	Midstream Project	Downstream Project
Reservoir HWL	765.0 m	270.0 m
Reservoir LWL	747.7 m	266.7 m
Effective reservoir capacity	335 MCM	2.0 MCM
Firm discharge	20.8 m^3/s	24.0 m^3/s
Minimum discharge	1 m^3/s	-
Peak power duration	8 hours	6 hours
Maximum discharge	60 m^3/s	96 m^3/s
Rated intake level	758.6 m	268.4 m
Rated tail water level	270.0 m	180.0 m
Rated effective head	463.0 m	81.0 m
Installed capacity	238 MW	67 MW
Firm peak capacity	230 MW (8 hr)	66 MW (6 hr)
Annual energy	1, 052 GWh	332 GWh

4.7 Preliminary Design of Main Structures

(1) Se Kong No.4 Project

a) The preliminary design of the main structures for the Se Kong No.4 Project is carried out based on the optimum development plan described in 4.6 (2).

b) **Civil Structures**

- Topographically around the dam site, the river is approximately 160m wide with relatively gentle slops on each side. The dam crest is expected to be about 900m long at HWL. Considering this topography, a fill dam is recommended. Minimizing the dam volume should be considered to allow faster construction method. To meet these requirements, a concrete facing rockfill dam (CFRD) is selected.

- A design flood of 16,400 m^3/s at the dam site is estimated from the hydrological analysis. To discharge the flood safely, a chute type spillway is adopted at a location separate from the dam and excavated at the left bank. The spillway structure is 136m wide and provides 8 sets of radial gates. The muck excavated from the spillway will be used as embankment material on the dam.

- The power intake is planned at the right bank. Two lanes of 6.2 m dia. headrace tunnels and two lanes of 5.4m dia. penstock are planned. Each penstock is branched and connected to the four turbines.

- The topography recommends the adoption of a semi-underground type powerhouse.

- It is necessary to construct a new road from the end of the existing road to the dam site as an access road. A 14-km access road which requires both improvement and new construction has been planned.

c) **Generators and Components**

- The output of the Se Kong No.4 power plant is planned to be 443 MW.

- It is conditioned that 30 m^3/s of river retaining flow is considered for the selection of the turbine size.

- Four turbine/generator units being 2 large Francis turbine/generators (125 m^3/s) and 2 small Francis turbine/generators (60 m^3/s) are selected in consideration of the river retaining flow. The river retaining flow is equivalent to a 50% flow for the small units. It should be operate with no cavitation or vibration problems.

- A vertical 3-phase AC synchronous generator is appropriate for direct connection to the turbine.

- Conventional switchgear is planned at the switchyard.

d) **Transmission Line**

- A 80 km long, 230 kV, 1 cct transmission line route from the powerhouse to the B.Houaykong substation is planned.

- Comparative studies of the transmission line up to the Thai border are carried out.

- A 22 KV, 2cct transmission line is also planned for domestic power supply.

e) The salient features of the Se Kong No.4 Project are summarized in 4.12. Outline of the Project is shown in **DWG. 14.2-1 and 14.2-2.**

(2) Xe Kaman No.1 Project

a) The preliminary design of the main structures for the Xe Kaman No.1 Project is carried out based on the optimum development plan described in 4.6 (3).

b) Civil Structures

- Around the dam site, the river is approximately 60m wide with steep sloping banks on either side with gradients of 40 to 45 degrees. The site is more suitable for a concrete dam and no specific problem with geological features are seen from the investigations carried out in this study.

  A 143m high RCC dam (roller compacted concrete dam) with a 440m long crest was finally selected.

- The design flood of 14,300 m^3/s at the dam site is estimated from hydrological analysis. To discharge the flood safely, a center overflow type spillway is adopted on the dam crest. 7 sets of large spillway gates are provided at the dam crest to control the flood.

- The power intake is planned at the left bank. Two lanes of 4.8m dia. headrace tunnels and two lanes of 4.2m dia. penstock are planned.

- In consideration of the topographic conditions, a semi- underground powerhouse is adopted.

- It is necessary to improve and/or construct an access road from Attapu Town to the dam site. It is planned to improve 23 km of the existing road and construct 22 km of new road.

c) Generators and Components

- The output of the Xe Kaman No.1 Power Plant is planned to be 256 MW.

- It is conditioned that 20 m^3/s of river retaining flow is considered for selection of turbine size.

- Four turbine/generators units (57 m^3/s) and a Francis turbine are selected in consideration of the river retaining flow. The river retaining flow is equivalent to a 35 % flow.

- A vertical 3-phase AC synchronous generator is appropriate for direct connection to the turbine.

- Conventional switchgear is planned at the switchyard.

d) **Transmission Line**

- A 140 km long, 230 kV, 1cct transmission line from the powerhouse to the B.Houaykong substation is planned.

- Comparative studies of the transmission line up to the Thai border are carried out.

- A 22 kV, 2 cct transmission line from the powerhouse to Attapu Town is planned for domestic power supply.

e) The salient features of the Xe Kaman Project are summarized in 4.12. Outline of the Project is shown in **DWG. 14.3-1 and 14.3-2**.

(3) Xe Namnoy Project

a) The preliminary design of the main structures for the Xe Namnoy Project including the Downstream Project is carried out based on the optimum development plan described in 4.6 (4).

b) **Civil Structures**

b-1) Xe Namnoy Midstream Project

- Topographically around the dam site, the river is approximately 80m wide with gentle sloping banks on both sides. A dam, 69m high with a 780m long crest is planned. Taking the consideration topographical/geological conditions into consideration, a zone type rockfill dam is selected.

- As a wide distribution of highly permeable basalt is present in the left bank at the dam site, further investigation will be required to determine the method and area for the dam foundation treatment.

- A design flood of 6,000 m^3/s at the dam site is estimated from hydrological analysis. To discharge the flood safely, a chute type spillway is adopted at a location separate from the dam and excavated at the left bank. The spillway structure is 114m wide and 550m long.

- The power intake is planned at the right bank. A 9,000m long, 4.5m dia. headrace tunnel is planned The headrace tunnel is connected to a surge tank, penstock and the powerhouse.

- A semi-underground powerhouse is planned at the right bank of the Xe Namnoy River.

- An outlet facility with a 1 m^3/s capacity is planned at the dam to discharge the river retaining flow to the downstream area.

- 40 km of new roads leading to the dam site and powerhouse site are planned as access roads.

b-2) Xe Pian Diversion

- To make the Midstream Project a more effective development, it is planned to divert water from the Xe Pian River, which lies next to the Xe Namnoy River, to the Xe Namnoy reservoir.

- Two small intake dams, 17m and 10m in height are planned in the Xe Pian basin.

- A 7,200m long open channel and a 900m long tunnel are planned to connect the Xe Pian River to the Xe Namnoy reservoir.

- 6 km of new road is planned for the Xe Pian Diversion work.

b-3) **Xe Namnoy Downstream Project**

- The dam site is located 4 km downstream from the junction of the Xe Namnoy and Xe Katam rivers.

- The dam site is selected from a 1/10,000 scale map. A 33m high concrete gravity dam with a 350m long crest is planned.

- The design flood of 9,000 m^3/s at the dam site is estimated from hydrological analysis. The flood is discharged by the dam center spillway.

- The power intake is planned at the right bank. A 3,680m long, 5.8m dia. headrace tunnel, surge tank and penstock are planned.

- A semi-underground type powerhouse is planned at the right bank of the Xe Namnoy River.

c) **Generators and Components**

c-1) **Xe Namnoy Midstream Project**

- The output of the Xe Namnoy Midstream power plant is planned at 238 MW.

- River retaining flow by turbine/generator is not considered because the flow is maintained by the dam outlet facility.

- Two turbine/generator units are adopted taking their technical reliability and the economical viewpoint into consideration. Although the Pelton turbine is applicable due to a high head, the Francis turbine is adopted because of a large 30 m^3/s discharge for one unit and there being two units.

- A vertical 3-phase AC synchronous generator is appropriate for direct connection to the turbine.

- Conventional switchgear is adopted at the switchyard.

c-2) **Xe Namnoy Downstream Project**

- The output of the Xe Namnoy Downstream power plant is planned at 67 MW.

- Two turbine/generator units are adopted. The Francis turbine was adopted in this study. As the effective head is 81m, a Deriaz turbine which provides a broad operation range is also applicable.

- A vertical 3-phase AC synchronous generator is appropriate for direct connection to the turbine.

- Conventional switchgear is adopted at the switchyard.

d) **Transmission Line**

d-1) **Xe Namnoy Midstream Project**

- A 10 km long, 230 kV, 1 cct transmission line from the powerhouse to the B.Houaykong Substation is planned.

- Comparative studies of the transmission line up to the Thai border are carried out.

- A 22 kV, 2 cct transmission line is planned for domestic power supply.

d-2) **Xe Namnoy Downstream Project**

- A 10 km long, 230 kV, 1 cct transmission line from the powerhouse to the Midstream powerhouse is planned.

e) The salient features of the Projects are summarized in 4.12. Outline of the Projects are shown in **DWG. 14.4-1, 14.4-4, 14.4-7 and 14.4-9** .

4.8 Construction Plan and Schedule

(1) Construction Plan

a) Conditions Common to All Projects

- The transportation of construction equipment and materials will be made via Thailand and Pakse. Paske, a center in southern Laos, is considered to be the transportation base. National roads will be used from Pakse to as near each site as possible. Some part of the roads, however, may require improvement and barges are required at the river crossing for the transportation of heavy construction equipment and generating equipment. Improvements to the local roads leading to the sites may be required in all sections. New roads leading from the end of the existing roads to the dam sites will be required.

- The construction plan includes preparation works such as that for construction roads and construction facilities.

- The number of monthly working days for the open work is assumed as 20 days, and that for underground work assumed as 25 days.

- Construction power is supplied by diesel power plants as there are no adequate power stations in the vicinity of the project sites.

- The necessary concrete plants including an aggregate plant will be provided.

- Telecommunication facilities such as a radio communication system between the project sites and the base camp will be required.

- Other facilities such as compressed air supply, water supply, a drainage system and a ventilation system will be required.

b) **Construction Plan of the Main Structures for Each Project**

- The construction method and schedule for the diversion tunnel and cofferdam are planned for the river diversion works.

- The construction method and schedule for the dam are planned based on the calculated quantities of the excavation, concrete or embankment.

- The construction method and schedule for the spillway, power intake, headrace tunnel, penstock, powerhouse and etc. are planned.

- The site installation schedules for the hydraulic equipment and electro-mechanical equipment and transmission line are planned.

(2) **Construction Schedule of Each Project**

a) **Se Kong No.4 Project (Fig. 15.2-1)**

- The dam construction work is planned as requiring approximately 8 years including for the preparatory works such as that for roads, the river diversion and the spillway.

- The waterway work and the powerhouse work will require 4.5 years. These works will be completed within the dam construction work.

- The hydraulic equipment, the electro-mechanical equipment and the transmission line will be completed within the dam construction work.

- The reservoir impounding will be require 8 months.

- The total construction period, including the running test of the power plant is planned as requiring 8.3 years (99 months).

b) **Xe Kaman No.1 Project (Fig. 15.2-2)**

- The dam construction is planned as requiring approximately 5.5 years. This includes the preparation works such as that for the access road and river diversion.

- The waterway work and powerhouse work will be require 3.5 years. These works will be completed within the dam construction work.

- The hydraulic and electro-mechanical equipment will be completed within the dam construction work.

- The transmission line work is planned to require 4 years.

- The reservoir impounding will require 30 months.

- The total construction period, including that for the running test of the power plant is planned as requiring 6.3 years (75 months).

c) Xe Namnoy Projects (Fig. 15.4-4)

c-1) Xe Namnoy Midstream Project

- The dam construction work is planned to require 4 years, including the preparation work such that for the access roads, the river diversion and the spillway.

- The waterway, including the headrace tunnel will require 3.8 years. Completion of this work will be delayed by the dam construction.

- The Xe Pian diversion work and the powerhouse will be completed within the dam construction work.

- The hydraulic and electro-mechanical equipment and the transmission line will be completed within the waterway construction work.

- The total construction period, including that for the running test of the power plant is planned as requiring 5 years(59 months).

c-2) Xe Namnoy Downstream Project

- The construction schedule of the Xe Namnoy Downstream Project is planned to be completed within the period of the Xe Namnoy Midstream Project.

- The total construction period, including that for the running test of the power plant is planned as requiring 40 months.

4.9 Construction Cost

(1) Basic Consideration

- Construction cost is estimated for the three projects carried out in the pre-feasibility study.

- The construction cost of the each project is roughly estimated as the stage of the pre-feasibility study.

- The work quantities of the major items are calculated based on the preliminary design.

- The unit prices of the civil work are referred by the prices of similar projects in Laos and neighboring countries.

- The costs of the hydraulic equipment, electro-mechanical equipment and the transmission line are estimated referring by the cost in the neighboring countries.

- The cost estimation for the project is based upon 1994 levels and no cost escalation is considered.

- The interest during construction is not included.

(2) Construction Cost Components

The construction cost of each project consists of the following items. The each item is divided into foreign currency and local currency.

	Foreign currency (%)	Local currency (%)
Preparatory work	0	100
Civil work	85	15
Hydraulic equipment	90	10
Electro-mechanical equipment	90	10
Transmission line	90	10
Compensation cost	0	100
Engineering fee	90	10
Administration cost	0	100
Contingency	90	10

(3) Construction Cost of Each Project

a) Se Kong No.4 Project

1) Base Case (including cost of T/L up to B. Houaykong substation)

Foreign portion	US$ 542,216,000
Local Portion	US$ 101,393,000
Total	US$ 643,609,000

2) Case 1 (Base case + B. Houaykong substation and 500kv T/L up to the Thai border)

Foreign portion	US$ 586,174,000
Local Portion	US$ 107,378,000
Total	US$ 693,552,000

3) Case 2 (Independent 230kv T/L up to the Thai border)

Foreign portion	US$ 583,283,000
Local Portion	US$ 106,986,000
Total	US$ 690,269,000

b) Xe Kaman No.1 Project

1) Base Case (including cost of T/L up to B. Houaykong substation)

Foreign portion	US$ 342,443,000
Local Portion	US$ 61,607,000
Total	US$ 404,050,000

2) Case 1 (Base case + B. Houaykong substation and 500kv T/L up to the Thai border)

Foreign portion	US$ 367,861,000
Local Portion	US$ 65,069,000
Total	US$ 432,930,000

3) Case 2 (Independent 230kv T/L up to the Thai border)

Foreign portion	US$ 375,934,000
Local Portion	US$ 66,168,000
Total	US$ 442,102,000

c) Xe Namnoy Projects

c-1) Xe Namnoy Midstream Project

1) Base Case (including cost of T/L up to B. Houaykong substation)

Foreign portion	US$ 237,578,000
Local Portion	US$ 44,229,000
Total	US$ 281,807,000

2) Case 1 (Base case + B. Houaykong substation and 500kv T/L up to the Thai border)

Foreign portion	US$ 267,880,000
Local Portion	US$ 48,355,000
Total	US$ 316,235,000

3) Case 2 (Independent 230kv T/L up to the Thai border)

Foreign portion	US$ 262,996,000
Local Portion	US$ 47,690,000
Total	US$ 310,686,000

c-2) Xe Namnoy Downstream Project

For Xe Namnoy Downstream Project, it will be developed together with of after Xe Namnoy Midstream Project. Therefore, the construction costs in the Case 1 and 2 are the same as the Base case.

Foreign portion	US$ 129,514,000
Local Portion	US$ 21,903,000
Total	US$ 151,417,000

4.10 Economic Analysis

(1) Methodology of Economic Analysis

Economic analysis is to be carried out by using "with and without" method. "With" means the project and "Without" means an alternative power plan equipped with an equivalent kW and kWh at Sending-out (powerhouse Exit) with those of the project. A combined cycle power plant is selected as an alternative power plant to be compared with the relevant project in respect to evaluating the economic performance of the projects based on the discussion with MIH.

The economic preference of the project is to be valued by using the Economic Internal Rate of Return (EIRR). Common conditions for economic analysis is shown in **Table 17.1-1**.

Economic performance of alternative plans of transmission line up to the Thai border are also verified for the Case 1 (allocated transmission line system) and the Case 2 (independent transmission line) because the transmission line in the basic condition is assumed to be constructed up to Ban Houaykong Substation.

(2) Se Kong No.4

a) Basic Conditions

The project consists of the following characteristics.

- Installed Capacity ··············· 443 MW
- Firm Capacity ·················· 406 MW
- Sending-out Energy ·············· 1,797.8 GWh
- Project Cost ···················· 643.61 M.US$

b) Result of Economic Analysis

The EIRR for the basic conditions resulted in 10.81%. Since the EIRR exceeds ARI (10%), the project is deemed to be economically feasible. The EIRR for the Sekong No.4, however, gives the lowest value among the three project sites (four plans).

Transmission Line up to the Thai Border

Case	Construction Cost	EIRR (%)
Base Case	1,585 $/kW (643.6 M.US$)	10.81
Case 1 (Allocated)	1,704 $/kW (691.6 M.US$)	10.01
Case 2 (Independent)	1,700 $/kW (690.3 M.US$)	10.03

(3) Xe Kaman No.1 Project

a) Basic Conditions

The project consists of the following characteristics.

- Installed Capacity ··············· 256 MW
- Firm Capacity ·················· 245 MW
- Sending-out Energy ·············· 1,125.6 GWh
- Project Cost ···················· 404.05 M.US$

b) Result of Economic Analysis

The EIRR for the basic conditions resulted in 11.78%. The Xe Kaman No.1 Project is deemed to be economically feasible.

Transmission Line up to the Thai Border

Case	Construction Cost	EIRR (%)
Base Case	1,649 $/kW (404.1 M.US$)	11.78
Case 1 (Allocated)	1,780 $/kW (436.2 M.US$)	10.74
Case 2 (Independent)	1,805 $/kW (442.1 M.US$)	10.57

(4) Xe Namnoy Project

(4.1) Xe Namnoy (Midstream + Downstream)

a) Basic Conditions

The project consists of the following characteristics.

- Installed Capacity ··············· 305 MW
- Firm Capacity ·················· 296 MW
- Sending-out Energy ·············· 1,370.2 GWh
- Project Cost ···················· 433.22 M.US$

b) **Result of Economic Analysis**

The EIRR for the basic conditions resulted in 16.67%. The Xe Namnoy (Mid + Down) Project is expected to be good economic return.

Transmission Line up to the Thai Border

Case	Construction Cost	EIRR (%)
Base Case	1,464 $/kW (433.2 M.US$)	16.67
Case 1 (Allocated)	1,575 $/kW (466.3 M.US$)	14.89
Case 2 (Independent)	1,561 $/kW (462.1 M.US$)	15.10

(4.2) Xe Namnoy (Midstream)

a) **Basic Conditions**

The project consists of the following characteristics.

- Installed Capacity ··············· 238 MW
- Firm Capacity ·················· 230 MW
- Sending-out Energy ·············· 1,041.5 GWh
- Project Cost ···················· 281.81 M.US$

b) **Result of Economic Analysis**

The EIRR for the basic conditions resulted in 21.83%. The EIRR gives the highest value among the three project sites (four plans). The project can be expected excellent return.

Transmission Line up to the Thai Border

Case	Construction Cost	EIRR (%)
Base Case	1,225 $/kW (281.8 M.US$)	21.83
Case 1 (Allocated)	1,369 $/kW (314.9 M.US$)	18.18
Case 2 (Independent)	1,351 $/kW (310.7 M.US$)	18.58

4.11 Financial Analysis

(1) Methodology of Financial Analysis and Conditions

a) Methodology

In this chapter, Debt Service Coverage Ratio (DSC) is used as an index for judging financial soundness of the project. Furthermore, Financial Internal Rate of Return (FIRR) is also calculated to evaluate the rate of profit return.
According to IBRD's guide line, more or equal to 1.5 is desirable as DSC value.

b) Conditions

i) Materializing Method of the Project

Two (2) materializing methods for the projects are assumed as follows.

Materialized by the Lao Government (Case-A)

- The Lao Government (EDL) will materialize the project by their own finance and by official loan such as ADB's loan, IBRD's loan and OECF's loan.
- Common conditions for financial analysis in Case-A is shown in **Table 18.1-1**.

Materialized by BOT (Build-Operate-Transfer) (Case-B)

- The Lao Government will establish the subsidiary (Lao PDR)
- Private company will joint the project.
- Both parties will establish the new electricity company.

- Common conditions for financial analysis in Case-B is shown in **Table 18.1-2**.

ii) **Treatment of Transmission Line**

Other additional two (2) cases concerning the transmission line up to the Thai border are also incorporated in this chapter. Case 1 and Case 2 are called "allocated transmission line system" and "independent transmission line" respectively.

(2) Se Kong No.4 Project

a) Basic Conditions

The project consists of following characteristics.

- Installed Capacity ··············· 443 MW
- Firm Capacity ·················· 406 MW
- Salable Energy ·················· 1,616.2 GWh
- Construction Cost ··············· 643.61 M.US$

b) Results of Financial Analysis

<u>Case-A</u>

The results are shown below.

Case	DSC	FIRR	Levelized Financial Generation Cost
Base	1.61	24.55%	56.93 $/MWh
Case 1	1.46	22.75%	61.33 $/MWh
Case 2	1.47	22.86%	61.04 $/MWh

DSC and FIRR almost satisfy the feasible conditions, say 1.5 point for DSC and 6.0% for FIRR. The project is expected good return.

Case-B

The results are shown below.

Case	DSC	FIRR	Levelized Financial Generation Cost	FIRR for BOT Period (25 years)
Base	0.85	-9.85%	78.15 $/MWh	8.03%
Case 1	0.78	-19.25%	83.79 $/MWh	6.88%
Case 2	0.78	-18.26%	83.42 $/MWh	6.96%

DSC and FIRR indicate that the project to be proceeded by BOT method cannot expect financially sound and good return over the repayment period. The conditions proposed by MIH does not provide project feasibility by BOT method.

(3) Xe Kaman No.1 Project

a) Basic Conditions of Xe Kaman No.1

The project consists of following characteristics.

- Installed Capacity ··············· 256 MW
- Firm Capacity ·················· 245 MW
- Salable Energy·················· 1,011.9 GWh
- Construction Cost ··············· 404.05 M.US$

b) Results of Financial Analysis

Case-A

The results are shown below.

Case	DSC	FIRR	Levelized Financial Generation Cost
Base	1.55	27.49%	54.95 $/MWh
Case 1	1.42	25.37%	58.85 $/MWh
Case 2	1.38	24.73%	60.10 $/MWh

Even though FIRR becomes better than that of Se Kong No.1, DSC becomes slightly lower than that of Se Kong No.4. The project can be expected good return for the base case.

Case-B

The results are shown below.

Case	DSC	FIRR	Levelized Financial Generation Cost	FIRR for BOT Period (25 years)
Base	0.83	-13.68%	74.67 $/MWh	7.97%
Case 1	0.76	-31.25%	79.61 $/MWh	6.83%
Case 2	0.74	N/A	81.19 $/MWh	6.48%

The conditions proposed by MIH does not provide project feasibility by BOT method.

(4) Xe Namnoy Project

(4.1) Xe Namnoy (Midstream + Downstream)

a) Basic Conditions of Xe Namnoy (Midstream + Downstream)

The project consists of following characteristics.

- Installed Capacity ··············· 305 MW
- Firm Capacity ················· 296 MW
- Salable Energy ················· 1,231.8 GWh
- Construction Cost ··············· 433.22 M.US$

b) **Results of Financial Analysis**

Case-A

The results are shown below.

Case	DSC	FIRR	Levelized Financial Generation Cost
Base	1.75	37.28%	46.51 $/MWh
Case 1	1.59	34.12%	50.19 $/MWh
Case 2	1.61	34.62%	49.60 $/MWh

DSC and FIRR indicate that the project will be run financially sound well.

Case-B

The results are shown below.

Case	DSC	FIRR	Levelized Financial Generation Cost	FIRR for BOT Period (25 years)
Base	0.93	-6.58%	63.06 $/MWh	10.33%
Case 1	0.85	-13.31%	67.64 $/MWh	8.84%
Case 2	0.86	-12.06%	66.90 $/MWh	9.07%

Although DSC and FIRR have slightly improved in comparison with those of the preceding two (2) project, the both indicators are still less than feasible conditions. FIRR for the BOT period has just cleared 10% for the base case. The project to be implemented by BOT method is deemed to be difficult from the financial viewpoint, especially from the short term view point.

(4.2) Xe Namnoy (Midstream)

a) **Basic Conditions of Xe Namnoy (Mid Stream)**

The project consists of following characteristics.

- Installed Capacity ··············· 238 MW
- Firm Capacity ··················· 230 MW
- Salable Energy·················· 936.3 GWh

- Construction Cost ··············· 281.81 M.US$

b) **Results of Financial Analysis**

Case-A

The results are shown below.

Case	DSC	FIRR	Levelized Financial Generation Cost
Base	2.12	43.45%	39.86 $/MWh
Case 1	1.84	38.75%	44.71 $/MWh
Case 2	1.88	39.46%	43.92 $/MWh

DSC and FIRR indicate the highest values among the three (3) project sites (four plans). The project is expected excellent return.

Case-B

The results are shown below.

Case	DSC	FIRR	Levelized Financial Generation Cost	FIRR for BOT Period (25 years)
Base	1.11	2.76%	54.80 $/MWh	13.60%
Case 1	0.97	-3.73%	60.83 $/MWh	11.15%
Case 2	0.99	-2.62%	59.86 $/MWh	11.51%

Although DSC and FIRR indicate the highest performance among the all, the both indicators are still less than feasible conditions. It seems to be difficult to conclude whether the BOT method is feasible or not under the proposed conditions by MIH.

4.12 Salient Features of Projects

Of the results on the pre-feasibility study, salient futures of the three projects are summarized as follows.

(1) Se Kong No.4 Project (DWGs. 14.2-1 and 14.2-2)

Reservoir	
Catchment area	5,400 km^2
Annual inflow	5,721 million m^3
High water level	EL 290.00 m
Low water level	EL 275.40 m
Available depth	14.60 m
Effective capacity	1,700 million m^3
Reservoir area	130 km^2
Dam	
Type	Concrete faced rockfill dam
Dam height	164 m
Crest length	910 m
Dam volume	14,400,000 m^3
Spillway	
Type	Chute type
Width, length, gate	136 m, 680 m, 8 sets
Maximum design flood	16,400 m^3/s
Headrace tunnel	
Diameter	6.20 m
Length	315 m / 365 m
Number of tunnel	2 lanes
Penstock	
Diameter	5.40 m
Length	442 m
Number of penstock	2 lanes, 4 branches
Powerhouse	
Type	Semi-underground type
Width, length	20 m, 80 m
Number of unit	Large size 2 units
	Small size 2 units

Turbine	Francis type
	Large size 150 MW
	Small size 71.5 MW
Generator	3 phase, alternative current, synchronous
Power generation plan	
Peak power duration	8 hours
Maximum discharge	370 m^3/s
Effective head	137.00 m
Installed capacity	443 MW
Firm peak capacity (8 hours)	406 MW
Annual energy	1,816 GWh
Plant factor	47 %
Access road	
New construction	14 km
Improvement	14 km
Transmission line (powerhouse-B.Houaykong substation)	
Capacity	230 KV, 1 cct
Length	80 km

(2) Xe Kaman No.1 Project (DWGs. 14.3-1 and 14.3-2)

Reservoir	
Catchment area	3,800 km^2
Annual inflow	4,245 million m^3
High water level	EL 260.00 m
Low water level	EL 253.20 m
Available depth	6.80 m
Effective capacity	1,270 million m^3
Reservoir area	193 km^2
Dam	
Type	Concrete gravity dam
Dam height	143 m
Crest length	440 m
Dam volume	1,670,000 m^3
Spillway	
Type	Dam overflow type
Width, length	122 m, 203 m
Maximum design flood	14,300 m^3/s
Headrace tunnel	
Diameter	4.80 m
Length	315 m/322 m
Number of tunnel	2 lanes
Penstock	
Diameter	4.80 m
Length	317 m
Number of penstock	2 lanes, 4 branches
Powerhouse	
Type	Semi-underground type
Width, length	18 m, 64 m
Number of unit	4 units
Turbine	Francis type, 64 MW
Generator	3 phase, alternative current, synchronous

Power generation plan

Peak power duration	8 hours
Maximum discharge	228 m^3/s
Effective head	129.90 m
Installed capacity	256 MW
Firm peak capacity (8 hours)	245 MW
Annual energy	1,137 GWh
Plant factor	51%

Access road

New construction	22 km
Improvement	23 km

Transmission line(powerhouse-B.Houaykong)

Capacity	230 kV, 1 cct
Length	140 km

(3) Xe Namnoy Project

a) Xe Namnoy Midstream with Xe Pian Diversion (DWGs. 14.4-1 and 14.4-4)

Reservoir	
Catchment area	
Xe Namnoy	531 km^2
Xe Pian	223 km^2
Annual inflow	1,042 million m^3
High water level	EL 765.00 m
Low water level	El 747.70 m
Available depth	17.30 m
Effective capacity	250 million m^3
Reservoir area	21.8 km^2
Dam	
Type	Rockfill dam
Dam height	69 m
Crest length	780 m
Dam volume	1,253,000 m^3
Spillway	
Type	Chute type
Width, Length	114 m, 550 m
Maximum design flood	6,000 m^3/s
Headrace tunnel	
Diameter	4.5 m
Length	9,010 m
Number of tunnel	1 lane
Penstock	
Diameter	4.0 ~ 3.5 m
Length	780 m
Number of penstock	1 lane
Powerhouse	
Type	Semi-underground type
Width, length	18 m, 50 m
Number of unit	2 units
Turbine	Francis 119 MW
Generator	3 phase, alternative current, synchronous

Power generation

Peak power duration	8 hours
Maximum discharge	60 m^3/s
Effective head	463 m
Installed capacity	238 MW
Firm peak capacity (8 hours)	230 MW
Annual energy	1,052 Gwh
Plant factor	50%

Access road

New construction	26 km
Improvement	34 km

Transmission line(powerhouse-B.Houaykong)

Capacity	230 kV, 1 cct
Length	10 km

Xe Pian diversion scheme

Intake dam

Type	Concrete gravity dam
Dam height	10 m

Diversion waterway

Type	Open Channel	Tunnel
Width	5.0 m	4.0 m
Length	7.2 km	900 m

Maximum diversion capacity 20 m^3/s

b) Xe Namnoy Downstream Project (DWGs. 14.4-7 and 14.4-9)

Reservoir

Catchment area	1,475 km^2
Direct	1,252 km^2
Indirect	223 km^2
Annual inflow	2,109 million m^3
High water level	EL 270.00 m
Low water level	EL 266.7 m
Effective capacity	2 million m^3 (daily regulating)
Reservoir area	0.7 km^2

Dam	
Type	Concrete gravity dam
Dam height	33 m
Crest length	350 m
Dam volume	133,200 m^3
Spillway	
Type	Dam overflow type
Width	158 m
Maximum design flood	9,000 m^3/s
Headrace tunnel	
Diameter	5.80 m
Length	3,670 m
Number of tunnel	1 lane
Penstock	
Diameter	5.60 ~ 5.40 m
Length	450 m
Number of penstock	1 lane
Powerhouse	
Type	Semi-underground type
Width, length	18.00 m, 50.00 m
Number of unit	2 units
Turbine	Francis 33.5 MW
Generator	3 phase alternative current, synchronous
Power generation	
Peak power generation	6 hours
Maximum discharge	96 m^3/s
Effective head	81 m
Installed capacity	67 MW
Firm peak capacity (6 hours)	66 MW
Annual energy	332 GWh
Plant factor	57%
Access road	
New construction	23 km
Transmission line (powerhouse-B.Houaykong substation)	
Capacity	230 kV, 1 cct
Length	10 km

Summary of Plans proposed in Hydropower Potential Study and Pre-feasibility Study

Description	Potential Study		Pre-feasibility Study	
1. Basic conditions				
Scale of topographic maps	1/50,000		1/10,000	
Discharge data period	5 years		10 years	
Reservoir operation	Annual operation		Carry-over operation	
Peak power duration	12 hours		8 hours	
2. Proposed Plans				
Se Kong No.4				
Reservoir HWL	300	m	290	m
Effective Storage Capacity	1,287	MCM	1,700	MCM
Regulated Firm Discharge	144	m^3/s	143	m^3/s
Maximum Discharge	288	m^3/s	370	m^3/s
Rated Effective Head	140	m	137.0	m
Installed Capacity	346	MW	443	MW
Plant Factor	63	%	47	%
Xe Kaman No. 1				
Reservoir HWL	280	m	260	m
Effective Storage Capacity	833	MCM	1,270	MCM
Regulated Firm Discharge	93	m^3/s	89	m^3/s
Maximum Discharge	186	m^3/s	228	m^3/s
Rated Effective Head	159	m	129.9	m
Installed Capacity	255	MW	256	MW
Plant Factor	61	%	51	%
Xe Namnoy Midstream				
Reservoir HWL	760	m	765	m
Effective Storage Capacity	255	MCM	250	MCM
Regulated Firm Discharge	25	m^3/s	20.8	m^3/s
Maximum Discharge	50	m^3/s	60	m^3/s
Rated Effective Head	446	m	463.0	m
Installed Capacity	192	MW	238	MW
Plant Factor	69	%	50	%
Xe Namnoy Downstream				
Reservoir HWL	280	m	270	m
Firm Discharge	33.4	m^3/s	24.0	m^3/s
Maximum Discharge	100	m^3/s	96.0	m^3/s
Rated Effective Head	74	m	81.0	m
Installed Capacity	63	MW	67	MW
Plant Factor	61	%	57	%

Notes: 1) Location of projects in the potential study is shown in Fig.2.
2) Location of projects in the pre-feasibility study is shown in the beginning of the Report.

CONCLUSION AND RECOMMENDATION

CONCLUSION

CONCLUSION

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CONCLUSION

1. Hydropower Potential Study in the Se Kong Basin

(1) The Se Kong river is a large tributary of the Mekong River. The river originates in the Annam Ranges which forms the boarder between Laos and Vietnam, flows around southern area of Bolaven Plateau and joins the Mekong River in Cambodia. The Se Kong river has a catchment area of 23,350 km^2 within Laos and is 150 km long which provides abundant hydropower resources including six tributaries.

(2) Hydropower development in the Se Kong basin is planned for two major reasons, (1) to develop an electric power source as a part of the Southern Laos Development Program and the (2) tenable power export to the neighboring countries.

(3) In the hydropower potential study, totally 15 development plans covered 3 plans on Se Kong main stream, 4 plans on Xe Kaman river, 2 plans on Xenamnoy river, 3 plans on Nam Kong river 1 plan on Xe Xou river and 2 plans on small rivers are studied and prepared a development plan inventory.

Out of the inventory, the following three projects are selected as priority development projects.

Se Kong No.4 Project
Xe Kaman No.1 Project
Xe Namnoy Midstream Project including Downstream Project

Pre-feasibility study was carried out for these three projects.

2. Pre-feasibility Study

2.1 Basic Data used in the Pre-feasibility Study

(1) Topographic maps of 1/10,000 scale around the each dam site and a part of reservoir area are prepared and used for the preliminary design.

(2) Meteorological data and hydrological data are preliminary analyzed using the records at the existing stations and or that of the newly installed stations in the study. Monthly

discharge, design flood at the each project sites are analyzed and applied for pre-feasibility design.

(3) Geological investigation such as a seismic prospecting survey, core drilling works were carried out and referred to the dam design.

(4) Preliminary environmental impact survey was carried out at the three selected project areas. Current state of the project areas related natural/social environment was surveyed and compensation costs were roughly estimated. More detailed survey will be required on the Feasibility Study stage.

2.2 Basic Concept for Hydropower Development Plan

(1) Hydropower projects by constructing a medium to large scale hydropower project providing the reservoir which is variances seasonally and one year to the next were selected for the main purpose of power export to the neighboring countries.

(2) Optimum development plan for the each project was selected after case study, which is varied dam height (HWL), effective reservoir capacity and etc. as parameters.

(3) Considering power export to the neighboring countries, a substation is planned at B.Houaykong in the Bolaven Plateau and the transmission line is planned divided into two stage. The first stage of the transmission line is a section from the powerhouse to the substation. the second stage of that is planned from the substation to the substation at Roi Et in Thailand. Allocated transmission line from B. Houaykong substation to the Thai border and independent transmission line from the powerhouse to the Thai border are also studied as comparative studies. Transmission lines to Vietnam and Cambodia are preliminary studied its routes and capacities.

2.3 Se Kong No.4 Project

(1) Se Kong No.4 Project is planned a dam reservoir type providing a concrete facing rockfill dam with 164 m in dam height, 910 m in dam crest length, 1,700 million m^3 in effective reservoir capacity, and a power plant generates 443 MW of installed capacity, 1,816 GWh of annual energy by 137 m of effective head.

The powerhouse is planned at the immediately downstream of the dam. 4 units of Francis turbines/generators (150 MW 2 unit, 71.5 MW 2 units) are planned.

(2) It is conditioned that 30 m^3/s of river retaining flows considered for the turbine size selection.

(3) Geology in the project area is generally satisfactorily. Survey results at present point out no geological problem in the reservoir area. Dam site is underlain by sandstone, shale and esitic tuff. The dam foundation is judged enough in strength, however, more detailed survey will be required for the dam design on the next stage including waterway, powerhouse and etc..

(4) Se Kong No.4 Project has 128 km^2 of reservoir area which is covered by forest. In the reservoir area, there are small villages with 3,500 peoples lying farmland and abandon slash-and burn agriculture. Implementing appropriate measures to alleviate impacts will forestall the occurrence of environmental impacts that will be hinder the project.

(5) Total construction cost of the Se Kong No.4 project is preliminary estimated as follows:

Base (Transmission line cost from the powerhouse to B. Houaykong Substation is included)
US$643,609,000

Case 1 (Addition to the Base, B. Houaykong substation cost and the transmission line cost up to Thai border are included by allocation)
US$693,552,000

Case 2 (Independent transmission line cost from the powerhouse to the Thai border)
US$690,269,000

(6) Total construction period is planned 8 yearrs including preparately work such as construction of access roads.

(7) Result of the economic analysis and financial analysis are shown in 2.6(2), (3)

2.4 Xe Kaman No.1 Project

(1) Xe Kaman No.1 Project is planned a dam reservoir type providing a concrete gravity dam with 143 m in height, 440 m in crest length, 1,270 million m^3 in effective reservoir capacity,

and a power plant generates 256 kW of installed capacity, 1,138 GWh of annual energy by 129.9 m of effective head.

The powerhouse is planned at the immediately downstream of the dam. 4 units of Francis turbine/generators (62 MW 4 units) are planned.

(2) It is conditioned that 20 m^3/s of river retaining flow is considered for the turbine size selection.

(3) Geology in the project area is generally satisfactorily. Survey results at present point out no geological program in the reservoir. Dam site is mainly underlain by sandstone. Shale and conglomerate are partly underlain. The dam foundation is judged enough in strength for the concrete dam, however, more detailed survey will be required for the dam design on the next stage including waterway, powerhouse and etc..

(4) Xe Kaman No.1 Project has 193 km^2 of reservoir area which is covered by forest. In the reservoir area, there are many small villages with 600 peoples lying farmland and abandon slash-and burn agriculture. Implementing appropriate measures to alleviate impacts will forestall the occurrence of environmental impacts that will be hinder the project.

(5) Total construction cost of the Xe Kaman No.4 project is preliminary estimated as follows:

Base (Transmission line cost from the powerhouse to B. Houaykong Substation is included)
US$404,050,000

Case 1 (Addition to the Base, B. Houaykong substation cost and the transmission line cost up to Thai border are included by allocation)
US$432,930,000

Case 2 (Independent transmission line cost from the powerhouse to the Thai border)
US$442,102,000

(6) Total construction period is planned 6 yearrs including preparately work such as construction of access roads.

(7) Result of the economic analysis and financial analysis are shown in 2.6(2), (3)

2.5 Xe Namnoy Project

(1) Xe Namnoy project is planned as two stage development plans of Midstream Project and Downstream Project.

a) Xe Namnoy Midstream Project

Xe Namnoy Midstream Project is planned a dam and waterway type providing a rockfill dam with 60 m in height, 890 m in crest length, 250 m^3 in effective reservoir capacity, and a power plant generates 238 MW of installed capacity, 1,052 GWh of annual energy by 463 m of effective head.

The powerhouse is planned at the right bank of Xe Namnoy river 20 km downstream from the dam. 2 units of Francis turbine/generators (119 MW 2 units) are planned, and a 9.2 km of headrace tunnel is planned between the dam and the powerhouse.
It is condition that 1 m^3/s of river retaining flow is considered to the downstream section of the dam.

b) Xe Namnoy Downstream Project

Xe Namnoy Downstream Project is planned to practical use of generated discharge of the Midstream Project and the discharge of the remaining catchment area effectively. This project is a medium scale and is planned a daily regulating reservoir type.

A concrete gravity dam is planned at immediately downstream of the confluence of H.Katak Tok river with 35 m in height, 350 m in crest length. A powerhouse is planned at the right bank of Xe Namnoy river 4 km downstream from the dam. 2 units of Francis turbine/generators (33.5 MW 2 units) are planned. The power plant generates 67 MW of installed capacity, 332 GWh by 81 m of effective head and 96 m^3/s of maximum discharge. A 3.4 km of headrace tunnel is planned between the dam and the powerhouse.

(2) At the dam site of Xe Namnoy Midstream Project, sandstone, shale and basalt are underlain. Basalt is distributed at lower part than the river bed at the left bank and develops seams overall. This basalt has high permeability so that more detailed survey will

be required including reservoir area. Geology at the waterway and the powerhouse areas are underlain sandstone, shale, and generally satisfactorily.

(3) Total construction cost of the Xe Namnoy Midstream project is preliminary estimated as follows:

Base (Transmission line cost from the powerhouse to B. Houaykong Substation is included)
US$281,807,000

Case 1 (Addition to the Base, B. Houaykong substation cost and the transmission line cost up to Thai border are included by allocation)
US$316,235,000

Case 2 (Independent transmission line cost from the powerhouse to the Thai border)
US$310,686,000

Construction cost of the Xe Namnoy Downstream Project is US$151,400,000.

(4) Construction period of the Xe Namnoy Midstream Project is planned 5 years including preparatory work such as construction of access roads, and the Downstream Project is planned to complete within the period of the Midstream Project.

(5) 1 m^3/s of river retaining flow to the downstream is considered for the Midstream project, but not considered for the downstream Project because there are no village in the section between the dam and the powerhouse.

2.6 Summary of Each Project

Results of the pre-feasibility study for the three selected projects are summarized as follows.

(1) Comparison of Technical Aspect

Items	Se Kong No. 4	Xe Kaman No. 1	Xe Namnoy
Development Plan Development type	Dam reservoir type	Dam reservoir type	·Dam reservoir type with Xe Pian diversion (Mid.) ·Run of river type with daily regulation
Installed capacity	443 MW	256 MW	·Mid. 238 MW ·Down. 67 MW
Annual energy	1,816 GWh	1,137 GWh	·Mid. 1,052 GWh ·Down. 332 GWh
Reservoir Reservoir area Effective reservoir capacit	128 km^2 1,700 x 10^6 m^3	193 km^2 1,270 x 10^6 m^3	·Mid. 21.8 km^2 250 x 10^6 m^3
Environmental impact Reservoir area	The greater part of the area is forest. Small villages and farmers practice slash-and burn agriculture	The greater part of the area is forest. Small villages and farmers practice slash-and burn agriculture	In the Bolaven Plateau. The greater part of area is forest. Small villages and farmers practice slash-and burn agriculture.
Resettled peoples (estimated)	3,500	600	900 (Mid.)
Site characteristic Reservoir operation	Stable power can be supplied with large reservoir.	Stable power can be supplied with large reservoir.	As vast differences in flow from dry season to rainy season, special attention on reservoir operation is required (Mid.). Effective regulation is expected using by reservoir operation of Mid. reservoir (Down.).
Access	· National roads to Sekong Town can be available throughout all seasons · No road from B.Phon to the dam site(18 km)	· National roads to Attapu are no good condition in rainy season. No bridge at Xe Namnoy river. · Local road at Attapu no bridge (Se Kong river) · Local road from Attapu to the dam site is very narrow and bad. Not available in rainy season.	· Local road to B.Latsasin is available throughout all seasons. · No road to Down. site.
Geology	· Good, sandstone, shale	· Good, sandstone, shale, conglomerate	· Sandstone, basalt (high permeability). Special attention is required for the basalt distribution.
Transmission line 1/	80 km to B.Houaykong s/s	140 km to B.Houaykong	10 km to B.Houaykong s/s (Mid.) 10 km to Mid. powerhouse

1/ Transmission line shows for base case (Ref. schematic diagram shown in (4)).

(2) Comparison of Economic Analysis Results

(a) Se Kong No.4 Project

Transmission Line up to the Thai Border

Case	Construction Cost	EIRR (%)
Base Case	1,585 $/kW (643.6 M.US$)	10.81
Case 1 (Allocated)	1,704 $/kW (691.6 M.US$)	10.01
Case 2 (Independent)	1,700 $/kW (690.3 M.US$)	10.03

(b) Xe Kaman No.1 Project

Transmission Line up to the Thai Border

Case	Construction Cost	EIRR (%)
Base Case	1,649 $/kW (404.1 M.US$)	11.78
Case 1 (Allocated)	1,780 $/kW (436.2 M.US$)	10.74
Case 2 (Independent)	1,805 $/kW (442.1 M.US$)	10.57

(c) Xe Namnoy Project (Mid + Down)

Transmission Line up to the Thai Border

Case	Construction Cost	EIRR (%)
Base Case	1,464 $/kW (433.2 M.US$)	16.67
Case 1 (Allocated)	1,575 $/kW (466.3 M.US$)	14.89
Case 2 (Independent)	1,561 $/kW (462.1 M.US$)	15.10

(d) Xe Namnoy Project (Midstream)

Transmission Line up to the Thai Border

Case	Construction Cost	EIRR (%)
Base Case	1,225 $/kW (281.8 M.US$)	21.83
Case 1 (Allocated)	1,369 $/kW (314.9 M.US$)	18.18
Case 2 (Independent)	1,351 $/kW (310.7 M.US$)	18.58

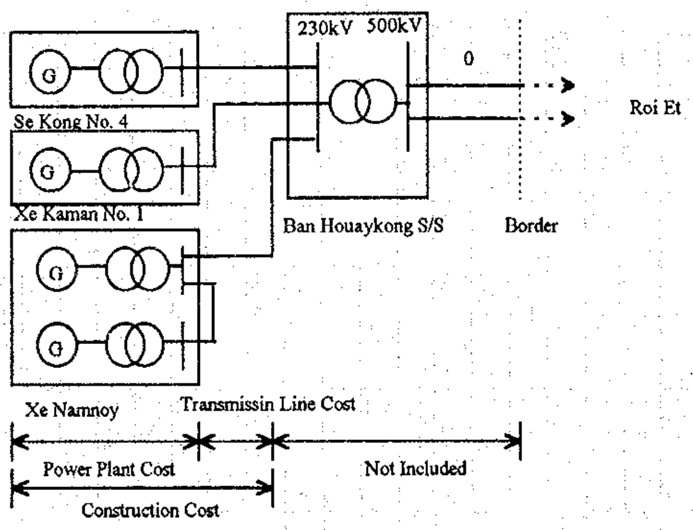
(3) Comparison of Financial Analysis Results

Project Name	Financial Condition a/	Case of T/L Facilitiy b/	Installed Capacity MW	Generation Energy GWh	Salable Energy GWh	Const. Cost M.US$	Unit Cost $/kW	FIRR for Repay. Period c/ %	FIRR for BOT Period e/ %	Averaged DSC f/ Times	Financial Generation Cost $/MWh
Se Kong No.4	A	Base	443	1816	1616	643.61	1,452.8	24.55	-	1.61	56.93
		1				693.55	1,565.6	22.75	-	1.46	61.33
		2				690.27	1,558.2	22.86	-	1.47	61.04
	B	Base				643.61	1,452.8	-9.85	8.03	0.85	78.15
		1				693.55	1,565.6	-19.25	6.88	0.78	83.79
		2				690.27	1,558.2	-18.26	6.96	0.78	83.42
Xe Kaman No.1	A	Base	256	1137	1012	404.05	1,578.3	27.49	-	1.55	54.95
		1				432.93	1,691.1	25.37	-	1.42	58.85
		2				442.10	1,727.0	24.73	-	1.38	60.10
	B	Base				404.05	1,578.3	-13.68	7.97	0.83	74.67
		1				432.93	1,691.1	-31.25	6.83	0.76	79.61
		2				442.10	1,727.0	N/A d/	6.48	0.74	81.19
Xe Namnoy (Mid + Down)	A	Base	305	1384	1232	433.22	1,420.4	37.28	-	1.75	46.51
		1				467.65	1,533.3	34.12	-	1.59	50.19
		2				462.10	1,515.1	34.62	-	1.61	49.60
	B	Base				433.22	1,420.4	-6.58	10.33	0.93	63.06
		1				467.65	1,533.3	-13.31	8.84	0.85	67.64
		2				462.10	1,515.1	-12.06	9.07	0.86	66.90
Xe Namnoy (Midstream)	A	Base	238	1052	936	281.81	1,184.1	43.45	-	2.12	39.86
		1				316.24	1,328.7	38.75	-	1.84	44.71
		2				310.69	1,305.4	39.46	-	1.88	43.92
	B	Base				281.81	1,184.1	2.76	13.60	1.11	54.80
		1				316.24	1,328.7	-3.73	11.15	0.97	60.83
		2				310.69	1,305.4	-2.62	11.51	0.99	59.86

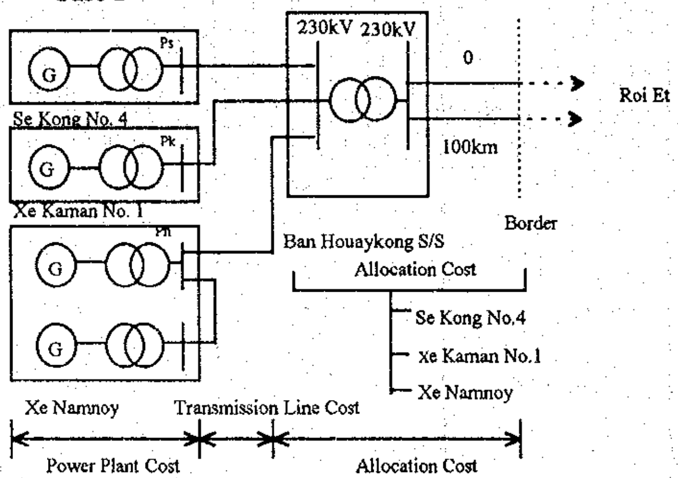
Note: a/ A :Government base B: BOT scheme
c/ Government Base : 25 years BOT scheme : 10 years
e/ 25 years
b/ 1: Allocated T/L system 2: Independent T/L
d/ N/A means less than -35 %.
f/ DSC is the abbreviation for Debt Service Coverage

(4) Schematic Diagram related to Transmission Line

Base



Case 1



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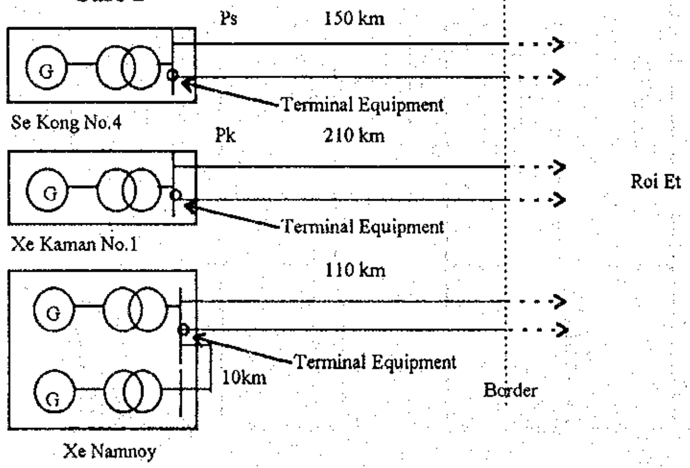

RECOMMENDATION

RECOMMENDATION

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RECOMMENDATION

1. Hydropower Potential Study in the Se Kong Basin

(1) Hydropower potential study has been conducted toward clarifying the overall hydropower development potential in the Se Kong basin and preparing a development plan inventory of the basin for selecting several medium to large scale priority projects. Taking these two purposes into account, the hydropower potential was studied so as to provide approximately 60% of plant factor for each project and to maximize the total net benefit (B-C) of the basin.

Although the project locations proposed in this study will remain rational as long as no significant change appears in hydrological conditions from the stand point of potential evaluation, different development scales will be proposed depending on criteria employed such as plant factor and economic evaluation criteria of the projects.

It is important for evaluation of the development plan inventory proposed in this study to understand the basic study policy employed.

(2) The development plan inventory has been established by using existing topographic maps and hydrological and meteorological data in this study. Particularly, availability of the hydrological data observed in the basin is very limited. Therefore, series of the inflow data estimated for each project site are not of accurate actually.

Accumulation of hydrological and meteorological data for a long period is important for development of hydropower projects. Even the observation records of water level and precipitation by the ordinary method, which are relatively easy to be applied, will be so valuable in the future. There are several economical projects in the Se Kong basin other than the three projects studied in the Pre-feasibility Study stage. It is recommended to start meteorological and hydrological investigations for these projects as soon as possible.

(3) The optimum development plans of the priority projects proposed in the Pre-feasibility Study are different from the plans in the development plan inventory. This difference of plans depends on the difference of accuracy of basic data such as topographic maps and discharge data and on the difference of study criteria employed.

By reviewing the difference of each plan, it is understood that no revise is required at this moment on the development plan inventory. However, when a significant change appears in basic conditions such as accumulation of hydrological and meteorological observation records and topographic maps or implementation of priority projects, it is necessary to revise development plan of related projects in the inventory.

2. Pre-feasibility Study

2.1 Common Items for Each Project

(1) Resulting the pre-feasibility study, three projects; Se Kong No.4, Xe Kaman No.1 and Xe Namnoy Project, selected from the hydropower potential study are promising projects technical and economical points of view. As for financial point of view, they are promising projects in case of official loan conditions. However, the financial condition of BOT development proposed by MIH provides extremely less financial performance than that of official loan case.

It is recommended that the Feasibility Study for the each project be carried out in future continuously.

(2) As the three projects are planned for power export purpose, transmission line systems are affected by the receiving facility of the power import country. Therefore, effective international power system plan including development plans in other basins will be required.

(3) Meteorological/hydrological data are not enough for the each project. Continual observation of river discharge, rain, evaporation and etc. are required. Especially, observation of river discharge at the gauging station of Sekong Town, Attapu Town, B.Hatsaykhao, B.Fangdeng and B.Latsasin will be very important data for the future study.

(4) As for environmental impact and compensation, more detailed surveys are required for the each projects. Especially, the three projects are dam reservoir type development plans, problem of the resettlement of inhabitants, disruption of ecosystem will be occurred. Measures on impacts of the river environment and the river utilization at the downstream area of the dam and powerhouse are also important. Further survey and study will be necessary for the problems.

(5) In the hydropower development plan study, optimum development plan is selected adopting 8 hours of peak power duration to evaluate the value (kW value) of peak supply by the powerplant.

Here, the 8 hours peak duration is referred Thailand's recent daily demand curve. In this case, approximately 50 % of plant factor are obtained.

However, it is considered that a certain extent smaller installed capacity and larger plant factor are profitable for the generating cost of power export. On the other hand, more larger installed capacity has tendency of profitable even higher generating cost as adopting in Nam Ngum Power Station.

At present, it is difficult to select the optimum development plan considering the condition above because the future tariff system of power export is not cleared. Re-examination of the development plan considering the condition is required in future study.

2.2 Se Kong No.4 Project

(1) It is recommended that the following topographic maps be prepared on the Feasibility Study Stage.

Reservoir area : Scale 1/10,000 (all areas except maps prepared by JICA)
Dam area : Scale 1/1,000 (including waterway and powerhouse)

(2) It is recommended that the following geological investigation be carried out on the Feasibility Study Stage.

Location	Seismic prospecting	Test pit	Core drilling
Dam axis	–	–	4 × 100 =400 m
Waterway	–	–	3 × 30 = 90 m
Spillway	–	–	1 × 30 = 30 m
Quarry site	–	–	1 × 50 = 50 m 1 × 100 = 100m
Aggregate	1.5 km	5 × 5 = 25 m	5 × 10 = 50 m
Borrow area	1.5 km	5 × 10 = 50 m	5 × 10 = 50 m
Total	3.0 km	75 m	20 holes 770 m

(3) In the reservoir area extended 128 km^2 and the dam area included related area, more detailed survey of environmental impact and compensation will be required in future.

(4) Prior to the project implementation, it is necessary to construct an access road from B.Nava Nua to the dam site.

2.3 Xe Kaman No.1 Project

(1) It is recommended that the following topographic maps be prepared on the Feasibility Study Stage.

Reservoir area : Scale 1/10,000 (all areas except the maps prepared by JICA)
Dam area : Scale 1/1,000 (including waterway, powerhouse)

(2) It is recommended that the following geological investigation be carried out on the Feasibility Study Stage.

Location	Seismic prospecting	Test pit	Core drilling	
Dam axis	–	–	3 × 100 =	300 m
Waterway	–	–	2 × 30 = 1 × 50 =	60 m 50 m
Dam right bank	–	–	1 × 50 =	50 m
Quarry site	–	–	1 × 100 =	100m
Aggregate site	2.0 km	5 × 5 = 25 m	5 × 10 =	50 m
Total	2.0 km	25 m	13 holes	610 m

(3) In the reservoir area extended 193 km^2 and the dam area included related area, more detailed survey of environmental impact and compensation will be required on Feasibility Study Stage.

(4) Prior to the project implementation, it is necessary to construct and improvement as access road from Attapu Town to the dam site.

2.4 Xe Namnoy Project

(1) It is recommended that the following topographic maps be prepared on the Feasibility Study Stage.

Dam site (Mid.) : Scale 1/1,000 (including powerhouse)
Dam site (Down.) : Scale 1/1,000 (including powerhouse)

(2) It is recommended that the following geological investigation be carried out on the Feasibility Study Stage.

Location	Seismic prospecting	Test pit	Core drilling	
a) Midstream Project				
Dam axis	–	–	3 × 30 = 2 × 50 = 1 × 60 =	90 m 100 m 60 m
Dam site (Xe Pian)	–	–	4 × 10 =	40 m
Waterway	–	–	1 × 50 = 2 × 150 =	50 m 300 m
Penstock & powerhouse	1.5 km	–	1 × 50 = 1 × 30 =	50 m 30 m
Quarry site	–	–	1 × 50 =	50 m
Borrow area	1.0 km	10 × 5 = 50 m	3 ×10 =	30 m
b) Downstream Project				
Dam axis	–	–	3 × 30 =	90 m
Waterway & powerhouse site	–	–	1 × 80 = 1 × 50 = 1 × 20 =	80 m 50 m 20 m
Total	2.5 km	50 m	25 holes	1,040 m

Especially, as the basalt lava is distributed at the left bank of Xe Namnoy Midstream Project, a watertightness including dam foundation treatment are worry about its measures and cost estimation. More detailed geological survey will be required in future.

(3) In the reservoir extended 21.8 km^2 and the Midstream dam area including related construction, more detailed survey of environmental impact and compensation will be required in future.

Survey on the river retaining flow at the downstream areas of the Midstream powerhouse and Xe Pian intake dam will be required.

(4) Prior to the project implementation, it is necessary to construct access roads from B.Houaykong to the Downstream Project site, to the Xe Pian intake dam site.

PART 1 GENERAL

1. Introduction

1. Introduction

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1. Introduction

1.1 Foreword

This Study was undertaken during the period June, 1993 to March 1995 to formulate the Master Plan Study on the Hydroelectric Power Development in the Se Kong Basin, Lao P.D.R., as a part of the technical assistance provided by the Japan International Cooperation Agency (JICA). In the Study, a hydropower potential studies were carried out in the Se Kong basin was carried out at first stage. Then pre-feasibility studies were carried out for the three projects selected from the projects in the development plan inventory.

This Final Report compiles the results of the studies and is composed of the following three sets.

- Final Report
- Summary
- Appendixes

1.2 Background

The Government of Lao P.D.R. requested the Government of Japan to assist in carrying out a hydropower potential study and pre-feasibility study for hydroelectric power development in the Se Kong Basin. Hydroelectric power development in the basin is planned for two major reasons, (1) to develop an electric power source as a part of the Southern Laos Development Program and the (2) to enable power export to the neighboring countries.

The Government of Japan agreed to provide assistance. JICA dispatched a preliminary study team, to Lao P.D.R. headed by Mr.N.SHIMOMURA (then Director, Natural Resources Div., Mining & Industrial Planning and Survey Dept., JICA) in March, 1993. The team undertook site reconnaissance, data collection, etc. and also held discussion with Ministry of Industry and Handicraft (MIH) of the Lao P.D.R. The Scope of Work (S/W) for master plan study on the project was prepared, the contents finally agreed, and duly signed on March 11, 1993.

In order to promote the Study contemplated in the above S/W, JICA selected the consultant firm and awarded the study works to the joint venture consisting of Electric Power Development Co. Ltd. (EPDC, leading firm), NEWJEC Inc. and PASCO International Inc..

The study team, organized in accordance with the above consultancy contract and headed by Mr. T. TEZUKA (EPDC), immediately started study works in June 1993.

The study team first prepared an Inception Report and presented the same to the MIH in July, 1993. This Report contained the policy, method of the study, and works to be undertaken by the MIH and the JICA. In the Report, the study team divided the works into two stages; a hydropower potential study stage and a pre-feasibility study stage.

Secondly, the study team carried out site reconnaissances, a hydropower potential study to prepare hydropower development inventory. Then the three priority projects were selected from the 15 projects in the inventory. These studies were reported in the Interim Report and submitted to MIH in November, 1993.

Thirdly, field investigations such as hydro-meteorological survey, topographic survey by aerial photogrammetry, geological investigations, environmental impact survey were carried out at the three selected project sites. Details of these field investigations were reported in the Progress Report and submitted to MIH in July, 1994.

Finally, pre-feasibility studies were carried out for the three selected projects.

The field works for the study were carried out in cooperation with the term's counterparts from the MIH. During this study, the study team provided technical transfer to their counterparts through the field investigations. In the mean time, JICA invited two counterparts in Japan and provided technical trainings for them. The study team also held a technical seminar at Vientiane in July 1994.
All study works were completed on March, 1995.

1.3 Objectives, Scope and Contents of Study

1.3.1 Objectives of Study

The objectives of this study is to prepare a master plan for hydroelectric power development in the Se Kong Basin, and conduct pre-feasibility studies on several promising project sites to decide the promising project site where feasibility study will be conducted in the future.

Also, during this study, technology concerning hydroelectric power development will be transferred to Lao's counterparts.

1.3.2 Areas and Scope of Study

(1) Areas to be Studied

The catchment area of about 23,350 km^2 inGgcluding the Se Kong main stream and its 6 main tributaries within Laos.

To collect reference materials from government institutions in Lao and public institutions outside of Laos such as the Mekong Committee.

(2) Scope of Study

Hydropower potential and pre-feasibility study for hydroelectric power development.

1.3.3 Contents of Study

Contents of the study to be performed is as follows.

(1) Hydropower Potential Study Stage

a) Data Collection

Collection and review of all existing data, reports and other relevant information including existing hydropower development plans in the basin.

b) **Site Reconnaissance**

Site reconnaissance from the view-points of topography, geology, hydrology, environment, and social and economic aspects.

c) **Power Survey**

- Study on organization of power supply including management and institution,
- Study on existing power supply system,
- Study on power market including power tariff structure,
- Survey on power demand forecast including export, and role of basin in the total power system in Laos.
- Survey on power balance including power expansion program in the basin and neighboring area.

d) **Preparation of Inventory**

Preparation of inventory for hydropower projects and studied in the previous studies including the alternative development schemes studied by use of maps in a scale of 1/50,000. The project high-light, such as reservoir capacity, main structure dimension, maximum discharge/firm discharge, installed capacity/firm output, annual energy production/firm energy, project cost, and preliminary economic analysis and environmental impact study are to be included in the study.

e) **Project Identification**

Identification of relatively high priority projects as the objectives of pre-feasibility study.

(2) **Pre-feasibility Study Stage**

Based on the results of hydropower potential study stage, following works are to be carried out on the selected projects:

a) **Topographic Survey**

Aerial survey and photogrammetric mapping of scale 1/10,000 and supplemental ground survey of the project area.

b) **Geological Survey**

- Seismic prospecting,
- Drilling work and permeability tests,
- Construction material survey,
- Preliminary geological and geo-technical study in the project area.

c) **Survey on Access to the Project Sites**

- Survey on existing port,
- Survey on existing road network and conceivable transportation route.

d) **Hydro-meteorological Survey**

- Installation of hydro-meteorological stations,
- Hydro-meteorological observation,
- Hydro-meteorological studies.

e) **Operation Study**

- Review and study of the optimum power generation program,
- Relevant transmission line,
- Establishment of preliminary operation study.

f) **Optimization Study**

Preliminary optimization studies on project sizes.

g) **Study on Environmental Impact**

- Study on natural environment,
- Study on social environment.

h) **Study on Compensation**

i) **Preliminary Design of Main Structure**

j) **Preliminary Construction Program**

k) **Preliminary Cost Estimate**

l) **Preliminary Economic Analysis**

m) **Recommendations**

Formulation of the recommendations for future works in the Feasibility study.

1.4 Field Survey

The field surveys were mainly carried out in Laos. A part of data related Mekong River Basin Development were collected at Mekong Committee Secretariat in Bangkok, and data related an electric power development plan in Thailand was collected at EGAT.

The periods and contents of the field surveys carried out by the study team are as follows.

(1) First Field Survey

a) **In Laos**

Period: From July 6, 1993 to August 18, 1993

Contents of work:

- Presentation of Inception Report
- Site reconnaissance (aerial survey in the Se Kong basin by helicopter, project sites survey, geological survey, power survey, access road survey)
- Data collection
- Technical transfer
- Exchange of minutes of meeting

b) **In Thailand**

Period: From August 19, 1993 to August 25, 1993

Contents of work:

- Data collection at Mekong Committee
- Data collection at EGAT

(2) **Second Field Survey**

a) **In Laos**

Period: From October 16, 1993 to December 30, 1993

Contents of work :

- Presentation of Interim Report
- Data collection
- Topographic survey (aerial photo), continued up to February 28, 1994
- Site reconnaissance (selection of survey areas, geological reconnaissance, hydro-meteorological survey)
- Seismic prospecting survey
- Preparation of field investigation works
- Access road survey
- Technical transfer
- Exchange of minutes of meeting

b) **In Thailand**

Period: From November 28, 1993 to November 29, 1993

Contents of work :

- Data collection at Mekong Committee Secretariat

(3) **Third Field Survey**

Period: From January 18, 1994 to February 13, 1994

Contents of work :

- Improvement of hydro-meteorological stations
- Advice of hydro-meteorological survey
- Data collection of hydro-meteorology
- Technical transfer

(4) **Fourth Field Survey**

Period: From February 24, 1004 to March 23, 1994

Contents of work :

- Advice of core drilling work

- Evaluation of core drilling work
- Geological reconnaissance
- Technical transfer

(5) Fifth Field Survey

Period: From July 3, 1994 to July 30, 1994

Contents of work :

- Presentation of Progress Report
- Site reconnaissance (geological survey, environmental impact survey)
- Technical seminar held by JICA study team
- Exchange of minutes of meeting

(6) Sixth Field Survey

Period: From February 14, 1995 to February 28, 1995

Contents of work :

- Presentation of Draft Final Report
- Exchange of minutes of meeting

1.5 Personnel related to Study

The personnel related to the study on Laos side and Thailand side, and the member of JICA study team are listed below.

(1) In Laos

MIH

Mr. Soulivong DARAVONG,	Minister
Mr. Khammone PHONEKEO,	Vice-Minister
Mr. Damdouane PHOMDOUANGSY,	Director of Cabinet
Mr. Sisomphet SIMUONG,	Acting Director of Electricity Department
Mr. Somboun MANOLOM	Deputy Director of Electricity Department
Mr. Khamsing NGONVORARATH,	Senior Advisor
Mr. Somsack PHRASONTHI,	National Project Director
Mr. Voradeth PHONEKEO,	Hydro Power Engineer

EDL

Mr. Houmphone BULIYAPHOL	General Manager
Mr. Khamphone SAIGNASANE,	Deputy General Manager
Mr. Outhay OUDAVONG,	Deputy Manager of Project Department
Mr. Hatsady SYSOURATH,	Manager of Economic, Planning Department
Mr. Sisanga,	Mechanical Engineer, Economic, Planning Department

HEC

Mr. Thongsamouth LUNAMMACHAK,	General Manager
Mr. Somsavanh PHANMATHA,	Hydro Power Engineer
Mr. Saykham SOUKVANHEUANG,	Civil Engineer/Survyer
Mr. Seng PANYASIRI,	Senior Hydrologist
Mr. Thongsay INDALANGSY,	Engineering Geologist
Mr. Khayka,	Geologist
Mr. Bounmy,	Geophysicist

Department of Geology and Mines

Mr. Phaychith SENGMANY,	Chief of Managerial Division of Mineral Resources

Ministry of Communication, Transport, Post and Construction (Department of Communication)

Mr. Khamphet PHONGRATSASY,	Project Manager of Bridge Management

National Geographic Department

Mr. Bouasoth SOUVANNAKOUMMANE,	Chief of Photogrammetry Section
Mr. Khamphone AMPHAYPHONE,	Engineer of Photogrammetry Section

MIH Pakse Office

Mr. Mang,	Director
Mr. Thongkham,	Deputy Director
Mr. Nouthak,	Deputy Director
Mr. Souvanh,	Administrator

EDL Pakse Office

Mr. Singthong,	Director
Mr. Thongphanh,	Deputy Director

EDL Nam Ngum Hydropower Station

Mr. Ounkham,	Manager
Mr. Vanthong,	Electrical Engineer

EDL Xe Set Hydropower Station

Mr. Sisouvanh SOUVANNAPHASY,	Director
Mr. Te KHOUNNOUVONG,	Deputy Director

EDL Selabam Hydropower Station

Mr. Kittiveth KONGVINGSAR,	Director
Mr. Khampha SIRIVONG,	Director of Extention Construction Office
Mr. Sitha,	Operator

EDL Bangyo Substation

Mr. Somphone SIMMALAVONG,	Director
Mr. Somphone SIBOUNHEUANG,	Deputy Director

Champassack Province

Mr. Souksamay CHANTHAMAT,	Deputy Chief of Geological Survey Unit Southern Laos (Pakse)
Mr. Bounsay SAPANGTHONG,	Chief of Department of Forest and Environmental Services
Mr. Souane, SILAVONG,	Chief of Department of Hydrology and Meteorology

Se Kong Province

Mr. Khamboun DUANGPANYA,	Governor of Se Kong Province
Mr. Bounmy,	Chief of Provincial Administration Office
Mr. Khamvy,	Head of Department of Industry and Commers
Mr. Khamphet,	Administrator, DIC
Mr. Phetsamone,	Geologist, DIC
Mr. Sounphanh,	Electrical Engineer, DIC
Mr. Youang CHANTHABOUHEUANG,	Director of Service of Agriculture and Forest
Mr. Somdy,	Chief of Statistic Unit of Service of Statistic, Planning and Financial

Mr. Somvang,	Chief of Service of Agriculture and Forest
Mr. Thongkham,	Planning Unit of Service of Agriculture and Forest

Attapu Province

Mr. Sinai MIENG LAVANH,	Deputy Governor of Attapu Province
Mr. Soulintha,	Chief of Eternal Economic Relation
Mr. Phounesouk PHICHIT,	Department of Hydrology and Meteorology in Vientiane (Dispatched to Attapu)

Mekong River Bridge Project

Mr. Bounthong PRASEUTSAK,	Civil Engineer

(2) In Thailand

Mekong Committee (Mekong Secretariat, Bangkok)

Mr. Hayao ADACHI,	Hydro Power Engineer
Mr. Yoshinori KEMMA,	Senior Project Officer
Mr. Vraluck CHATARUPAVANICH,	Assistant Executive Agent and Officer-in-Charge

EGAT (Bangkok)

Mr. Smarn PHONGPRAPAPHAN,	Assistant Director, Systems Planning Department-Planning
Mr. Prutichai CHONGLERTVANICHKUL,	Chief, Power System Division

(3) JICA Study Team

Mr. Tokuji TEZUKA,	Team Leader,	EPDC
Mr. Katsuhiko YAMADA,	Civil Engineer,	NEWJEC
Mr. Shigeru NAKAMURA,	Hydropower Planning Engineer,	EPDC
Mr. Kazunori INOUE,	Hydrologist,	NEWJEC
Mr. Nobuo HOSHINO,	Geologist,	EPDC
Mr. Toshiro WADA,	Electrical Engineer,	EPDC
Mr. Kazuhisa ISHIDA,	Trans. Line Engineer (1993),	NEWJEC

Mr. Yoshiro SEKIMURA,	Trans. Line Engineer (1994),	NEWJEC
Mr. Hiroshige TANIGUCHI,	Environmental Engineer,	EPDC
Mr. Yasuharu MATSUDA,	Project Economist,	NEWJEC
Mr. Hideo SUZUKI,	Drilling Work Specialist,	EPDC
Mr. Tomohide OHTSUBO,	Seismic Pros. Specialist,	EPDC
Mr. Hitoshi KOIZUMI,	Seismic Pros. Specialist,	EPDC
Mr. Shigeru SHIKANO,	Seismic Pros. Specialist,	EPDC
Mr. Kuniaki TAKAMATSU,	Topo.Survey Specialist (1993),	PASCO
Mr. Fujio ITO,	Topo.Survey Specialist (1994),	PASCO
Mr. Yutaka KOKUFU,	Topo.Survey Specialist,	PASCO
Mr. Yukihiro IKEGUCHI,	Coodinator (1993),	EPDC
Mr. Yoichi SHIBUYA,	Coodinator (1994),	EPDC

Notes

EPDC	:	Electric Power Development Co. Ltd., Tokyo
NEWJEC	:	NEWJEC Inc., Osaka
PASCO	:	PASCO International Inc., Tokyo

1.6 Reference Data and Reports

List of data and reports reffered in the study are as shown in **Table 1.6-1.**

Other than the Main Report and Appendixes, the meteorological and hydrological data collected and used in the study, and documents compiling the results of the filed investigation works carried out in this Study are shown below.

- Collected Meteorological and Hydrological Data
- Topographic Maps and Data of Aerial Photogrammetric Survey
- Report and Data of Core Drilling Work
- Report on Environmental Impact and Compensation

Table 1.6-1 List of Data and Reports referred in the Study

No. Title

REPORTS

1. Lao P.D.R. Basic Statistics about the Socio-economic Development '92, State Statistical Centre
2. Lao P.D.R. Statistics of Demography, 1992
3. Lao P.D.R. Socio Economic Development Strategies, UNDP, Mar.1992
4. Lao P.D.R. Development Co-operation, 1991 Report, UNDP, Nov.1992
5. Inventory of Promising Tributary Projects in the Lower Mekong Basin, Volume II, Laos, Mekong Committee, Sep.1970
6. Lower Mekong Water Resources Inventory, Summary of Project Possibilities, Mekong Committee, WATCO, Sept. 1984
7. Perspective for Mekong Development - Summary Report -, Mekong Committee, 1987
8. Feasibility Study on Xe Katam Small-scale Hydroelectric Power Development Project, JICA, Mar. 1992
9. Six Possible Medium Scale Hydropower Projects in the Province of Saravane, Champassak and Attapu, Norpower, Feb.1991
10. Power Distribution Associated with Proposed Secatam Hydropower Project, EDL/ADB, Feb. 1990
11. Lao P.D.R. Southern Area Development Master Plan - Sectoral Report - Geology and Mineral Resources, ADB/UNDP, May 1987
12. Sekong Province Integrated Rural Development Project Report, UNDP, Feb. 1985 and May 1989
13. Lower Mekong Hydrologic Yearbooks, Mekong Committee, 1980 to 1990
14. Xe Set Hydropower Project, Hydrology Design Memorandum, Norconsult, Nov. 1985
15. The Lower Mekong Basin, Suspended Sediment Transportation Problems, Mekong Committee, Oct.1992
16. Evaluation of Sediment Data in Lower Mekong Basin, Mekong Committee, 1988
17. Assessment of the Magnitude and Frequency of Flood Flows, ECAFE/WMO, 1967
18. Sedimentation in the Nam Ngum Reservoir, Mekong Committee, Oct.1992
19. Basinwide Water Quality Studies Phase I and Phase II, Mekong Committee, Oct.1982
20. Ecologically Sound Development of Water and Land Resources in the Mekong Delta, Mekong Committee
21. The Review of Seminar on the Southern Forest, Lao P.D.R.
22. An Assessment of the Current Status of Kouprey and Other Wild Cattle in Southern Laos, International Union for Conservation of Nature and Natural Resources, June 1990

23. The Environmental Impacts from the Xe Set Hydropower Project, Mekong Committee/SWECO, 1998
24. Nam Leuk Hydropower Development Project F/S Report - Environmental Impact Assessment, ADB, Jan.1992
25. Nam Song Diversion Project F/S Report - Environmental Impact Assessment, ADB, Jan.1992
26. Nam Theun 1/2 Hydropower Project F/S - Initial Environmental Impact Assessment Report, Norpower, Sep.1992
27. Nam Theun 1 Hydropower Project Updating of Pre-F/S Phase I - Part II Environment and Resettlement Report, SWECO/HEC, Nov.1992
28. Tat Nam Nua Small Hydropower Development Project - Report on Socio-economic Environment Assessment, Burapha Development Consultants
29. Lao P.D.R. National Transport Study, Final Report - Appendix -, SWECO 30. Lao.P.D.R. Irrigation Subsector Review - Final Report, ADB, May 1989
31. Lao P.D.R. Import Tax Regulation
32. Se Don 2 Hydropower Project F/S, Report Volume 2, Apr. 1991
32. Nam Theun 1/2 Hydropower Project F/S Report, Norpower, May 1993
33. Nam Theun 2 Hydropower Project F/S Report, SMEC, Nov. 1990
34. General Information - EGAT Power Development Plan, EGAT, Sep.1992
35. Power Sector in Thailand, EPDC
36. Report of Study on Vietnam Power Development - A Long Term and Medium Term Plan-, Institute of Energy Economics Japan, Jun.1989

OTHERS

1. Aerophotograph of Se Kong Basin (scale 1:30,000)
2. Hydrological and meteorological data at related stations
3. Power demand and supply records in Lao P.D.R., EDL
4. Operation records of Nam Ngum Power Station, EDL
5. Description of existing power plants, transmission lines, substations and distribution lines in Lao P.D.R., EDL
6. Route map of existing transmission lines (including future plan), EDL 7. Long term power system development program, EDL
8. Location Map of EGAT Power System, EGAT
9. Power flow diagrams and impedance diagrams, EGAT
10. Annual gross energy generation record, EGAT
11. Daily load curves on peak days, EGAT
12. Energy import and export to EDL in FY1992, EGAT

2. General Condition in Laos and in the Se Kong Basin

2. General Condition in Laos and in the Se Kong Basin

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2. General Condition in Laos and in the Se Kong Basin

2.1 General Condition in Laos

2.1.1 Geography

Laos has a land area of 236,800 km^2. The country has no seaboard and is completely enclosed by China, Myanmar, Thailand, Vietnam and Cambodia. Laos is divided into 17 provinces and a special region. For economic purposes, these are again divided into (1) the northern section containing 8 provinces and a special region centered around Luangprabang, (2) the central section containing 5 provinces centered around capital city of Vientiane, and (3) the southern section containing 4 provinces centered around Pakse (See **Fig. 2.1-1**).

In western Laos, the Mekong River flows for more that 1,500 km, forming a border with Thailand. 85% of Laos lies within its basin. The main tributaries of the Mekong River in Laos are the Nam Ou (448 km), the Nam Ngum (354 km), the Xe Banghieng (338 km), the Nam Tha (325 km) and the Se Kong (320 km).

To the east, the Annam Ranges form a border with Vietnam.

Topographically, 80% of Laos is mountainous peaks ranging from area with 200 m-2,800 m in height. The greater part of this area is covered with forest. Plains expand along the Mekong River and its tributaries. Only 8% of Laos is cultivated.

2.1.2 Population

In 1993, the population of Laos was 4.47 million. The northern section had 1.65 million people, the central section had 1.94 million, and the southern section had 0.88 million people. The population density for all Laos is 19 persons/km^2. **Table 2.1-1** shows the populations and population densities of each province.

2.1.3 Industry and Economy

While Laos is rich in natural resources such as water, forests, minerals, etc.. These resources have not been developed effectively.

60% of Laotian industry is agriculture with rice, corn, tobacco, sugar cane, coffee, etc. being the main products. Manufacturing accounts for only 16% and is represented by timber, plywood, furniture, clothing, tobacco, etc. with most electric power and timber being mainly exported to Thailand. Table 2.1-2 shows the principal exported goods.

The gross domestic production (GDP) of 1993 was estimated as 721,819.3 million Kip (per capita-approx. US$ 230).

The economic activity of Laos is expected to expand in future due to the completion of the Mekong Friendship Bridge between Vientiane and Nonkhai (Thailand) in April, 1994.

Table 2.1-1 Population and Population Density

	Name of Provinces	Area (km^2)	Population (Th. persons)	Density (Persons/km^2)
	Whole country	236,800	4,474	19
1	Vientiane Mun.	3,920	503	128
2	Phongsaly	16,270	152	9
3	Luangnamtha	9,325	128	14
4	Oudomxay	15,370	193	13
5	Bokeo	6,196	106	17
6	Luangprabang	16,875	365	22
7	Huanphanh	16,500	238	14
8	Xayabury	11,795	200	17
9	Xiengkhuang	17,315	196	11
10	Vientiane	19,990	330	17
11	Borikhamxay	16,470	155	9
12	Khammuane	16,315	265	16
13	Savannakhet	21,774	692	32
14	Saravane	10,691	243	23
15	Sekong	7,665	60	8
16	Champasack	15,415	490	31
17	Attapu	10,320	84	8
	Special region	4,594	74	16

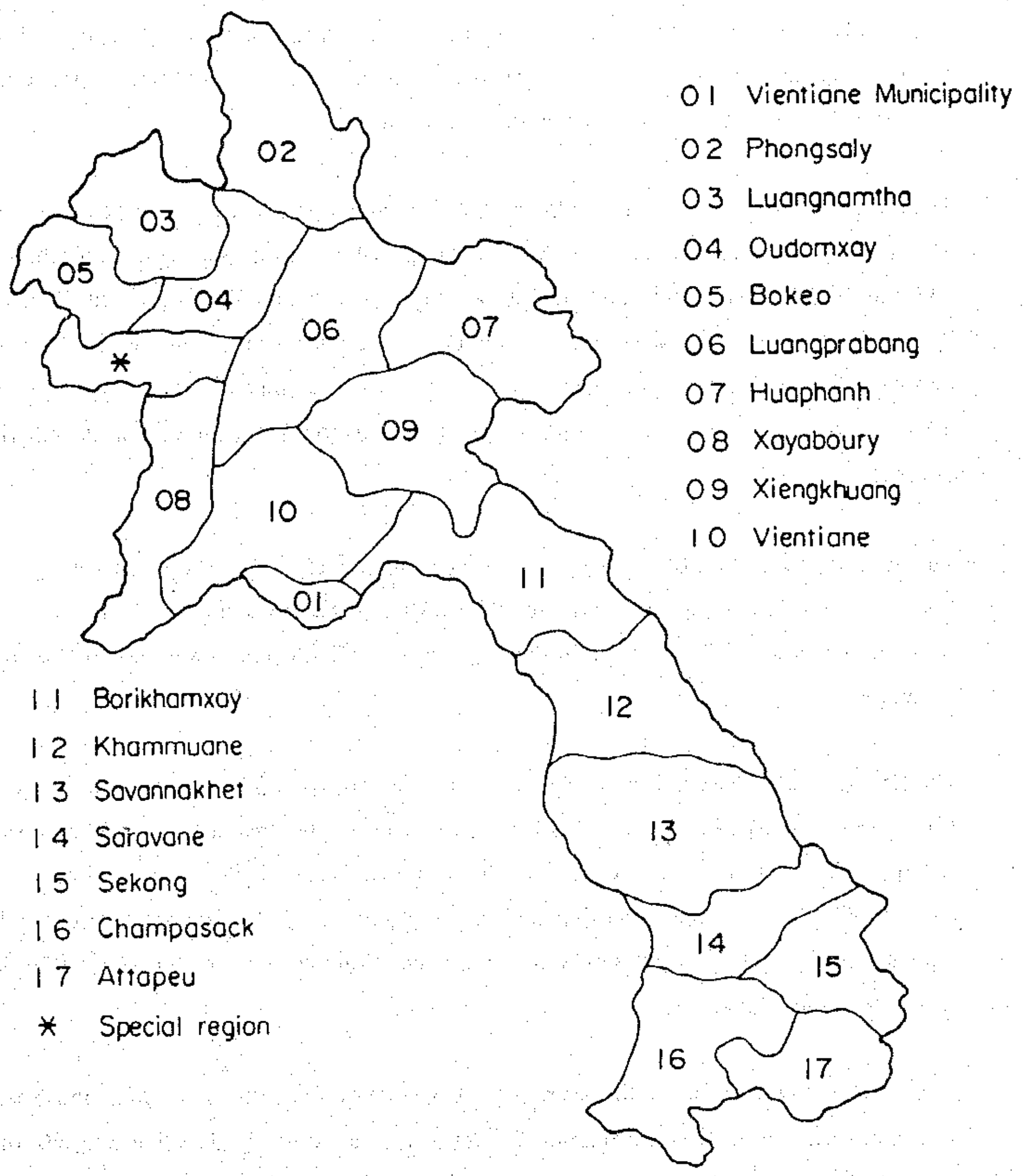
Source: Basic Statistics in Lao P.D.R., 1993

Table 2.1-2 Principal Exported Goods

Items	Unit	1993
Electric Power	Mill. kWh	596
Timber	Th. m^3	20.1
Lumber	Th. m^3	261.2
Plywood	Th. Sheet	972
Coffee	Tons	5,489.1
Gypsun	Th. tons	100
Tin	Tons	60

Source: Basic Statistics in the Lao P.D.R., 1993

Fig. 2.1 - 1 Provinces of Lao P.D.R.



Area : 236,800 km²
Population : 4,474 Th.p.
Density : 19 P/km²

Source : Basic Statistics in Lao P.D.R. (1993)

2.2 General Condition in the Se Kong Basin and Surrounding Area

2.2.1 Geography

Southern Laos consist of 4 provinces; Saravane, Champasack, Sekong and Attapu. Pakse city is the economic and social center because the circulation of subsistence commodities are very active with Thailand via the national road, Route 10.

The Se Kong river basin covers the Sekong, Attapu and a part of Champasack provinces. The Se Kong river originates in the Annam Ranges which has peaks rising to heights of 1,000 m-2,000 m and which forms the border between Laos and Vietnam. The Bolaven Plateau is located on the west side. A mountain area with peaks rising to 1,200 m is located in the south forming the border between Laos and Cambodia. The Se Kong river basin is 150 km wide in east/westerly direction, and 150 km long in north/southerly direction.

The Se Kong river has tributaries such as the Xe Kaman river, the Xe Namnoy river, the Xe Pian river, the Nam Kong river and joins the Mekong River in Cambodia. The Se Kong river catchment area is 29,600 km^2 at the confluence of the Mekong River and 10,500 km^2 at Attapu.

The Se Kong river basin forms V shape in the upstream mountain area, a plain of 110-150 m in the midstream area and the Bolaven Plateau. The greater part of the basin is covered by forest and there are very few cultivated areas in the basin. There are no large villages other than Attapu township and Sekong township. The mountain areas still present virgin forest although, secondary forest and slash-and burn method agriculture is prevalent throughout the area.

Located on the western side in the basin, the Bolaven Plateau is 1,000 m-1,500 m above sea level and forms an oval shape running 90 km in the east/westerly direction and, 60 km north/southerly direction. Many villages stand in the Plateau and products of coffee and vegetable are very active due to the good climate. Many rapids and waterfalls are present on the upstream reaches of the tributaries such as the Xe Namnoy river and the Xe Pian river which run east of the Plateau. The eastern edge of the Plateau forms a continuously high cliff along the Se Kong river.

2.2.2 Climate

Southern Laos is located in the Asian seasonal wind zone and being in the tropical zone it is affects by the monsoon. Which provide a clearly distinctive rainy season (May to October) and a dry season (November to April).

Especially, Bolaven Plateau which lies in the basin receives heavy precipitation with an annual mean precipitation of approximately 3,560 mm. Lying at EL.1,000 m, this area also has low temperatures. The annual mean temperature is 19°C at Nikkom 34 meteorological station. At Attapu, an annual mean precipitation of 2,000 mm with an annual mean temperature 27°C have been recorded.

2.2.3 Population

The Population of southern provinces is 877,000 people. Champasack province, including Pakse accounts for 55% of that population. The population density of the Se Kong river basin is very low and there are no large villages other than Sekong and Attapu townships. **Table 2.2-1** shows the population and area of the southern provinces.

2.2.4 Industry and Economy

Except for Pakse, the industry and economy activity in southern Laos is very low due to its little population. Especially, the greater part of Sekong and Attapu provinces are dedicated to farming and forestry with very little industry. A great deal of burn and slash agriculture is carried on the mountain areas. **Table 2.2-2** shows the data for industry and economy of the southern provinces, and **Table 2.2-3** shows the agricultural data for the provinces.

Table 2.2-1 Data of Southern Laos

Provinces	Population (persons)	Area (km^2)
Champasack	490,000	15,415
Saravane	243,000	10,691
Sekong	60,000	7,665
Attapu	84,000	10,320

Source: Basic Statistics in the Lao P.D.R., 1993

Table 2.2-2 Industry and Economy for the Southern Provinces (1993 Data)

No.		Unit	Champasak Province	Sekong Province	Attapu Province	Salavan Province
I.	Idustry:					
	Saw mill	No	19	3	2	3
	Rice mill	No	836	22	28	496
	Handicraft	No	3	1	2	5
	Repair shop	No	13	3	3	1
	Furniture shop	No	26	3	8	0
	Cloth making	No	1	245	168	0
	Electricity	No	2	1	1	1
	Market	No	11	4	5	8
	Industry production:					
	Timber	m^3	33,620	4,138	6,534	20,080
	Sawwood	m^3	383	2,634	2,229	9,630
	Clothing	Sheet				
	Electricity	kwh	92,364,235	4,536	5,400,000	1,633,000
II.	Ecomony:					
	1. Agriculture production					
	Rice	Ton	203,853	9,820	6,628	132,245
	Upland rice	Ton	7,933	6,600	4,048	17,747
	Lowland rice	Ton	194,426	3,150	2,563	112,743
	Irrigated rice	Ton	1,494	70	17	1,755
	Upland crop	Ton				
	Maize	Ton	288	1,360	576	
	Potatoes	Ton	814	19,240	736	
	Vegetable	Ton	728			
	Soybeans	Ton	267	4.7	0.2	
	Mungbeans	Ton	335	30.8	6	213
	Peanut	Ton	197	7.7	18	
	Tabacco	Ton	294	32	56	
	Cotton	Ton	18	30.8	12	150
	Suger can	Ton	637	1,500	300	
	Coffee	Ton	13,770	715	45	800
	Tea	Ton	86		0.2	
	2. Livestock					
	Buffaloes	head	123,342	23,010	43,000	74,100
	Cattle	head	126,923	13,923	6,000	91,330
	Pig	head	112,680	36,540	35,390	155,600
	Goat and sheep	head	223	3,045	639	3,740
	Poultry	head	1,613,620	143,440	2,060	532,500
	Horse	head	512			

Source: Report on Environmental Impact and Compensation in the Se Kong Basin., JICA, 1994

Table 2.2-3 Agricultural Data for the Southern Provinces

Feature	Unit	Champasak Province	Sekong Province	Attapu Province	Salavan Province
Ricefield					
Upland rice	ha	7,887	5,144	3,374	34,584
Lowland rice	ha	4,449	1,279	950	7,750
Irrigated rice	ha	437	20	9	450
Upland crop area					
Maize	ha	109	1,134	443	
Potatoes	ha	147	2,643	368	
Vegetable	ha	293	7	0	
Soybeans	ha	309	44	1	
Mungbeans	ha	450	10	10	266
Peanut	ha	328	8	45	
Tabacco	ha	604	44	80	
Cotton	ha	30	50	17	1,200
Sugar can	ha	121	1,234	50	
Coffee	ha	17,239		30	
Tea	ha	358		1	
Land use area					
Forest area	ha	402,046		1,080,000	800,000
Current forest	ha			716,922	
Potential forest	ha			184,578	
Other wood area	ha			163,980	55,000
Permanent agr. area	ha			14,520	42,000
Other non forest area	ha			105	250,000

Source: Report on Environmental Impact and Compensation in the Se Kong Basin., JICA, 1994