x 8.0 m height x 140 m length Gate 5.0 m width x 4.1 m height
Sand Stilling Basin	R.C open channel type 5.0 m width x 7.0 m height 33.0 m length
Culvert	Round reinforced concrete pressurized 2.0 m inside diameter 75.64 m length
Headrace Tunnel	Round lining reinforced concrete 2.0 m inside diameter 342.25 m length 25 cm lining thickness
Penstock	Exposed type & backfill type Steel pipes and FRP pipes First Stage: 336.788 m length Latter Stage: 290.104 m length
Powerhouse	Reinforced concrete, surface type First Stage: 15 m width x 11 m height 26 m length Latter Stage: 15 m width x 11 m height 25 m length Tail Water Level 306.7 m

GENERAL PROJECT FEATURE (2/3)

Items	Description
Turbine	Horizontal shaft Pelton turbine First Stage: 1,030 kW x 2 units Latter Stage I: 2,060 kW x 1 unit Latter Stage II: 2,060 kW x 1 unit
Generator	Horizontal shaft AC synchronous generator First Stage: 1,180 kVA x 2 units 3.3 kV Latter Stage I: 2,350 kVA x 1 unit 3.3 kV Latter Stage II: 2,350 kVA x 1 unit 3.3 kV
Transmission Line	to Sekong / to Attapeu Number of Circuit: 1 / 1 Line Length: 50 km / 73 km System Voltage: 22 kV / 22 kV Cable Type and Size: HAL 55 mm^2 / HAL 150 mm^2 Transmission Capacity: 2,000 kW / 3,000 kW
Construction Period	First Stage: 17 months (March 1994 - July 1995) Latter Stage I : 17 months Latter Stage II: 16 months
Total Construction Cost (including transmission line and interest during construction)	First Stage (2,000 kW): US$15,677,000 Latter Stage (4,000 kW): US$10,096,000 Total: US$25,772,000 (in 1991 price)

GENERAL PROJECT FEATURE (3/3)

Items	Description
Economic Evaluation (for final installed capacity of 6,000 kW) The net present value of the total cost to be incurred over the service life is assumed to be C, whereas that of the alternative diesel power plant during the same depreciation period is assumed to be B. The surplus benefit (B-C) and the benefit cost ratio (B/C) were calculated at a social discount rate of 10% in Laos. The economic equalizing discount rate (EEDR) at which the net present value of B and C are balanced was also calculated.	B - C = 1,365 x 10^3\$ B/C = 1.08 EEDR = 10.08% (which exceeds a social discount rate of 10%)
Financial Analysis (for final installed capacity of 6,000 kW) (1) Financial Analysis of the Project in terms of Invested Capitals The net present values of electricity sales revenue and total cost (Construction Cost + Operation and Maintenance Cost) are assumed to be B and C respectively. The surplus benefit (B-C) and the benefit cost ratio (B/C) were calculated at a discount rate of 10%. The financial equalizing discount rate (FEDR) at which the net present value of B and C are balanced was also calculated.	In case invested capitals are summed up for the first 2,000 kW: B - C = -1,178 x 10^3\$ B/C = 0.37 FEDR = 2.7% In case the amount of invested capitals is regarded as zero for the first 2,000 kW: B - C = +1,107 x 10^3\$ B/C = 1.2 FEDR = 14.3%
(2) Financial Analysis from the Standpoint of Power Utilities Debt Service Ratio (ratio of internal funds generated (operating profit + depreciation allowance) to debt (repayment of principal + payment of interest)) was calculated for the cases.	In case invested capitals are accounted up for the first 2,000 kW: Debt Service Ratio: 1.16 (Cumulative Average for 40 years) In case the amount of invested capitals is regarded as zero for the first 2,000 kW: Debt Service Ratio: 1.49 (Cumulative Average for 40 years)

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CHAPTER I BACKGROUND OF PROJECT

The objective of this report is to establish the feasibility of the Xe Katam Hydroelectric Project to be developed in the Xe Namoy River Basin in the southern district of Laos. For the purpose of this report, the general status of the nation of Laos, in particular, its resources, industries and energy situation, must be first reviewed, and then the necessity of developing the area under consideration as well as the past activities leading to this survey must be described.

1. Laos; its People, Land, Resources, Industry and Energy

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1. Laos; its People, Land, Resources, Industry and Energy

1.1 Land and People of Laos

1.1.1 Location

The Lao People's Democratic Republic (Lao PDR, to be termed "Laos" hereafter) is an inland country located in Indo-China Peninsular. The eastern boarder of this nation adjoins with Vietnam. To the west, the national territory mostly adjoins with Thailand except for a small northern portion where it adjoins with Myanmar. In the north, there is a border between Yunnan Province of the People's Republic of China where the border between Vietnam is separated. The southern border adjoins with Kampuchea [Note 1]. The land of Laos lies in the region roughly from 14° to 23° latitude north, and from 100° to 107°30', longitude east, and the whole territory belongs to the tropical zone.

1.1.2 Geographical Features

(1) Mekong River and Laos

The territorial land of Laos is 236,800 km^2 in area. Some 85% of this area, or 202,400 km^2, is included in the Mekong river [Note 2] Basin, and 45% of the total length of the Mekong River main stream of 4,200 km, or 1,865 km flows through the territory of Laos.

The Mekong River originates from Tibet plateau, flows down towards south along the northwestern border of Laos and Myanmar. The river further flows down to form the border between the northeastern region of Thailand and Laos for a distance of 1,500 km. The Mekong River then flows through the southern region of Laos to finally enter the territory of Kampuchea.

Among the tributaries which flow inside the Laos territory, the Nam Ou River in the northern region is the longest, being 448 km. The next longest river is the Nam Ngum River that is 345 km long and flows near the capital city of Vientiane. These rivers are large rivers although they are tributaries.

(2) Geographical Features of Laos

Laos is a mountainous country, with 80% of its territory consisting of mountain areas, and 30% of the national land area is above the elevation of 1,000 m.

Mountain ranges having elevation of 2,800 m to more than 1,500 m runs along the northern part to the eastern part of Laos [Note 3)], creating deep forests and plateaus which contain gorges here and there. Low, flat lands are found only along the Mekong River and the downstream areas of large and medium scale tributaries.

There is a plateaus named Bolaven Plateau on the eastern bank of the Mekong River at the southernmost region of Laos. The elevation of this plateau is approximately 900 m to 1,300 m. The area of this Project is in this Bolaven Plateau.

(3) Climate

The four nations including Laos which are in the lower basin of Mekong River are located in the center of Asian monsoon region, and are affected by the seasonal winds and rains in each year. The river basin experiences a distinctive dry season when the northeastern monsoon prevails. This climate starts in November and continues to around April. On the other hand, the southwestern monsoon starts to prevail for a period from late April to June, and this timing is different from year to year. The southwestern monsoon is called the summer monsoon, which carries wet and warm air (the humidity throughout a year changes from 50% to 90%). The annual average temperature is roughly from 20°C to 30°C.

The amount average precipitation for the whole land of Laos is not known. The annual precipitation in Vientiane from 1900 to 1980 was 2,291 mm (in 1980) at the maximum, and 1,247 mm (in 1971) at the minimum, the overall average being from 1,600 to 1,900 mm. The annual precipitation in other areas is roughly from 1,500 mm to 2,00 mm. At Pakse, which is near the Project Site, the maximum annual precipitation observed during the period form 1976 to 1989 was 2,545 mm (in 1985) at the maximum, and 1,676 mm (in 1985) at the minimum, the average being roughly 2,000 mm.

The lower basin of the Mekong is sometimes attached by the typhoon which is born is the Pacific Ocean at the east of the Philippines and blows westward. However, as typhoons are blocked by the mountain ranges in the eastern part of Laos to have their energy exhausted, Laos is seldom attacked by typhoons but for a few exceptional case [Note 4)].

1.1.3 People

The population of Laos is small, and the people are scattered in wide areas. The total population was 4,170,000 according to the governmental statistics of 1990. This means population density of 17.6 persons/km^2, which is the lowest in Asian countries. According to the census of 1990 (Table-1), population is concentrated in the capital city, the province of Vientiane, and Champassack Province and Salavane Province in the south. The next most populated provinces are Luang Prabang in the north. On the other hand, the area where the population density is low is Se Kong Province and Attapeu Province which are near the Project Site. The annual population growth rate is from 2.7 to 2.9%.

Table-1 Land Area and Population of Laos (1990)

Area (km^2)	Population (10^3)	Male (10^3)	Female (10^3)	Papulation Density (persons/km^2)	Province
3,920	442	225.4	196.6	113	Vientiane Mun.
18,270	142	69.6	72.4	9	Phongsaly
9,325	114	55.9	58.1	12	Luangnamtha
21,190	291	142.6	148.4	14	Oudomxay
4,970	64	31.4	32.6	13	Bokeo
16,875	339	166.1	172.9	20	Luangphrabang
18,500	243	119.1	123.9	15	Houaphanh
11,795	182	89.2	92.8	15	Xayaburi
17,315	189	92.6	96.4	11	Xiegkhuang
19,990	312	159.1	152.9	16	Vientiane
16,470	145	71.1	73.9	9	Bolikhamsay
16,315	249	122.0	127.0	15	Khammuane
22,080	640	313.6	326.4	29	Savannakhet
10,385	211	103.4	107.6	20	Salavane
7,665	58	28.4	29.6	8	Sekong
15,415	469	229.8	239.2	30	Champasack
10,320	80	39.2	40.8	8	Attapeu
Total 236,800	4,170	2,043.3	2,126.7	18	

(Source: "Basic Statistics (1975 - 1990)" issued by State Statistical Center of Ministry of Finance and Economic Planning of Laos)

The feature of Laos population is that the people belong to different ethnic groups. 55% of the population is Lao race, while 40% is non-Lao races, and the latter are divided into 65 different ethnic groups. The Lao race people are engaged in rice cultivation, and settle in low lands along rivers.

They are called the Lao Loum. Majority of citizens living in Attapeu town are Lao Loums. The people whose life style is opposite to the Lao Loum are the mountain people called the Lao Soung, who account for 15% of the total population. Races called Hmong, Yao, Man, etc. belong to this category. Many of them still cultivate traditional plants which can be exchanged with cash, such as opium, and the Laos Government is making effort to modify their tradition.

There are people called the Lao Theung who have a lifestyle which is somewhere between Lao Loum and Lao Soung. These people account for nearly 25% of the population . Most of them live in high lands between mountain areas and low lands, and usually make their living by shifting cultivation. Note 5). Around 70% of the citizens of Se Kong Town belongs to Lao Theung.

In addition, there are approximately 400,000 people who migrated from Vietnam, China, and other countries, and most of them live in low lands. Many of them are engaged in individual trade activities to make their living.

In some part of swampy land inside Vientiane City, the Vietnamese who entered Laos as refugees at the time of independence of Vietnam from France have settled down.

1.2 Resources, Industry and Transportation

Laos, being a mountainous country, is naturally endowed with mineral and forestry resources. However, most of these resources are left undeveloped, and there is no remarkable industry as yet. Yet, it is rich in future potential.

1.2.1 Mineral Resources and Their Development

It is well known that various mineral resources exist in many places in Laos.

First, reserves of lead, lignite and antimony is known in the northern Laos near the border with Myanmar. Also, there exist copper, lead, tin, zinc, manganese and lignite in Phone Sally district near the border with China. It has been reported that there are deposits of limestone and coal to the north of vientiane City, gold and iron along the Mekong River to the upstream of Vientiane, gold, lead, copper, iron, gypsum, tin, limestone and salt in Khammouan Province and Savannakhet Province, gold, silver, copper, lead, iron, gypsum and salt in Champassak area, gold, silver, copper and lead in Attapeu Province, and silver, copper, gold, lead, zink and tin in Se Kong Province.

Tin was mined in the river basin of the Nam Theun in Khammouan Province. Some 1,800 tons of refined tin ores were produced before the Second World War, which was one of the most important industry in Laos at that time. The coal mine to the northwest of Vientiane City was also operated before the War.

However, no substantial mining industry has been developed in Laos of today. Only mining industries we can observed today are the mining of 100,000 tons of gypsum per year at Dong Heng in Savannakhet Province which is exported to Vietnam, a small coal mine in Bo Chan area of Vientiane Province which produce 1,000 tons of coal per year for domestic consumption, and the mining of around 350 tons of tin ores per year at Phon Tiou and Bo Neng for export to COMECON countries with the aid of USSR. Among these mineral resources, the tin reserves of Bo Tiou and Bo Neng are estimated to exceed 130,000 tons, and it is expected that tin metal of high quality can be produced only if electric power is made available. On the other hand, the reserves of iron ore in

various locations of Laos are estimated to one billion tons, and there is a possibility of bauxite reserves. Some recent trend of mineral productions in recent years in Laos is presented in Table-2. That is, there has not been any remarkable in mineral industry development so far in general.

Table-2 Trend of Minerals Production in Laos

Fiscal Year	Tin	Gypsum	Salt	Coal
1981	255	40,000	3.3	-
1982	356	-	5.1	111
1983	362	70,000	6.5	750
1984	430	84,000	7.8	830
1985	520	100,000	9.1	1,000
1986	559	98,000	8.6	1,556
1987	450	70,000	13.8	1,550

(Source: "Economics", "Laos, Country Profile 1990 - 91")

1.2.2 Forests and Their Development

42% of the land area of Laos, or approximately 10,000,000 ha of her land is covered by forest (1989).

Of these forests, it is being estimated that approximately 4,000,000 ha can be developed economically. As a matter of fact, 68% of the total land of Laos has been covered by forests until recently , but 200,000 hectares of forests were lost every year by timber production (legal and illegal), shifting cultivation, charcoal manufacturing, etc. To deal with this situation, the Government is now implementing the forest protection and afforestation policy. That is, with the objectives of protecting forests and encouraging sound development of timber processing industry, the Government of Laos has decided to gradually decrease the export of raw timber (October, 1987) and to prohibit the export of all raw timbers and vines (1988). However, Thailand strongly

demanded the export of timber, and the ban on export to Thailand was canceled in January, 1989.

The forests in Laos consists of cedar, hard mahogany, Celtis sineusls, pine, teak, etc. The eulaias are found in abundance in plateaus of Laos, which makes a Japanese visitor to remind his home land. Although forests are indispensable for preservation of soil and water resources, thy are used to as construction materials, fuel and production of papers. The major item of export of Laos used to be the export of electric power to Thailand from Nam Ngum Dam Power Plant. However, the export of timber has become the largest times of export since these several years. In terms of amount of timber production, it was 170,000 m^3 (with the target being 400,000 m^3) in 1984, and 230,000 m^3 (with the target being 2500,000 m^3) in 1986.

As of 1989, 213,000 m^3 timbers were supplied for lumbers, veneers and sleepers, 108,000 m^3 for industrial wood, and 3,992,000 m^3 for fuel. These figures clearly indicate the increase of deforestation of Laos forests.

In 1989, the Government started to levy high taxes on production of timbers, vines and related products with the objective of protecting tropical forest. The Government intends to suppress the growth of timber production at 20% per year for the coming 5 years (1990 - 1995). This measure may save the extraordinary deforestation [Note 6)] in many provinces including Vientiane. However, it can not be denied that the Government is confronted with the two contradictory responsibilities of "securing revenue from forests" and "protecting forests".

1.2.3 Fishery

The total extension of the main stream and its tributaries of the Mekong River to the upstream of Kratie in Kampuchea is at least 10,000 km. Substantial portion of this water lengths lies inside the territory of Laos. Based on this fact, it is logical that river fish are important food resources for the Laos people.

It is estimated that around 200 species of fish live in the Mekong river. 54% of these fish is a kind of carp named Cyprindal, 19% catfish (Claridae, Schiheidae, Bagridae, Sisoridae, Akysisae), 8% murrel (Ophicephalidae), and the remaining 19% are worthless fish such as Featherback. Among these 200 species, there are some migrating fish which swim up an down the upper and middle streams of the Mekong River over long distances. The well known species among these is the female of large fish named Bla Buk that freely swim up and down from the downstream of the Mekong River inside Kampuchea to the upstream part in Yunnan Province of China. All along the main stream of the Mekong River, from Paske to Xanakham which is to the upstream of Vientiane, lights of fishing boats are observed at night. The fishing in the main stream and tributaries are performed by trawls, drift nets, weirs, etc. However, we cannot find a comprehensive statistics of fishery. Since the completion of the Nam Ngum Dam, substantial amount of carps and crucian carps are fished, and it is reported that the total catch is between 1,500 and 2,000 tons per year. It is expected that, as development of reservoir type hydroelectric power plant progresses in the future, fish production will be increased. Also, fish cultivation in reservoirs can be accounted to the local people as their new way of sustaining their lives.

1.2.4 Agricultural Land and Agricultural Production

As discussed before, Laos is a country of mountains and plateaus. However, there are low, flat lands which are suitable for paddy field in the limited areas along the main stream of the Mekong River and at the middle stream and downstream areas of large and medium sized tributaries. That is, there are relatively open lands at Luang Prabang, and Sayaburi of northern Laos, and the Vientiane plain at the downstream of the Nam Ngum River. Further south, low and flat lands exist in the middle stream and downstream areas of the Se Bang Fai, the Se Band Hieng, the Se Done and the Se Kong Rivers.

The land areas that can be used for agricultural cultivation in Laos, including Bolaven Plateau in the south, are estimated to account for 22% of the national land, or 5,000,000 ha, but only 700,000 ha of lands are currently utilized. The Vientiane plain is the most important land for paddy field agriculture of Laos, but the area used for rice cultivation is around

100,000 ha. (See Table-3.) The amount of production of unhulled rice in the whole Laos in fiscal 1990 was from 1.4 to 1.5 million tons. (See Table-4 and Table-6.)

Table-3 Trend of Cultivated Land Area (ha)

1976	1980	1985	1986	1987	1988	1989	1990	Provinces
-	-	37,459	38,246	33,884	36,658	39,673	42,247	Vientiane.M.
20,785	29,018	26,989	24,300	9,832	22,090	23,764	24,900	Phongsaly
23,722	34,162	18,666	18,750	16,886	16,138	17,827	18,726	Luang Namtha
35,876	40,272	43,521	52,586	43,597	45,884	40,437	42,160	Oudomxay
-	-	9,697	9,510	9,398	9,247	5,449	8,782	Bokeo
43,216	51,421	59,557	57,196	34,115	39,965	42,106	71,498	Luang Prabang
34,032	42,064	39,557	33,940	43,167	45,070	30,531	41,397	Houaphanh
26,070	55,085	33,821	27,942	25,400	22,689	27,419	25,634	Xayaboury
16,880	27,137	28,089	30,800	17,339	19,471	20,242	22,738	Xieng Khouang
79,205	113,396	58,704	58,000	41,829	41,257	58,200	57,500	Vientiane
-	-	22,535	19,152	24,174	22,883	24,100	29,000	Borikhamxay
46,641	50,393	42,083	40,984	32,451	22,080	39,200	45,010	Khammouane
70,984	113,439	94,009	90,588	92,401	89,003	90,183	85,840	Savannakhet
38,728	55,955	36,038	37,724	34,461	34,720	40,165	41,088	Salavane
-	-	7,601	7,570	7,665	6,419	7,303	7,498	Se Kong
75,639	97,046	84,014	80,854	76,965	60,093	77,484	79,995	Champasak
10,045	14,954	12,622	13,490	12,873	10,981	12,077	12,641	Attapeu
521,823	724,342	654,962	641,632	556,437	544,828	596,160	656,654	Total

(Source : "Basic Statistics (1975-1990)" Lao.P.D.R)

Table-4 Trend of Rice Production (tons)

1976	1980	1985	1986	1987	1988	1989	1990	Provinces
-	-	106,068	114,803	92,187	125,212	136,862	159,899	Vientiane.M.
20,055	26,093	38,201	39,025	15,755	33,045	36,352	39,720	Phongsaly
19,397	48,988	28,939	30,579	25,997	28,076	35,711	33,129	Luangnamtha
44,041	45,140	60,922	84,048	75,373	82,893	85,675	86,732	Oudomxay
-	-	17,281	19,748	17,684	19,606	15,593	22,467	Bokeo
46,028	68,998	83,303	8,747	54,938	65,489	71,657	111,419	Luangprabang
39,509	50,620	59,566	52,967	71,219	66,649	64,368	82,490	Houaphanh
37,232	73,881	56,383	57,043	39,303	47,329	65,217	49,527	Xayaboury
17,623	36,413	63,567	63,480	37,299	47,991	47,965	54,068	Xiengkhouang
101,262	183,467	121,481	128,484	91,116	104,033	138,537	130,017	Vientiane
-	-	44,970	40,514	47,059	53,249	52,250	63,600	Borikhamxay
33,411	73,398	106,168	107,169	82,189	34,076	98,572	117,868	Khammouane
101,051	175,507	235,108	234,297	233,612	94,016	247,613	235,877	Savannakhet
38,234	95,246	89,401	97,672	88,244	73,410	102,820	98,464	Salavane
-	-	10,218	11,076	10,247	4,384	8,812	10,646	Sekong
153,569	154,099	244,780	252,410	207,573	105,833	167,934	183,869	Champasack
9,544	21,278	28,801	29,604	25,716	18,092	28,165	28,610	Attapeu
660,938	1,053,128	1,395,177	1,450,266	1,215,511	1,003,383	1,404,103	1,508,402	Total

(Source : "Basic Statistics (1975-1990) " Lao. P.D.R)

Table-5 Productivity of Rice (tons/ha)

1976	1980	1985	1986	1987	1988	1989	1990	Provinces
-	-	2.36	3.00	2.72	3.42	3.45	3.78	Vientiane.M.
0.96	0.90	1.26	1.61	1.60	1.50	1.53	1.60	Phongsaly
0.82	1.43	1.38	1.63	1.54	1.74	2.00	1.77	Luang Namtha
1.23	1.12	1.31	1.60	1.73	1.81	2.12	2.06	Oudomxay
-	-	1.89	2.08	1.88	2.12	2.86	2.56	Bokeo
1.07	1.34	1.36	1.53	1.61	1.64	1.70	1.56	Luang Prabang
1.16	1.20	1.51	1.56	1.65	1.48	2.11	1.99	Houaphanh
1.43	1.34	1.55	2.04	1.55	2.07	2.38	1.93	Xayaboury
1.04	1.34	1.76	2.06	2.15	2.46	2.37	2.38	Xiengkhouang
1.28	1.62	1.79	2.22	2.18	2.52	2.38	2.26	Vientiane
-	-	2.10	2.12	1.95	2.33	2.17	2.19	Borikhamxay
0.72	1.46	1.80	2.61	2.53	1.54	2.51	2.62	Khammouane
1.42	1.55	1.94	2.59	2.53	1.06	2.75	2.75	Savannakhet
0.99	1.70	1.90	2.59	2.56	2.11	2.56	2.40	Salavane
-	-	1.38	1.46	1.34	0.68	1.21	1.42	Se Kong
2.03	1.59	2.15	3.12	2.70	1.76	2.17	2.30	Champasak
0.95	1.42	1.92	2.19	2.00	1.65	2.33	2.26	Attapeu
1.27	1.45	1.77	2.26	2.18	1.84	2.36	2.30	Total

(Source : "Basic Statistics (1975-1990) " Lao. P.D.R)

Table-6 Projection of Crop Production from 1990 to 1995

Product	1990 Production (000 tons)	Annual Growth over Plan (%)
Paddy (total consisting of	1,407.5	2.3
- Rainfed lowland	1,068.0	2.9
- Irrigation	45.5	8.8
- Upland	294.0	(-1.0)
Vegetables	72.8	10.9
Maize	51.4	12.2
Cotton	4.8	8.7
Coffee	5.3	14.9
Tobacco	38.7	13.0
Root Crops	176.1	20.0
Groundnuts	6.9	15.9
Mung beans	3.1	4.9
Soybeans	5.5	15.0
Tea	0.8	33.5
Sugarcane	144.7	15.0

(Source: Finance and Economic Planning Ministry of Laos, "Policy Framework for Pubic Investment Program, 1990, 11")

Although there are swampy lands which can not be drained in the Vientiane plain, some of them can be converted to cultivated land by constructing irrigation and drainage facilities. At present, Japan and Australia are attempting irrigation for a part of this plain for an area of 7,000 ha. Another area which promises good agriculture for Laos is Bolaven Plateau to the south. This place is endowed with suitable rain and good soil, and cultivation of coffee, tea, etc. has been attempted for a long time, and this place is also regarded as the most suitable dairy farming. However, lands near the Project Site of Xe Katam on Bolaven Plateau is used only for shifting cultivation here and their for domestic supply (cycling cultivation of rice and coffee). Therefore, there is no risk that construction of any run-of-river type power plant would damage the plateau agriculture.

80% of the population of Laos is engaged in agriculture, and the industry of Laos is overwhelmingly dominated by agriculture. However, the agricultural lands are narrow and modernization of agriculture is not advancing. The self-sufficient supply of food seems to be difficult to attain. In particular, the damage on agricultural production is very large in drought year [Note 7)]. The Government of Laos has exercised all its efforts to improve this situation. In particular, since the socialist government was established in December, 1975, the self-sufficient supply of food was set at the top priority target in the 3-Year National Development Plan (1978 - 1980), the First 5-Year Plan (181 - 1985) and the Second 5-Year Plan (1986 - 1990). In the First 5-Year Plan, efforts were placed on the self-sufficient supply of food and local development, and the economic growth rate of 5% per year was attained, and the cultivated lands were expanded. In the Second 5-Year Plan, more emphasis was placed on promotion of industry, but the largest contribution to the GDP in fiscal 1988 of 550,000,000 US dollars (140 US dollars per capita) was agriculture (65%). In this year, the contribution of manufacturing industry (including the forestry sector) was 12%, commerce was 14%, and others 9%. For the national economy of Laos, the development of agricultural production is far more important than any other sector.

Currently, only 700,000 ha (14%) of the total land that can be cultivated is used for farming of rice and secondary crops, 750,000 ha (10%) is used for pasturing land, and 50,000 ha (1%) is occupied by reservoirs such as the Nam Ngum where fish farming is performed.

The rice farming is conducted by utilizing rain water, and also on the dry land cleared by burning bushes. In recent years, irrigation was started in many places, and planting of high yield corps and use of fertilizer and insecticide was started.

The Government plans to increase the agricultural production with an average annual growth rate of 7.5% during the 5 years of the Third 5-Year Plan, which is from 1990 to 1995. In this plan, the growth of only 2.3% per year is estimated for rice production which was around 1,400,000 tons in 1990. The rice farming in Laos is still vulnerable to drought (see Table-6).

In March, 1989, the Government revised its traditional policy, and set down the principle that "the Government owns but only supervises lands" in order to realize more effective utilization of cultivated land. The citizens of Laos was given the long-term right to use the land by this principle. On the other hand, there is the provision that a farmer whose productive efficiency is low must transfer the right of use to other farmers. The Government is now advancing an ambitious agriculture reform policy by abolishing the agricultural cooperative supported by the Government in the middle of 1990, and expanding the cooperative sale system to facilitate distribution of fertilizer, seeds and insecticide.

On the other hand, the Government encourage stock farming with the objective of improving the nutrition of the people. The productions in 1987 and 1990 are given by the figures in the left and central columns of the table below. The Government hopes to increase the stock at the rates given in the right column of the table in the 5 years from 1990 to 1995 (with the exception of water buffaloes which will be decreased). (See Table-7.)

Table-7 Projection of Growth in Stock Production from 1990 to 1995

Production	1987 Production (000 heads)	1990 Production (000 heads)	Annual Growth Rate (% planned)
Water Buffalo	1,000.0	997.0	-1.8
Cattle	700.0	830.0	8.8
Hog	1,400.0	1,351.0	9.7
Sheep and Goat	82.0	116.0	8.9
Poultry	8,000	8,039.0	5.9

(Source: Finance Ministry of Laos, "Policy Framework of Public Investment Program, 1990. 11")

1.2.5 Industrial Production

Decades ago, the industry of Laos mainly consisted of lumbering and tin production. Up to the present time, the industrial activities in Laos which are commonly known to us are food products processing, lumber processing, mining of mineral resources and energy production of THE Nam Ngum Dam. However, the industry encouragement policy of the Government started to produce its effect, and today the industrial products of Laos has more varieties, consisting of such industries as textile, clothing, metal processing pharmaceuticals, pottery, paper making and printing. As the textiles of Laos has particular artistic style, it will become an important export item in the future when this industry is modernized and publicity is gained.

Currently, these industries are operated by approximately 300 state operated enterprises, and two thirds of them are engaged in agriculture products processing and lumber processing (see Table-8).

Table-8 Composition of Laos Industrial Production in 1987

Industry Type	Production in %
Food Processing	15
Forestry	9
Lumbering	11
Lumber Products	6
Textiles and Clothing	22
Metal Products	12
Building Materials, porcelain and glass products	11
Chemicals and Pharmaceuticals	9
Others	5
Total	100

(Source: Finance Ministry of Laos, "Policy Framework for Public Investment Program, 1990 11")

Almost all factories are concentrated to the area surrounding Vientiane City, where there are 295 state factories and from 300 to 500 private factories.

However, most of these factories are small, and those employing more than 300 people are the Lao Lumber Industry Company, a tobacco production factory, a soft drinks production factory, a beer brewery and the EDL. Smaller enterprises include those producing textiles, detergents, insecticides, plastics, farming equipment and agricultural product processing shops.

As timber cutting and lumbering are operated mainly for the purpose of export, the price of lumber in Laos is increasing. For this reason, there is tendency in Vientiane City that houses made of stone, brick and concrete are increasing instead of wooden houses. Also the factories manufacturing construction materials are increasing, and it looks as if new trend is occurring.

The companies producing these industrial products have been given autonomy since 1985, and they can now make their own business plan based on its assets and liabilities, and seek profit.

On the other hand, companies which can not produce profit may get broke. The state control was further loosened in 1990, and it is expected that general productivity will be improved.

According to the announcement of the Government made in 1986, 15% of Laos population was employed in public service and industries at that time. 1.5% of the population are private owners of manufacturing business. Although the Government's policy of deregulation started in 1986 will improve the situation, there is concern on the large number of job-less people. It is estimated that the number of unemployed people was 15% of the total population, and it is strongly desired that the industry expands in future.

These industries used to be operated under assistance of Soviet Union and Eastern European nations. As economy of Soviet Union and Eastern European nations quickly declined in recent years, the Government started to seek other ways of obtaining assistance. It is expected that the assistance by neighboring nations such as Thailand and Vietnam, as well as Western nations including Japan increases in the future. Recent success of the Kampuchea Peace Conference (October,1991) in Paris will certainly accelerate such promising situation. The Foreign Investment Code which is now in force in Laos may be revised to accept more western assistance.

The amount of future investments expected by Laos Government is illustrated in Table-9. The total expected amount is 123×10^6 US dollars [Note-8)]

Table-9 Amount of Investment of Industries of Increase Production

(1990 to 1995)

Industry	10^6 US Dollars
Food Processing	18
Forestry	25
Lumbering	14
Textiles and Clothing	7
Electrical and Metal Products	27
Construction Materials and Porcelain	15
Chemicals and Pharmaceuticals	11
Others	6
Total	128

(Source: Finance Ministry of Laos, "Policy Framework for Public Investment Program, 1990. 11")

1.2.6 Transportation and Traffic as Bases of Industrial development

The infrastructures that support all development activities of a nation are energy supply, transportation and communication.

The status of development of roads is described below.

It must be reported that the road conditions are still very poor at the present time in Laos. As of 1985, the total extension of roads is 13,000 km, of which only 2,250 km (17%) is asphalt paved and 3,400 km is covered with gravels. The remaining roads can not be used satisfactorily even in the dry season, not speaking of the rainy season.

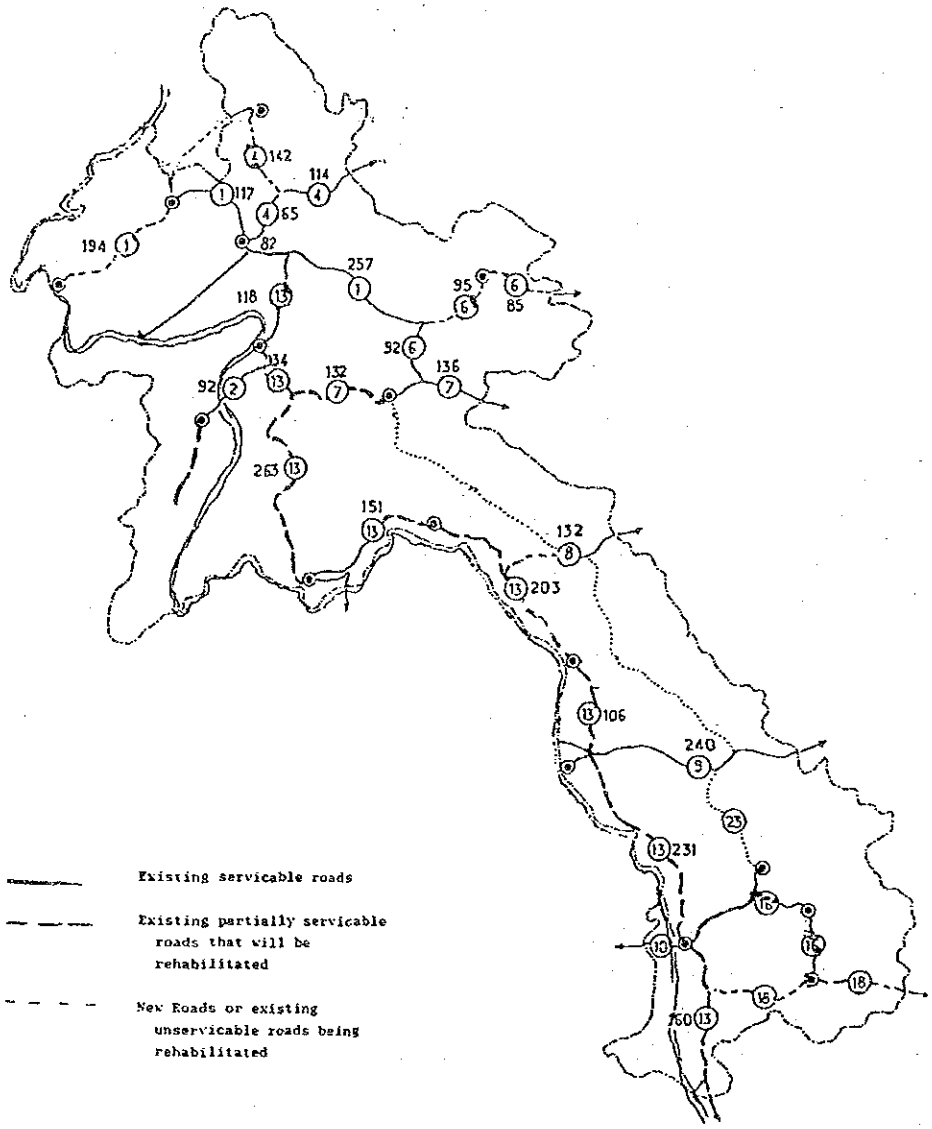
In early 1990, Thailand and Laos agreed on the construction of an international bridge with assistance from Australia, which will be 750 m long and connect Tha Na Laeng of Vientiane Province to Ban Chom Manec, near Nong Khai Town of Thailand. This is what is called Nong Khai Bridge. It is scheduled to be completed in 1994, and upon completion, this will be the first bridge on the main stream of the lower Mekong River Basin. As formal diplomatic relation has been established recently between Laos and Thailand, the trade between Vientiane and Nong Khai across the Mekong River is steadily increasing, and completion of this bridge is expected to further strengthen the tie between these two nations.

The main highway is Laos is Route 13, which is built along the left bank of the Mekong River for the total extension of 1,245 km, starting from Luang Pralang to the north and reaching the boarder of Kampuchea to the south. This road is generally paved with asphalt, but the portion from Vientiane to approximately 60 km towards north is not paved yet. This Route 13 was mostly constructed by France before the Second World War, and repair works are currently being performed at various locations. Routes 7, 8 and 9 connects to Routes 7, 8 and 9 of Vietnam and lead to sea harbors of Vietnam (see Figure-1).

Route 9 starts from Savannakhet and leads to the sea harbor of Da Nang in middle Vietnam via Quang Tri City, and this road was completed in 1988. This road is used to export the products of southern Laos, and in turn transport the Vietnamese products as well as industrial products of foreign nations which are unloaded at the sea harbor. The ADB is currently investigating the plan of constructing a bridge that connect Savannakhet, the original part of Route 9, to Mukdahan Town across the river in the northeastern part of Thailand. This bridge plan has been studied since 1980's, and when this bridge is completed, the traffic on Route 9 will be drastically increased, thereby providing substantial positive impact on the social economy of southern Laos.

As Laos is an inland nation, its economic activity heavily depend on import from Thailand and Vietnam and export of certain products to these nations. The import from Vietnam is increasing remarkably in recent years [Note 9].

Figure-1 Highways in Laos (Existing and Planned)



(Source: Finance Ministry of Laos, "Policy Framework for Public Investment Program, 1990. 11")

In 1985, the registered amount of freights transported by land was approximately 1 billion tons, and 150 million tons of freights were transported by water (rivers). The exchange of goods not only with Vietnam but with Thailand with which the diplomatic relation has been improved recently, as well as between provinces in Laos has increased, which has substantially increased the freight transportation by rivers. The small river harbor at the outskirts of Vientiane City has been rehabilitated recently under Grant Aid of the Japanese Government, and liner transportation is provided 3 times a week between Vientiane and Savannaket.

Since Route 13 is being improved, and the east-west trade between southern Laos and Thailand has been revived, it is excepted that, in the future, the movement of goods in east-west direction between Laos and Thailand/Vietnam will be increased in addition to the exchange of goods in the north-south direction that has been performed so far.

One item to be noted in relation to goods transportation is the completion of construction of an oil pipeline. In 1987, an oil pipeline has been completed covering a distance a little less than 400 km from the Vietnam border to Vientiane. The original point of this line in Vietnam is near Vinh. It has become possible to import approximately 300,000 tons of petroleum of Soviet origin by means of this pipeline. At present, however, only 100,000 tons of petroleum has been consumed in the whole Laos.) The completion of this pipeline is expected to supplement the poor road transportation conditions, and the utilization of this pipeline will be further promoted as the industrialization of Laos progresses.

Another item to be noted is the resumption of trade between northern Laos and China [Note 10]. It has been long prohibited to navigate the Mekong River above Chiang Saen Town, but as the diplomatic relation with China has been improved, it now becomes possible for ships to cross the national border and navigate from Chinese territory to Luang Prabang and other Lao towns. It is expected that the resumption of diplomatic relation between these two nations (November, 1991) will drastically encourage the traffic and transportation between these two nations both by land and river, because the Chinese products are attractive to the Laos people.

Along the main stream of the Mekong River, there are locations between Sayaburi and Paklay at the downstream of Luang Prabang where navigation is very difficult in dry seasons. Further downstream, there are many locations where navigation is difficult, including the famous rapid of Ken Kabao, between Thakhek and Pakse. For this reason, the ship transportation on the Mekong main stream is only partially possible. Nevertheless, this resumption of ship transportation between China will have substantial impact on towns and villages of Laos located at upstream of the river. On the other hand, it is anticipated that Route 13 will constitute the most important land transportation route between China after the road in Yunnan Province of China is improved.

The trade and human traffic between Laos and Kampuchea will also be increased, although the extent will depend on the future situation. The navigation on the Mekong mainstream between Laos and Phnom Penk in Kampuchea is interrupted by the famous Khone Falls and the Sambor Rapids which is located at its downstream. However, it is possible for the people for southern Laos to travel to Stumg Treng and other towns Kampuchea via Se Kong River, which is a tributary of Mekong. When Route 13 inside Kampuchea territory is repaired and order is restored in that country, the trade between Laos and Phnom Penh, and further with Ho Chi Ming City of Vietnam, will become possible.

At present, air transportation of Lao people and visitors as well as goods is gradually increasing. Further improvement of air transportation system and inland roads network is the most important factor for the future development of Laos.

As a conclusion, it is expected that trade and traffic between riparian countries in the Mekong River Basin will become even busier than they were before the start of the Vietnam War. Now that the Peace Conference on Kampuchean issues has turned out to be successful, rehabilitation of these nations must be conceived from the point of view of the development of the whole region in the Mekong River Basin, and Laos will eventually attain a great development if rehabilitation projects were supported by assisting nations based on the above point of view.

1.3 Energy Development

Laos, being an inland country with its territory mostly consisting of mountains and plateaus, its hydroelectric potential attracted attention of the French in the early period of this Century. In particular, the concept of diverting the river flow of the Nam Theun tributary basin to the adjacent Nam Hin-Boun River or the Se Bang Fai River, and providing hydroelectric power plants by effectively utilizing the high head thereby obtained, has been known as the most attractive potential project. Also, the development concept of the Pa Mong Dam on the main stream of the Mekong River attracted attention of European and American planners by the middle of this century. Later on, the Japanese Government conducted a comprehensive reconnaissance survey on the main stream and the major tributaries of the Mekong River by late 1950's, and the advantages of hydroelectric potential of Laos was further stressed. In spite of such abundant hydroelectric potential, their development did not progress due to problems related to international politics as well as economic and social circumstance. Even today, no large-scale hydroelectric power has been developed except the Nam Ngum Power Plant, and the people are using energy other than hydroelectric power, with the exception of the vicinity of Vientiane and a few other places. Before discussing hydroelectric energy, we shall briefly describe the status of energy other than hydroelectric power.

1.3.1 Energy Sources Other Than Hydroelectric Power

(1) Oil Supply and Diesel Power Generation

As has been discussed, an oil pipeline, extending 400 km from Vinh of Vietnam, was completed in 1987, thereby enabling to supply the oil of Soviet Union origin to the capital city of Vientiane (with annual transportation capacity of 300,000 tons). (Oil used to be imported from Soviet Union before the completion of this pipeline, consisting of 30 to 50% gasoline and 50% gas oil.) In addition, Shell Oil Company imported 200,000 to 300,000 ton/year of oil from other nations. In recent years, however, the feasibility of oil extraction inside Laos has ben established. There is an oil and gas field (20,200 km^2) in Savannhakhet Province, and oil fields (26,000 km^2) are registered in

Salavane Province and Champassack Province. It is reported that extraction of oil will be started in all these oil fields in the near future.

Although the general status of oil import and development is as described above, lighting is provided in municipal offices and households by means of electricity supplied by small diesel power plants which are scattered all over the country (in spite of abundant hydroelectric potential of the country as discussed above). Small business firms also rely on diesel power generation. The total capacity of these small diesel power plants throughout the country amount to approximately 10 MW, so far.

Today, the demand for electrification is raised in cities, towns and villages which are on the border with Thailand in particular in order to enjoy the TV broadcast in Thailand. Public TV reception sets are installed in squares of small towns and villages, but household TV ownership is increasing. In this survey, it was confirmed that a 1,600 kW diesel generator was installed (in addition to the Selabam hydroelectric facility) in Pakse in order to meet the power demand of small industries, household and public lighting, and TV reception. In Sekong Town, diesel generators of 100 kW (for residential lighting) and 220 kW (for public usage) are installed. There are also 160 kW (for public usages) and 100 kW (for lumbering) generators in Attapeu Town. Generating facilities of 50 to 200 kW are commonly found in many other towns.[Note: 11)]

(2) Coal Energy

Coal is mined at Bo Chan coal mine which is located 150 km to the north of Vientiane City, which is used mainly for industrial purpose such as fuel coal in the brick factory in Vientiane[Note 12)]. However, coal being is not being used for the power generation.

(3) Woods for Fuel

In Laos, woods are important as household and industrial fuel, in addition to their use as construction materials. It is reported that 80% of fuel demand in Laos today is met by firewood. There is opinion that this is waste of precious natural resource and that timbers should be processed and consumed or exported with added value, while domestic fuel demand should be met by mining coal, if this is possible. It is also agreed that charcoal production must be industrialized in national scale so that the destruction of forest which is currently spreading at awful speed could be stopped.

Such improvement however, may be difficult in reality. There is opinion that, in order to stop the current waste of woods in Laos, the domestic wholesale price of logs must be raised to the export price at the border.

(4) Chaff Fuel

Chaffs are utilized to supplement other fuels in brick factories.[Note 13)]

1.3.2 Hydroelectric Power Generation

(1) Hydroelectric Potential

The geography, meteorology, hydrology of Laos and the related data indicate that this country has abundant hydroelectric potential. Table-7 was released by the Mekong Committee in 1970[Note 14)], which indicates that Laos possesses a hydroelectric potential which is large by an order of magnitude among the four nations in the Lower Mekong River Basin. However, this is a theoretical potential of hydroelectric energy, and it is inferred that the amount of hydroelectric power which can be practically developed inside Laos, excluding those on the main stream of the Mekong River, would be around 20% of the figure of 37,000 MW given in this table, or approximately 7,500 MW (in terms of conventional hydroelectric generation (refer to Table-10 and Table-11).

This figure is comparable to the economical hydroelectric potential of the whole France (which has a national land area 3.4 times as large as that of Laos).

Table-10 Hydropower Potential in Lower Mekong Basin

	Catchment Area km^2	Annual Runoff $10^6 m^3$	Annual Energy 10^6 kWh	Potential Capacity 10^3kW
Khmer Republic				
(a) Major Tributary Areas	93,825	49,534	27,063	3,094
(b) Areas along the Mainstream and Other Small Tributaries	47,608	22,630	4,676	534
(c) Total	(141,433)	(72,164)	(31,739)	(3,628)
Laos				
(a) Major Tributary Areas	160,745	180,835	325,466	37,195
(b) Areas along the Mainstream and Other Small Tributaries	41,655	31,915	40,829	4,662
(c) Total	(202,400)	(212,750)	(366,295)	(41,857)
Thailand				
(a) Major Tributary Areas	147,310	35,555	16,653	1,903
(b) Areas along the Mainstream and Other Small Tributaries	36,935	19,363	8,981	1,027
(c) Total	(184,245)	(54,918)	(25,634)	(2,930)
Republic of Viet-Nam				
(a) Major Tributary Areas	29,850	41,797	80,950	9,256
(b) Areas along the Mainstream and Other Small Tributaries	Nil	Nil	Nil	Nil
(c) Total	(29,850)	(41,797)	(80,950)	(9,256)
Grand Total				
Whole Lower Mekong Basin except Deltaic Area	557,928	381,629	505,000	58,000

(rounded figures)

(Source: UN Mekong Secretariat "Report on Indicative Basin Plan, 1980")

Table-11 Comparison of Hydropower Potential in Upper to Lower Mekong Basin and in European Countries

River Basin or Country		Catchment Area km²	Potential				
			Theoretical	Technical		Economical	
			10^6 kWh	10^6 kWh	Per cent in Theoretical	10^6 kWh	Per cent in Theoretical
1a	Up. Mekong Basin (area upstream Chiang Saen)	186,000	665,000*	-	-	-	-
1b	Lr. Mekong Basin (except delta area)	557,928	505,000*	150,000	29.7	-	-
1	Whole Mekong Bn.	743,928	1,170,000*	-	-	-	-
2	Sweden a/	450,000	199,000	-	-	85,000	42.7
3	Finland a/	337,000	46,500	-	-	18,000	38.7
4	Switzerland b/	41,000	144,000	70,000	48.6	27,000	18.7
5	Austria b/	84,000	152,500	-	-	30,000	19.7
6	France	547,000	314,000	138,000	44.0	60,000	19.2
7	Czechoslovakia b/	128,000	39,000	-	-	7,000	17.8
8	East and West Germany b/	356,000	111,000	26,000	23.5	18,000	16.2
9	Poland	313,000	32,000	-	-	5,500	17.2
10	Hungary b/	93,000	7,000	2,000	28.5	1,500	21.5

- : Data not available

* : Reference level is M.S.L. (at Ha Tien)

a/ : Report of group of experts on hydro-power resources, ECE Geneva (1964)

b/ : United Nations, "Hydro-electric Potential in Europe and its Gross Technical and Economic Limits" (E/ECE/EP/131), May 1953.

(Source: UN Mekong Secretariat, "Report on Indicative Basin Plan, 1970")

As a matter of fact, the Mekong River has 34 major tributaries in its Lower Basin, and 10 of these tributaries flow through the territory of Laos. In particular, the Nam Theun River and the Nam Ngum River have long been well known for their highly promising hydroelectric potential. In addition, these rivers offer opportunities for not only hydroelectric power development but irrigation, navigation, water supply, flood control, etc. That is, the development and utilization of the water resources of Laos are the key to the sustained development of this nation in the future.

All major rivers inside the territory of Laos are included in the Mekong River Basin.[Note 15] The rivers having relatively high hydroelectric development potential can be listed as below from north to south; the Nam Ou, the Nam Seung, the Nam Khan (all of these being near Luang Prabang), the Nam Heug, the Nam Ngum, the Nam Nhiep, (the Nam Mang near Vientiane has large head but available water flow is small), the Nam Theun, the Xe Bang Fai (near Thakhek), the Xe Bang Hieng (near Savannakhet), the Xe Don (near Pakse and Salavane), and the Se Kong (upper and middle stream sections, including the Xe Kammane and the Xe Namnoy of the Bolaven Plateau).

However, with a few exceptions, access to the potential development site of these rivers is difficult, as discussed before, and little meteorological and hydrological data are available concerning most of these rivers. In addition, there has not been economic and social demand for the development of these rivers. It is needless to say that the construction fund is not immediately available. Therefore, it will take a long time before these rivers are regarded as realistic objectives of development, except for the Nam Theun River, the middle stream of the Nam Ngum River, and the middle stream of the Xe Don River, for which investigations are currently being performed. Concerning other rivers, there will arise problems of long distance for power transmission, economic feasibility, etc. even when these rivers are picked up as objects of development.

On the other hand, there are numerous sites for development of very small hydroelectric power, such as the Nam Chia in the northeast of

Vientiane. When the economy of these small hydroelectric powers is compared with diesel power generation, few can be competitive. However, diesel power may be a negative factor for Laos which imports fuel oil, even if it is more economical than hydroelectric power.

Another concept is the development of the main stream of the Mekong River. Since 1950's, the Mekong Committee has pointed several possibilities of international development of the Mekong main stream, including the Pa Mong. However, it would be difficult to realize such projects due to the problems of impoundment and project financing.

(2) Power Demand Projection, Existing Power Facilities and Export/Import of Power

(a) Power Demand Projection and Existing Power Facilities

The projection of electric power demand in Laos (up to year 2020) is presented in Tables 12, 13 and 14.

Table-12 Projection of Electric Power Demand in Laos (MW)

	1989	1995	2000	2005	2010	2010
Interconnected Zones						
1. Vientiane	35.0	58.0	94.0	137.0	174.0	285.0
2. Luang Prabang	2.5	5.7	10.7	15.0	19.1	31.0
3. Thakhek (1)	4.2	8.3	14.6	20.0	26.1	42.0
4. Savannakhet	4.0	7.8	14.0	19.0	26.1	40.0
5. Pakse and Sarabanue	3.5	8.7	14.2	19.9	26.1	41.0
Sub total	49.2	87.9	146.9	212.0	269.0	440.0
Isolated zones						
	0.5	0.7	1.1	1.5	2.2	3
6. Phongsaly	1.0	1.4	2.0	2.9	4.3	7
7. Luang Nam Tha	1.2	1.8	2.9	4.7	7.5	12
8. Bokeo	1.0	1.3	1.9	2.8	4.1	6
9. Oudomxay	1.8	2.4	3.1	4.6	6.7	10
10. Huaphenh	2.2	2.9	4.3	6.4	8.1	13
11. Xiang Khoang	1.5	2.0	2.9	4.3	6.4	10
12. Xayaboury	2.0	2.7	4.4	7.1	11.4	18
Paklay & Boten						
13. Vientiane						
Sanakham	1.5	2.9	4.3	6.4	8.1	13
Muang Phuong	1.0	1.3	2.1	3.4	5.5	8
Muang Hom	0.5	0.7	1.1	1.4	2.2	3
Muang Xaisom boun	0.5	0.7	1.1	1.4	2.2	3
14. Borikhamxai						
Paksane	1.2	1.9	3.0	5.4	8.7	14
Muang Mai	1.0	1.3	2.1	3.2	5.5	8
Laksao	2.0	3.5	5.7	9.2	14.8	24
15. Khammouane	1.5	2.9	4.3	6.4	8.1	13
16. Savannaket						
Keng Kabao	1.2	1.9	3.0	5.4	8.7	14
Kengkok	1.5	2.9	4.3	6.4	8.1	13
Muong Phine	1.5	2.9	4.3	6.4	8.1	13
Se Bang Hieng	1.2	1.9	3.0	5.4	8.7	14
17. Khong Sedone	1.5	2.9	4.3	6.4	8.1	13
18. Sekong & Attapeu	2.0	2.7	4.4	7.4	11.9	18
	18.1	40.8	69.5	108.1	158.9	259
Total	67.3	128.7	216.0	320.1	428.3	700

(Source : H E C, Australia S M E C "Nam Theun II Hydroelectric Project, Feasibility Study ", November, 1990)

Table-13 Projection of Electric Energy Demand in Laos (GWh)

YEAR	1986	1990	1995	2000	2005	2010	2020
Interconnected Zones							
Vientiane	128.0	159.9	273.8	384.2	490.3	625.4	1,018.00
Luang Prabang	3.3	7.5	12.1	19.5	29.3	39.2	65.10
Thakhek (1)	3.2	20.5	36.1	50.7	65.3	83.3	135.70
Savannakhet	11.1	17.2	25.8	34.6	44.1	56.3	91.70
Pakse and Sarabanne Saravanne	6.0	9.3	16.2	24.2	32.2	41.1	67.00
Sub Total	151.6	214.4	364.0	513.2	661.2	845.3	1,377.5
Isolated Zones							
Northern provinces	26.9	32.8	44.6	63.0	86.3	115.5	188.1
Central provinces	13.6	16.5	22.4	31.6	43.3	57.9	94.4
Southern province	21.1	25.7	34.9	49.3	67.5	90.3	147.1
TOTAL	231.1	289.4	465.9	657.2	858.4	1,109.1	1,807.1

(Source : H E C, Australia S M E C "Nam Theun 2 Hydroelectric Project Feasibility Study ", November, 1990)

Table-14 Projection of Power Demands in Isolated Electrification Areas in Laos (GWh)

YEAR	1989	1995	2000	2005	2010	2020
Northern province						
Luang Nam Tha	2.60	3.92	5.95	8.15	10.90	17.75
Mouei Say	3.10	6.25	8.76	12.00	16.10	26.22
Sayaboury	9.20	13.17	18.47	25.30	33.80	55.05
Alang Khoang	5.78	8.12	11.39	15.60	20.87	33.99
Vientiane	9.20	13.17	18.47	25.30	33.85	55.14
Sub Total	29.88	44.63	63.40	86.35	115.52	118.15
Central Province						
Borikhamxzay	11.04	16.50	23.30	31.91	42.69	69.53
Khammouane	3.94	5.90	8.33	11.41	15.26	24.80
Sub-Total	14.98	22.4	31.63	43.32	57.95	94.33
Southern Province						
Savannakhet	14.20	21.20	29.93	40.99	54.83	89.29
Attapue & Sekong	5.25	7.85	11.08	15.17	20.29	33.04
Khong Sedone	3.94	5.89	8.31	11.38	15.22	24.78
Sub-total	23.39	34.94	49.32	67.54	90.34	147.11
TOTAL	68.25	101.97	143.99	197.21	263.81	429.64

(Source : H E C, Australia S M E C "Nam Theun II Hydroelectric Project Feasibility Study", November, 1990)

The situations are different from one locality of the nation to another. However, when one look at the overall status of the nation as a whole, the power demand in immediate future will not be large as compared to abundant hydroelectric potential. The future possibility of developing hydroelectric power in Laos (excluding the issues of very far future) depends on the needs of electric power markets in neighboring nations, especially Thailand. So far, 80% of the hydroelectric power of the Nam Ngum has been exported to Thailand, while a small amount of electric power is imported in southern Laos from Thailand.

According to a report of the World Bank (1988), the total power generation facilities of Laos consisted of 153.3 MW hydroelectric power plants (the Nam Ngum Power Plant with 150 MW capacity, plus 4 other hydroelectric power plants located in three provinces of Luang Prabang, Phong Saly, and Houaphanh) and 13.7 MW diesel power plants, with the total capacity being 167 MW. As the Xe Set Hydroelectric Power Plant (45 MW) was commissioned in Salavane Province of southern Laos, the present total installed capacity is 212 MW[Note 16].

The annual available energy generation has reached 800 to 1,000 GWh as the Xe Set Hydroelectric Power Plant has been commissioned. This figure is larger than the total electric energy demand of 657.2 GWh which is projected for the year 2000 (refer to Table-13).

When the available energy generation per capita is calculated based on the above figure, and compared with that of Thailand, the current figure of Laos correspond to the electric energy generation per capita in Thailand in 1980. That is, so long as we look at the total available electric energy generation, the current generating facilities in Laos should be more than sufficient to meet the electricity demand. In reality, however, the latent power demands which exist in local areas can not be met at all with the current power facilities. In other words, the current electric power facilities of Laos is not linked to