NO

BASIC DESIGN STUDY REPORT

ON

THE PROJECT

FOR

NAM NGUM I HYDROPOWER STATION REHABILITATION

IN

THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

JULY 2001

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD., TOKYO, JAPAN

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BASIC DESIGN STUDY REPORT

ON

THE PROJECT

FOR IMPROVEMENT OF EXISTING AIR TRAFFIC SERVICES EQUIPMENT SYSTEM UNDER THE TRIBHUVAN INTERNATIONAL AIRPORT MODERNIZATION PROJECT

IN

THE KINGDOM OF NEPAL

JULY 1999

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD., TOKYO, JAPAN

PREFACE

In response to a request from the Government of the Lao People's Democratic Republic, the Government of Japan decided to conduct a basic design study on the Project for Nam Ngum I Hydropower Station Rehabilitation and entrusted the study to the Japan International Cooperation Agency (JICA).

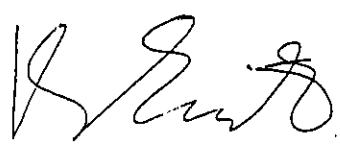
JICA sent to Lao PDR a study team from January 22 to February 25, 2001.

The team held discussions with the officials concerned of the Government of Lao PDR, and conducted a field study at the survey area. After the team returned to Japan, further studies were made. Then, a mission was sent to Lao PDR in order to discuss a draft basic design, and as this result, the present report was finalized.

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 teams.

July, 2001



Kunihiko Saito
President
Japan International Cooperation Agency

July, 2001

Letter of Transmittal

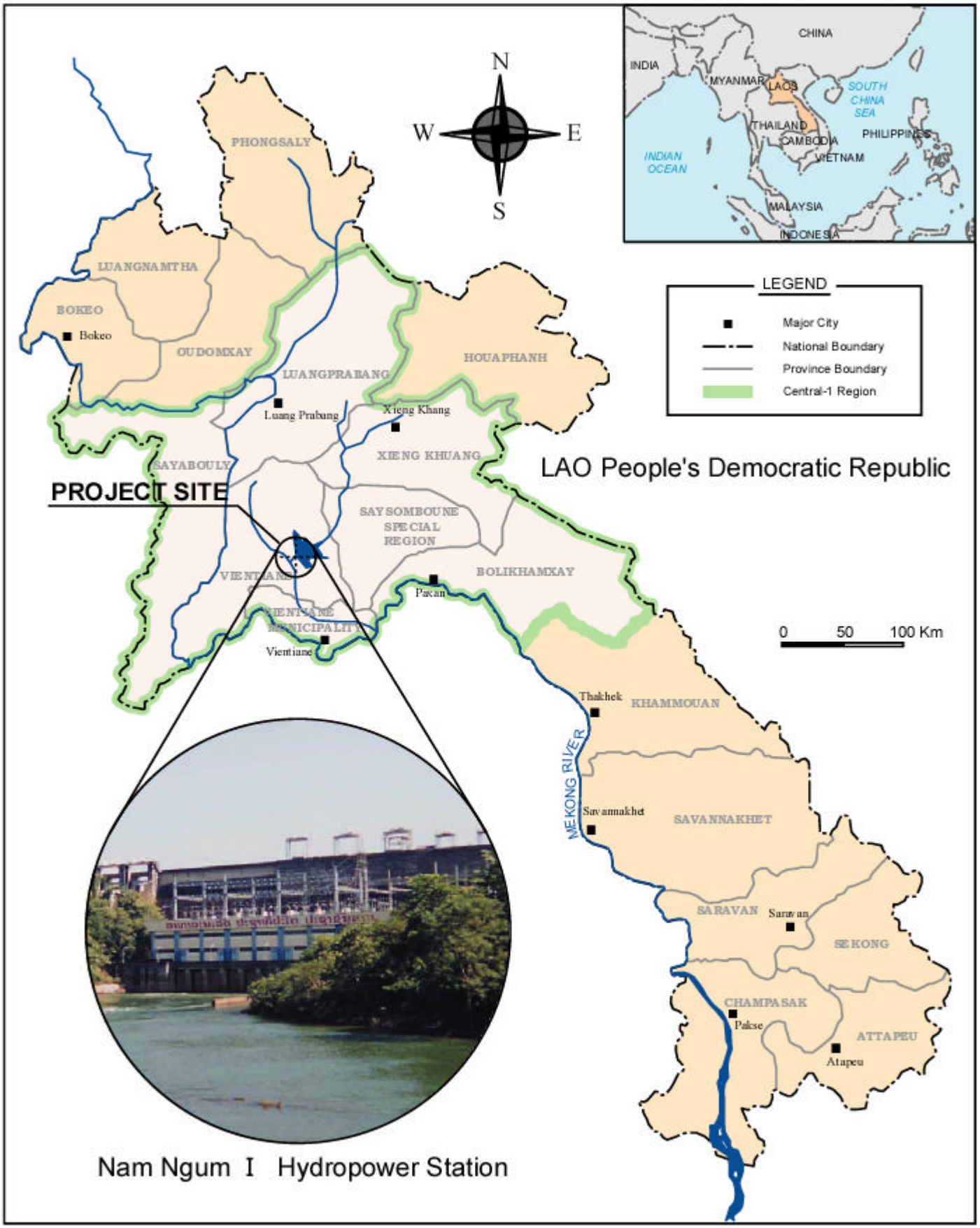
We are pleased to submit to you the basic design report on the Project for Nam Ngum I Hydropower Station Rehabilitation in the Lao People's Democratic Republic.

This study was conducted by Nippon Koei Co., Ltd. under a contract to JICA, during the period from January, 2001 to July, 2001. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Lao PDR and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

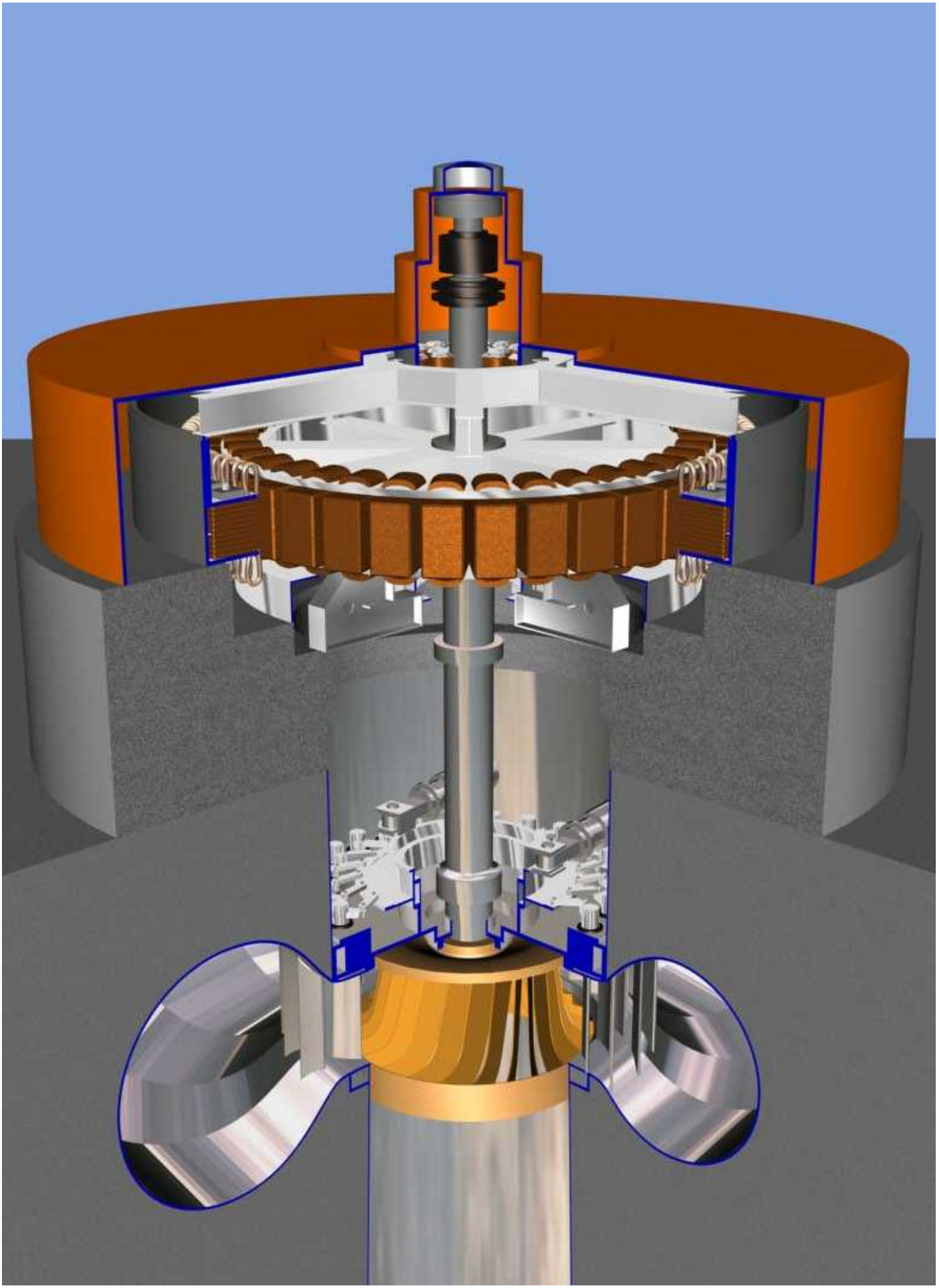
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Naoji Nakato
Project manager
Basic design study team on
The Project for Nam Ngum I Hydropower
Station Rehabilitation
Nippon Koei Co., Ltd.



LOCATION MAP



Nam Ngum I Hydropower Station
Turbine and Generator（Unit No. 1 and No. 2）

Nam Ngum I Hydropower Station
Generator Unit No. 1 and No. 2 from this side

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ABBREVIATIONS

ACSR	:	Aluminium Conductor Steel Reinforced
ADB	:	Asian Development Bank
BOT	:	Build-Operation-Transfer
EGAT	:	Electricity Generating Authority of Thailand
EDF	:	Electricite du France
EDL	:	Electricite du Laos
GDP	:	Gross Domestic Product
GWh	:	Gigawatt-hour
IBRD	:	International Bank for Reconstruction and Development
IDA	:	International Development Association
IEC	:	International Electrotechnical Commission
IPP	:	Independent Power Producer
JEC	:	Japanese Electromechanical Committee
JIS	:	Japanese Industrial Standard
LLDC	:	Least among Less-Developed Countries
MIH	:	Ministry of Industry and Handicraft
MVA	:	Megavolt-ampare
MW	:	Megawatt
NDF	:	Nordic Development Fund
OJT	:	On-the-job Training
OPEC	:	Organization of Petroleum Exporting Countries

Summary

Lao P.D.R. has considerable hydropower energy resources. The developable hydropower potential of the country is estimated at 18,000 MW but the hydropower developed to date is only 630 MW, which is corresponding to about 3 % of the hydropower potential. The hydropower projects in Lao P.D.R. are developed not only for domestic electricity supply but also for electricity export to the neighboring countries to produce foreign currency earnings. In such circumstances, dozen of hydropower development projects are planned under the financing of international donors and private sectors. Viability of these planned projects is largely dependent on electricity tariffs to be applied as well as socio-environmental impact to be incurred. Implementation of the new hydropower projects have been delayed due to extreme devaluation of the Lao currency, reduction of export tariffs, project financing problems, etc., any of which was caused by economic depression in recent years.

Lao P.D.R. comprises 1 municipality, 16 provinces and 1 special zone. The service area for domestic electricity supply is divided into four regions; namely, Northern Region, Central-1 Region, Central-2 Region and Southern Region. At this time there is no interconnection grid among these four regions. The Central-1 Region covers Vientiane Municipality, 5 provinces and 1 special zone. Household electrification rate in the whole Central-1 Region (population: 2.1 million) is as low as 44.8 %, while that in Vientiane Municipality (population: 0.58 million) has reached to 95 %. Currently, the power transmission and development project is ongoing to promote rural electrification in the Central-1 Region. Thus, the power demand in the Central-1 Region is forecasted to increase continuously at an average rate of about 9 % per annum. However, little progress has been made in the development of new hydropower stations. If additional power stations cannot be completed by 2007, the domestic power demand in the Central-1 Region will exceed the total power supply capacity in the same region.

The Nam Ngum I Hydropower Station is located at approximately 90 km north of Vientiane Municipality and on the Nam Ngum River that is a tributary of the Mekong. It is the largest hydropower station operated by Electricite du Laos (EDL) and has a total installed capacity of 150 MW and an annual energy production of 1,000 GWh. The existing Units No. 1 and No. 2 have been operated for over 30 years since their commissioning in 1971. Their operating performances have deteriorated as a whole due to aging and corrosion. A large-scale rehabilitation for the Units No. 1 and No. 2 was once carried out on the turbines in 1982, and now 18 years have already past since then. The turbines have been damaged again due to further corrosion, erosion and cavitation. The electrical equipment such as generators, main transformers, switchgear and control boards have never been rehabilitated since 1971 and they are being operated exceeding their normal service life without sufficient maintenance and proper repairs. Such conditions cause serious concern that the Unit No. 1 and No. 2 will have heavy faults and troubles to interfere with stable supply of electricity from the power station. As one of this indicator, a 115 kV circuit breaker installed in 1971 was troubled due to aging in 1999 and this trouble caused a complete shutdown of the power station.

The Nam Ngum I Hydropower Station has been supplied electricity to the Central-1 Region including Vientiane Municipality. Besides, the surplus electricity from the domestic market has been exported to Thailand, which produces significant export revenues to the country for economical development. The Central-1 Region consumed 71 % of the total domestic power demand in the whole country in 1999. The Nam Ngum I Hydropower Station now bears a share of 80 % (1,000 GWh) in the total annual energy production of the Central-1 Region (1,244 GWh) even after the Nam Leuk Hydropower Station (60 MW, 230 GWh) was put into operation in June 2000. Thus, the Nam Ngum I Power

Station is the most important power station for EDL even now.

In Lao P.D.R., the domestic power demand will positively increase year by year and no alternative energy is available at present. Therefore, the rehabilitation of the Nam Ngum I Hydropower Station is urgently required to realize a stable supply of electricity.

Under such circumstances, the Government of Lao P.D.R. requested a Grant Aid to the Government of Japan for the rehabilitation of the Units No. 1 and No. 2 at the Nam Ngum I Hydropower Station.

In response to the request from the Government of Lao P.D.R., the Government of Japan decided to conduct a basic design study on the Project for the Nam Ngum I Hydropower Station Rehabilitation and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Lao P.D.R. a study team from January 22 to February 25, 2001. The study team held discussions with the officials concerned of the Government of Lao P.D.R., and conducted a field survey at the project site. This study aimed not only to formulate the contents and scope of work for the Project but also to ascertain the effect of the project and the eligibility for the Japan's Grant Aid program. After the team returned to Japan, further studies were made. Then, a mission was sent to Lao P.D.R. in order to discuss a draft basic design.

This Japan's Grant Aid program is to provide non-reimbursable funds to procure the goods and services required for implementation of the Project for the rehabilitation of the Nam Ngum I Hydropower Station, which aims to restore the existing Unit No. 1, Unit No. 2 and their associated common equipment to their original conditions. The basic policy for the rehabilitation plan is as follows:

(1) Rehabilitation is to achieve further long-term operation of the Units No. 1 and No. 2.

(2) Primary objective of rehabilitation is to restore the existing equipment to its original construction and/or performance. In case necessary replacement parts and spare parts are no longer available in the market and/or the restoration to the original condition has no economic merit, the equipment should be renewed with current technology.

(3) In principle, rehabilitation will be applied to the existing equipment of which the rehabilitation is highly essential and urgently required for keeping it in service consecutively.

(4) The scope of rehabilitation on the control and relay boards will be limited to the required minimum. This is because the control and relaying systems for the Units No. 1 and No. 2 will preferably be modernized together with the Units Nos. 3 to 5 in the near future.

(5) The turbine parts using grease lubricant, which is causing water pollution, will be renewed with grease-less construction and the electrical equipment containing toxic chemicals will be renewed with harmless design, to minimize adverse effect to the surrounding environment.

(6) The turbine discharge will be recovered to the original design value. The turbine discharge has been currently decreased due to the elevated reservoir water level after completion of the Units No. 1 and No. 2. (As a result, the output of Units No. 1 and No. 2 will increase by 2.5 MW x 2)

Following the examination into the request from Lao P.D.R., the rehabilitation plan is formulated as follows:

Equipment	Extent of Rehabilitation
1. Turbines	Repair
2. Generators	Repair（Excitation Equipment: Renewal）
3. Intake Gates and Control Panels	Repair（Control Panels: Renewal）
4. Protective Relays	Supply of Spare Overcurrent Relay
5. Governors and Pressure Oil Supply System	Repair（Governors: Renewal）
6. Air Compressors	Repair
7. Water Supply System and Drainage System	Repair（Drainage Pump: Renewal）
8. Overhead Traveling Crane	Repair
9. Main Transformers	Renewal（Fire Extinguishing System: Repair）
10. 11 kV Switchgear	Renewal
11. 110 V DC Supply Equipment	Renewal
12. 115 kV Switchyard Equipment and Busbars	Repair (Partly Renewal)
13. House-Service Transformer	22/0.38 kV Transformer: Renewal
14. Control Boards	Repair
15. Gantry Cranes	Operator Consoles: Renewal

This Project will be completed in 25 months calculated from the conclusion of the Exchange of Notes (E/N) by both Governments. This schedule includes 4 months for bidding and conclusion of the contract(s), and 21 months for manufacturing, transportation, site rehabilitation works, site tests and transfer of technology.

The execution of this Project will have the following beneficial effects:

1) The technical performance, reliability and safety of the Units No. 1 and No. 2 will be restored and the extension of service life can be expected by implementation of the Project.

2) The rated output of the Unit No. 1 and No. 2 will increase from 15 MW x 2 to 17.5 MW x 2 and the total installed capacity of the Nam Ngum I Hydropower Station will increase from 150 MW to 155 MW. This additional output will make some contribution to enhance revenues to the country from the power generation.

3) The Units No. 1 and No. 2 can be operated with high working ratio as they used to do before. This will come to restore and improve the reliability of power supply of the entire power station. Then, the Nam Ngum I Hydropower Station is able to continue its important role in a stable supply of electricity to domestic market as well as acquisition of export revenue by electricity export to Thailand.

4) The frequency of maintenance intervention and the possibility of faults and troubles on the Units No.1 and No. 2 will be reduced so that the maintenance cost will be greatly mitigated.

5) The technical skills for dismantling and re-assembling of the turbines and generators will be transferred to the EDL's maintenance crews through on-the-job-training so that periodical overhaul and trouble shooting in case of emergency of the turbines and generators can be managed by them. Especially, this Project will provide a greater opportunity for young engineers to learn the power station equipment.

Thus, innumerable benefits are expected by the implementation of the Project. In this respect, this Project has a great significance in being implemented under the Japan's Grant Aid program.

CONTENTS

CHAPTER 1

BACKGROUND OF THE PROJECT

CHAPTER 1 BACKGROUND OF THE PROJECT

The Nam Ngum I Hydropower Station is located at approximately 90 km north of Vientiane Municipality and on the Nam Ngum river that is a tributary of the Mekong. It is the largest hydropower station operated by Electricite du Laos (EDL) and has a total installed capacity of 150 MW and an annual energy production of 1,000 GWh.

The Nam Ngum I Hydropower Station was constructed in three stages as shown in Table-1.

Table 1-1 Development of Nam Ngum I Hydropower Station

	Installation of Units	Output	Completion
First Stage	Units No. 1 and No. 2	15 MW x 2	1971
Second Stage	Units No. 3 and No. 4	40 MW x 2	1978
Third Stage	Unit No. 5	40 MW x 1	1984

The existing Units No. 1 and No. 2 have been operated for over 30 years since its commissioning in 1971. Their operating conditions have deteriorated as a whole due to aging and corrosion. A large-scale rehabilitation for the Units No. 1 and No. 2 was once carried out on the turbines in 1982, and now 18 years have already past since then. The turbines have been damaged again due to further corrosion, erosion and cavitation. The electrical equipment such as generators, main transformers, switchgear and control boards have never been rehabilitated since 1971 and they are operated exceeding their normal plant life without sufficient maintenance and proper repairs. Therefore such electrical equipment causes serious concern over the possibility of heavy faults and troubles. Actually, a 115 kV circuit breaker installed in 1971 was troubled due to aging in 1999 and this trouble caused a complete shutdown of the power station.

The Nam Ngum I Hydropower Station has been supplied electricity to the Central-1 Region including Vientiane Municipality. Besides, the surplus electricity from the domestic market has been exported to Thailand, which produces significant export revenues to the country for economical development.

The Central-1 Region consumed 71 % of the total domestic power demand in the whole country in 1999. The Nam Ngum I Hydropower Station now bears a share of 80 % (1,000 GWh) in the total annual energy production of the Central-1 Region (1,244 GWh) even after the Nam Leuk Hydropower Station (60 MW, 230 GWh) was added in June 2000. Thus, the Nam Ngum I Power Station is the most important power station for EDL. In Lao P.D.R., the domestic power demand will positively increase year by year and no alternative energy is available at present. Therefore, the rehabilitation of the Nam Ngum I Hydropower Station is urgently required to realize a stable supply of electricity.

Under such circumstances, the Government of Lao P.D.R. requested a grant aid to the Government of Japan for the rehabilitation of the Units No. 1 and No. 2 at the Nam Ngum I Hydropower Station.

CHAPTER 2

CONTENTS OF THE PROJECT

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2.1 Basic Concept of the Project

The Nam Ngum I Hydropower Station is the largest hydropower station operated by Electricite du Laos (EDL) and has a total installed capacity of 150 MW and an annual energy production of 1,000 GWh. It was commissioned in 1971 and has performed well for 30 years for supplying electricity to the Central-1 Region including Vientiane Municipality. Besides, the surplus electricity from the domestic market has been exported to Thailand to provide export revenue to the country for economic development.

The existing Units No. 1 and No. 2 have been operated for over 30 years since its commissioning in 1971. Their operating conditions have deteriorated as a whole due to aging and corrosion. Such conditions causes serious concern that the Units No. 1 and No. 2 will have heavy faults and troubles to interfere with stable supply of electricity from the power station.

Currently, the power transmission and development project is ongoing to promote rural electrification in the Central-1 Region. Thus, the power demand in the Central-1 Region is forecasted to increase continuously at an average rate of about 9 % per annum. However, little progress has been made in the development of new hydropower stations.

Under such circumstances, the Government of Lao P.D.R. has an intention of restoring the reliability of the Nam Ngum I Hydropower Station in order to keep its important role not only for a stable supply of electricity to domestic market but also for electricity export to Thailand.

The objective of this Project is to rehabilitate the Unit No. 1, Unit No. 2 and the associated station common equipment, which is essential to their operation, for restoration of their technical performances, reliability and safety to the original conditions to achieve their further long-term operation.

Necessary goods and services for implementation of the Project will be procured and installed under the Japan's grant aid program.

2.2 Basic Design of the Requested Japanese Assistance

2.2.1 Design Policy

2.2.1.1 Basic Design Policy

The rehabilitation plan was formulated based on the following design policies.

(1) The rehabilitation is to achieve further long-term operation of the Units No. 1 and No. 2.

The service life of the generating equipment for hydropower plants is expected to be 50 to 60 years. A large-scale rehabilitation on the Units No. 1 and No. 2 will extend their service life for 20 to 30 years more until complete renewal of their whole units become necessary.

This Project is aiming to achieve successful continuous operation of the Units No. 1 for at least 20 years more.

(2) Primary objective of rehabilitation is to restore the existing equipment to its original performances and/or conditions. In case necessary replacement parts and spare parts are no longer available in the market and/or the restoration to the original condition has no economic merit, the equipment should be renewed with current technology.

(3) In principle, rehabilitation will be applied to the existing equipment of which the rehabilitation is highly essential and urgently required for keeping it in service consecutively.

(4) The scope of rehabilitation on the control and relay boards will be limited to the required minimum. This is because the control and relaying systems for the Units No. 1 and No. 2 will preferably be modernized together with the Units Nos. 3 to 5 in the near future.

(5) The turbine parts using grease lubricant, which is causing water pollution, will be renewed with grease-less construction and the electrical equipment containing toxic chemicals will be renewed with harmless design, to minimize adverse effect to the surrounding environment.

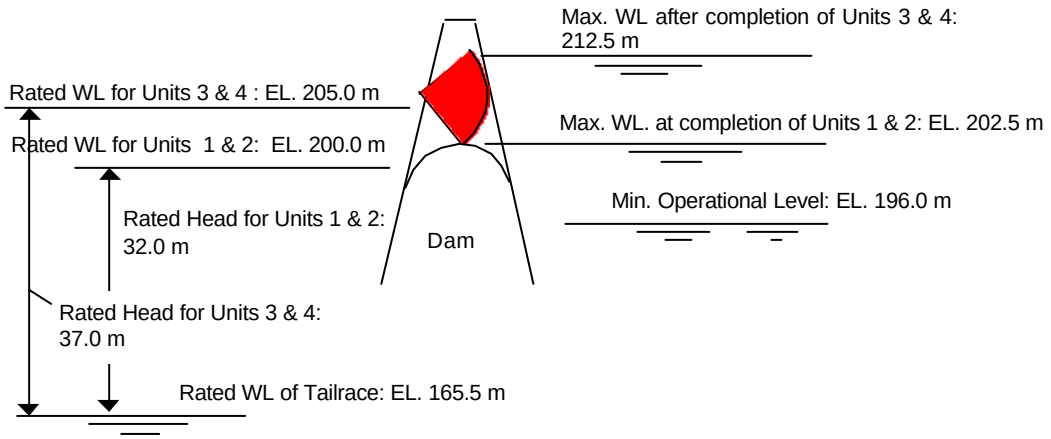
(6) The turbine discharge will be recovered to the original design value. The turbine discharge has been currently decreased due to the elevated reservoir water level after completion of the Units No. 1 and No. 2. (As a result, the output of Units No. 1 and No. 2 will increase by 2.5 MW x 2 to 17.5 MW x 2.)

2.2.1.2 Examination on Restoration of Turbine Discharge

(1) Background of This Examination

At the second stage development for the Units No. 3 and No. 4, the spillway gates were added on the dam. Consequently, the maximum and average water levels of the reservoir became 10 m and 5 m higher respectively than they were when the Units No. 1 and No. 2 were installed. The rated net head for the turbines No. 1 and No. 2 was designed at 32 m, while that for the turbines Nos. 3 to 5 was set at 37 m to suit the elevated water level of the reservoir.

Figure 2-1 Reservoir Water Levels and Rated Net Heads of Turbines



The Units No. 1 and No. 2 cannot operate with loads exceeding their rated output. Whenever operating at net heads higher than their rated net head of 32 m, the turbine is forced to limit its discharge to smaller than the rated so that the turbine output should not exceed its rated one. The maximum discharge of the Units No. 1 and No. 2 at a net head of 37 m is estimated at 83 % of the rated.

On the other hand, the inflow to the Nam Ngum I Reservoir has increased by additional inflow from the Nam Son Diversion and the Nam Leuk Hydropower Station. This will cause a spill-out of the water from the dam. Actually, a lot of spill-outs were observed in 2000.

It is a basic design policy to change the rated net head of the turbines No. 1 and No. 2 from 32 m to 37 m, which is equal to that for the turbines Nos. 3 to 5, and to recover the turbine discharge to the rated value originally designed for them.

The recovery of the turbine discharge will cause changes of the equipment ratings. The capabilities of the rehabilitated turbines and generators as well as necessary change of the equipment specifications were examined in the following articles.

The following examinations concluded that the turbine discharge can be recovered without any technical problem and the recovery of the turbine discharge will come to upgrade the Units No. 1 and No. 2 to 17.5 MW x 2. In addition, the examinations show that the upgrading of the Units No. 1 and No. 2 is technically and economically reasonable.

(2) Turbines

The existing turbines No. 1 and No. 2 was designed to operate safely and satisfactory at any net heads between 32 m to 45.5 m and at any discharges up to the rated discharge of 55.4 m^3/s. The turbines are therefore able to operate at a net head of 37 m and a discharge of 55.4 m^3/s without any technical problem.

The turbine output is determined by a net head and a turbine discharge. If net head and turbine discharge are changed, the turbine output is also changed.

Table 2-1 Net Head, Discharge and Output

	Net Head	Discharge	Turbine Output	Generator Output
Original Design	32 m	55.4 m^3/s	15.5 MW	15.0 MW
Present Operating Condition	37 m	46.0 m^3/s	15.5 MW	15.0 MW
Basic Plan	37 m	55.4 m^3/s	18.3 MW	17.5 MW

If the turbine discharge is recovered to 55.4 m^3/s at the rated net head of 37 m, the turbine rated output will increase to 18.3 MW.

On the other hand, an increase of turbine output will modify the turbine performance. Whether the turbine output can be increased or not is technically dependent on the modified turbine performance. The technical examination was therefore required for

the following performances.

(a) Maximum pressure

Maximum pressure means maximum momentary pressure developed in the turbine and penstock during a sudden load rejection of the generator. The maximum pressure should not exceed 65.4 m, which is the guaranteed value for the exiting turbines No. 1 and No. 2.

(b) Maximum speed rise

Maximum speed rise means maximum momentary speed rise caused by sudden full load rejection of the generator. According to current practice in Japan, maximum speed rise for Francis turbine is generally set at 45 to 50 %.

(c) Suction head

Static suction head is conveniently defined as a level difference between elevation of the turbine (guide vane) centerline and the tailrace water level. Insufficient suction head will cause cavitation problem on the turbine. When the rated output of the turbine is changed, a change of the suction head will be required in the calculation. However, the actual suction head is unchanged because the turbine center elevation cannot be changed. Therefore, it will be required to ascertain that a suction head calculated for the new turbine output has a sufficient safety margin on the actual suction head.

The results of the technical examination on the above three items are summarized in Table 2-2.

Table 2-2 Effect of Output Increase on Turbine Performance

	Turbine Output	Maximum Pressure	Maximum Speed Rise	Margin on Suction Head
Original Design	15.5 MW	65.4 m	37 %	+ 1.12 m
Basic Plan	18.3 MW	65.4 m	44 %	+ 1.93 m
Criteria	-	65.4 m or less	50 % or less	+ 1.12 m or more
Judgement	-	No Problem	No Problem	No Problem

As shown in Table 2-2, upgrading of the turbine output will have no problem with the turbine performance. Accordingly, upgrading of the turbine output is technically feasible.

(3) Generators

The replacement of the generator stator windings is planned but the existing stator cores and rotors are to be re-used for the rehabilitated generators. Although the turbine output can be increased, upgrading of the Units No. 1 and No. 2 will not be achieved unless the generator output can be increased by the rehabilitation of the generator. The examination was carried out to check whether the generator output is possible to be

increased only by the replacement of the stator windings.

The stator winding will be replaced in the manufacturer's current standard practice using the latest materials. The replacement of the stator winding will come in effect to increase the current carrying capacity of the winding, to reduce losses in the winding and to improve the generator efficiency a little bit. That is why the generator output can be increased by the replacement of the stator windings. This increase can be achieved as a natural consequence because the replacement windings need to fit into the existing stator slots to be re-used. Therefore, no additional cost is required for the increase of the generator output.

According to the technical analysis on the temperature rise of the generator windings, the rehabilitated generator can be upgraded to not less than 20 MVA on continuous duty although the existing rotor is re-used.

In this connection, the output of the rehabilitated generator can be limited theoretically to the existing one (17.5 MVA) if smaller size of conductor is applied to the new stator windings. In this case, additional spacers of a little bit thick are required to fill the gaps between stator coil and stator slot and between stator coil and stator wedge to hold the stator coil securely. Such additional spacers are liable to be loosening subject to slight electro-magnetic oscillation and will shorten the life of the stator windings.

This idea will be costly for the following reasons.

i) Manufacturing design for the additional spaces are required.
ii) Space insert works are additionally required and the period for the replacement works will become longer.
iii) The cost for site supervisor will increase for the additional spacer work.

Therefore, such design to forcedly limit the generator output is not practicable from both technical and economical points of view. The continuous output of the rehabilitated generator can be increased to 20 MVA as a natural consequence of the replacement of the stator windings.

In conclusion, the replacement of the stator windings by using a current standard practice is technically and economically reasonable. Therefore, it is planned to change the turbine rated output to 18.3 MW and the generator rated output to 17.5 MW (20 MVA).

(4) Rating of Other Equipment

According to the basic plan of this Project, the existing excitation equipment and main transformers are to be renewed because of serious deterioration due to aging. On the renewal of these items, their capacities need to be increased to successfully achieve the upgrading of the Units No. 1 and No. 2.

By the way, the normal current on the generator and main transformer circuits will be increased by 14.3 % in proportion to the upgrading of the generators and main transformers. However, the power cables, switchgear and instrument transformers on

the associated circuits have sufficient current ratings and no change is required on their specifications.

(5) Cost and Effect of Upgrading of Units No. 1 and No. 2

Additional cost is required to increase the capacities of the excitation equipment and main transformers. The desired effect for the additional cost was examined as follows:

(a) Additional cost for upgrading

Additional cost to increase the output of the two units from (15 MW x 2) to (17.5 MW x 2) is estimated as follows:

Table 2-3 Additional Cost for Upgrading

	No Upgrading	Upgrading	Additional Cost
Turbine Output	15.5 MW x 2	18.3 MW x 2	¥ 0
Generator Output	17.5 MVA x 2	20.0 MVA x 2	¥ 0
Excitation Capacity	260 kVA x 2	280 kVA x 2	¥ 700,000
Transformer Power	17.5 MVA x 2	20.0 MVA x 2	¥ 7,000,000
Total			¥ 7,700,000

(b) Construction cost for alternative power plant

The restoration of the turbine discharges will result in upgrading the total output of the Units No. 1 and No. 2 by 5 MW (2.5 MW x 2).

A diesel power plant is usually considered as an alternative power plant with the installed capacity of 5 MW. If the construction cost is assumed at US$ 1,500/kW, the construction of the 5 MW diesel power plant will cost ¥ 898,425,000.

(c) Additional revenue by upgrading of the output

If the increase of the output (5 MW in total) is all exported to Thailand, the additional revenue is estimated at ¥ 98,000,000 per annum. This estimate is based on the assumption that export tariff is 0.03 US$/kWh, load factor is 70 % for both the Units No. 1 and No. 2 and transmission efficiency is 89 %.

It is ascertained by these examinations that the upgrading of the Units No. 1 and No. 2 is technically and economically reasonable.

2.2.1.3 Design Policy for Environmental Conditions

Since the project site is located in tropical climate, ambient air and water temperatures are relatively high. At the project site, yearly average ambient temperature is 7.4 °C higher than the normal service condition for designing the equipment, and average water temperature is 5 °C higher than it as shown in Table 2-4.

Yearly average ambient temperature will affect the temperature limit on the transformers and water temperature will affect the cooling effect of the water-cooled equipment. The renewal

of these items needs to be designed considering such high temperature conditions.

Table 2-4 Normal Service Conditions and Climatic Conditions at Site

	Normal Service Conditions	Climatic Conditions at Site
Altitude	Not exceeding 1,000 m	160 m to 230 m
Max. ambient temperature	Not exceeding 40 °C	34.7 °C
Yearly average ambient temperature	Not exceeding 20 °C	27.4 °C
Water temperature	Not exceeding 25 °C	30.0 °C (18.8 °C - 32.8 °C)

2.2.1.4 Policy for Applied Standards

The Japanese Industrial Standard (JIS) and the Japanese Electrotechnical Committee Standard (JEC) will generally be applied to the design, materials, manufacture, testing, inspection and performance of all electrical and electromechanical equipment. The International Electrotechnical Commission Standard (IEC) will also be acceptable.

Particularly, the IEC standard will be applied to the main transformers that will be procured from Japan or from the third country.

2.2.1.5 Policy for Utilization of Local Contractor and Local Materials

Most of local contractors for electrical works are mainly working for the construction of substations, distribution lines and transmission lines. However, they have no experience for installation of generating equipment except mini hydropower stations. Since local contractors have no sufficient number of skilled and qualified workers, the utilization of contractors in Thailand or other third countries needs to be considered for this Project.

A marketing survey shows that the equipment and materials available in Lao P.D.R. for the Project will be limited to some consumables and materials for temporary facilities, such as lubricating oil, grease, paint, etc.

2.2.1.6 Policy for Transfer of Technology for Operation and Maintenance

Proper operation and maintenance of the rehabilitated equipment is essentially required to secure the desired effect of the rehabilitation for long time. Technical knowledge and skills will be transferred to the EDL's personnel to ensure that the equipment rehabilitated under this Project can be operated and maintained properly by them.

(1) Guidance and Instructions for Operation and Maintenance of Renewed Equipment

The system configurations of the governors and the excitation equipment will be changed entirely by renewal of these items. Accordingly, their operation and maintenance methods will also be changed.

Operation guidance and maintenance instructions for these items will be provided at the site by the contractor to the operators and maintenance crews before the first

rehabilitated unit is put into operation. Necessary instruction manuals for operation and maintenance of the associated equipment will be prepared by the contractor.

(2) Technical Guidance for Recording of Operation Data and Maintenance Events

Operation data and maintenance results should be recorded properly and compiled as a database for the operation management and scheduling of the future maintenance plans.

The technical guidance for improvements in data recording will be provided at the site by the Consultant to the operators and maintenance crews before the first rehabilitated unit is put into operation.

(3) Transfer of Technical Skills for Dismantling and Reassembling of Turbines and Generators

Technical skills for dismantling and reassembling of the turbines and generators are essentially required in order that periodical overhaul and trouble shooting in case of emergency of the turbines and generators can be managed by EDL own.

Transfer of the technical skills will be done by the contractor through on-the-job-training. For this purpose, at least ten (10) personnel of the maintenance crews will participate directly in the site rehabilitation works of the turbines and the generators. Working procedures and manuals for the disassembling and reassembling works will be prepared by the contractor.

2.2.1.7 Policy for Scope and Grade of Works

(1) Design Policy for Further Long-Term Operation of Units No. 1 and No. 2

The contents of the rehabilitation will be necessary and sufficient to achieve successful continuous operation of the Units No. 1 for at least 20 years more.

The equipment and parts to be re-used will be overhauled as far as possible during the site rehabilitation work, to maintain their present performance and functions.

(2) Attention to Existing Civil and Building Structures

The renewed equipment will be installed at the same place as the existing one by using the existing foundations and floor openings as much as possible to minimize the modification of the existing civil and building structures.

Especially, the main transformers and other heavy equipment will be fixed exactly at the same locations as the existing ones in order not to change the loading conditions on the existing structures.

(3) Attention to Other Units and Remaining Parts Not Covered by the Project

The rehabilitation works will be programmed so as not to interfere with continuous operation of the other units and will be carried out with careful attention to the existing equipment and remaining parts that are not covered by this Project. Necessary

coordination and interface with the existing equipment/parts to be re-used and the civil and building structures will be incorporated in designing the rehabilitation works.

2.2.1.8 Policy for Construction Time Schedule

The rehabilitation works for the Units No. 1 and No. 2 will be carried out for each unit one after another taking into account the working space, manpower and manufacturing schedule. Five (5) months of the unit shutdown will be required for the rehabilitation works for each unit including site tests and transfer of technology to the EDL's personnel.

The implementation schedule for each unit will be 16 months including design, procurement, manufacturing, transportation, site rehabilitation works, site tests and transfer of technology. If the site rehabilitation works for the two units will be done in series, the overall implementation schedule will take twenty-one (21) months.

Judging from the required time schedule, the Project will be implemented from 2002 to 2004.

2.2.2 Basic Plan

(1) Overall Plan

Following the examination into the request from Lao P.D.R. based on the results of the field survey and the Design Policy described in Clause 2.2, the rehabilitation plan is formulated as tabulated below. The principal equipment for the rehabilitation is shown in Figure 2-2.

Equipment	Results of Site Survey	Contents of Rehabilitation
1. Turbines		Repair of two (2) turbines
Turbine Interior	• Damaged by corrosion, erosion and cavitation	Repair with overlay, surface preparation and coating
Turbine operating mechanism	• Corrosion on metallic parts	Surface preparation and coating
	• Grease leakage from bearings	Change to grease-less bearings
Shaft sealing box	• Grease leakage from seals	Change to grease-less seals
Guide bearing	• Deterioration of bearing metals	Replace of bearing metals
	• Deterioration of lubricating oil	Replace of lubricating oil
	• Corrosion on bearing housing	Replace of housing and cooling coils
	• Failure of some detectors	Replace of defective detectors
	• Deterioration of resistance temperature detectors (RTD)	Replace of RTD
Instrumentation	• Deterioration of pressure gauges	Replace of pressure gauges
	• Failure of pressure switches	Replace of pressure switches
Others	• Not overhauled for 20 years	Overhaul of each turbine part
2. Governors	• Old and obsolescent type • Spare parts are not available because of obsolescence • Deterioration as a whole • Failure of distribution valves • Frequent trouble with speeder • Failure of limit switches	Renewal of governors Change to electro-hydraulic type of latest design
3. Pressure Oil System	• Deterioration of pressure oil	Replace of pressure oil
	• Paint peeling from pressure tank	Cleaning and coating
	• Paint peeling from sump tank	Cleaning and coating
	• Oil leakage from valves	Replace of valves
	• Deterioration of pressure gauges and oil level gauges	Replace of pressure gauges and oil level gauges
	• Failure of pressure switches	Replace of pressure switches
4. Compressed Air System	• Failure of safety valves and automatic drain valves	Replace of safety valves and automatic drain valves
	• Deterioration of pressure gauges	Replace of pressure gauges
	• Failure of pressure switches	Replacement of the switches

Equipment		Results of Site Survey	Contents of Rehabilitation
5. Cooling Water System		• Corrosion on pipes	Replace of exposed pipes
		• Failure of strainer	Replace of strainer
		• Corrosion and failure of valves	Replace of valves
6. Drainage System		• Corrosion on pipes	Replace of exposed pipes
		• Corrosion and failure of valves	Replace of valves
		• Failure of a drainage pump	Replace of the drainage pump
7. Generators			Repair of two (2) generators
	Stator windings	• Residual insulation withstand-ability of the windings is estimated at 65 %. • Deterioration of insulation materials of the windings • Removal and loosening of wedges	Replace of stator windings
		• Deterioration of resistance temperature detectors (RTD)	Replace of RTD
	Stator cores	• Not overhauled for 20 years	Deformation check Re-tightening of core bolts
		• Contamination and rust	Cleaning, removal of rust and varnishing over stator cores
	Stator frames	• Not overhauled for 20 years	Cleaning and deformation check
	Rotors	• Contamination on surface on windings	Cleaning and varnishing over the surface of windings
		• Rust on metallic parts	Removal of rust and coating
	Air coolers	• Remarkable rust due to water leakage	Replace of air coolers
		• Corrosion on cooling water pipes	Replacement of pipes in the generator housing
		• Deterioration of resistance temperature detectors (RTD)	Replace of RTD
	Generator bearings	• Deterioration of bearing metals and high operating temperatures	Replace of bearing metals and cooling coils
		• Deterioration of lubricating oil	Replace of lubricating oil
		• Deterioration of resistance temperature detectors (RTD)	Replace of RTD
		• Failure of detectors	Replace of defective detectors
	Others	• Deterioration of current transformers	Replace of current transformers
		• Breakage of acrylic plastic cover for operation indicating lamp	Replace of lamp cover
		• Paint peeling from generator housing	Coating over all surfaces

Equipment	Results of Site Survey	Contents of Rehabilitation
8. Excitation Equipment		Renewal of two (2) excitation equipment
Main and pilot exciters	• Wearing of commutators • Deterioration of insulation on connection busbars • Deterioration of brush holders	Change to static type excitation system Capacity of excitation system to suit the output of the generator
Voltage regulating equipment	• Old and obsolescent type • Spare parts are not available because of obsolescence • Deterioration as a whole • Wearing of sliding rheostats • Wearing and discoloration of contacts • Discoloration and breakage of auxiliary relays	
Excitation transformer	• Insulating oil contains toxic chemicals	
9. Main Transformers	• Insulation of windings may have been deteriorated • Deterioration of insulating oil • Oil leakage from various parts • Breakage of 11 kV bushings • Rust on various parts • Corrosion and rust in local control box	Renewal of two (2) main transformers The rated power of transformer is 20 MVA corresponding to rated output of the rehabilitated generator
10. Fire Extinguishing System for Main Transformers	• Breakage of fire detectors	Replace of fire detectors
	• Failure of water spray nozzles	Replace of water spray nozzles
	• Corrosion and rust in local control boxes	Replace of local control boxes
11. House-Service Transformers		
22/0.38 kV Transformer	• Long time operation • Windings and cores may have been loosed because of high operating noise	Renewal of 22/0.38 kV transformer
11/0.38 kV Transformer	• No abnormality was observed	
12. 11 kV Switchgear	• Deterioration as a whole • Discoloration of busbars • Trouble with circuit breakers • The following equipment contains toxic chemicals - Voltage transformers - Capacitors - Excitation transformers - Neutral grounding transformers • A large-scale modification is required to connect the new excitation transformer	Renewal of 11 kV switchgear

Equipment	Results of Site Survey	Contents of Rehabilitation
13. 115 kV Switchyard Equipment and Busbars		
Disconnectors (#189-1, #189-2, #189P, #189B, #189T, #189T1, #189T2)	• Discoloration and corrosion of blades • Discoloration and wearing of contacts	Replace of rotating insulators with blades and contacts
	• Open and close operations are very hard	Replace of operating mechanism
	• Rust on metallic parts	Removal of rust and coating
	• Corrosion of local control box	Replace of local control box
	• Corrosion of earthing switch for #189-1	Replace of earthing switch
	• #189P has been deteriorated heavily	Renewal of #189P
Current transformers for transmission line No. 1 circuit	• Oil leakage from terminals • Blur on oil level gauge • Rust on supporting structure • Current transformers for two phases have already been replaced by new ones because of heavy oil leakage.	Renewal of current transformer for one phase only
115 kV surge arrester	• Malfunction of discharge counter	Replace of discharge counter
115 kV busbars	• Lack of current carrying capacity on the existing bus conductors because of additional power flow from Nam Leuk P/S	Replace of bus conductors and fittings to suit the size of bus conductor for Units Nos. 3 to 5.
14. Control and Protective Relaying Equipment		
Main control board	• Deterioration of measuring instruments	Replace of measuring instruments
	• Deterioration of control and selector switches	Replace of switches essential to control and operation of Units No. 1 and No. 2
	• Indication items on operating status and fault indicators will be changed for new governors and excitation equipment	Replace of marking plates for indicators
Relay boards	• Proper operation of each relay was confirmed • There are spare relays except overcurrent relay for generator	Supply of one overcurrent relay for generator as spare for Units No. 1 and No. 2
Automatic control board	• Deterioration as a whole including wiring • Breakage of auxiliary relays • Wearing of contacts of auxiliary relays • Automatic synchronizing device was made in 1990	Renewal of automatic control board Automatic synchronizing device will be re-used.
AC control source distribution panel	• Deterioration as a whole, including busbars and wiring • Malfunction of circuit breakers • Breakage of terminal blocks	Renewal of AC control source distribution panel

Equipment		Results of Site Survey	Contents of Rehabilitation
	Motor control centers	• Deterioration as a whole, including wiring • Heavy deterioration of magnetic contactors, control switches and indicators • Spare parts are not available because of obsolescence	Renewal of motor control centers
15.	DC Power Supply Equipment		
	Storage batteries	• Breakage of battery containers • Leakage of battery liquid • Chemical corrosion on terminals • Dropping of active substance from plates（Typical indication of terminal stage of battery life) • Have been used exceeding normal service life of 10 years	Renewal of storage batteries
	Battery chargers	• Deterioration as a whole, including wiring • Wearing of adjusting rheostat • Wearing of contacts of magnetic contactors • Spare parts are not available because of obsolescence	Renewal of battery chargers
	DC distribution panels	• Deterioration as a whole, including wiring • Malfunction of circuit breakers • Breakage of terminal blocks	Renewal of DC distribution panels
16.	Overhead Traveling Crane	• Long braking distance	Adjustment of braking system
		• Looseness of hoist rope	Repair and adjustment of rope tension for 5 ton hoist
17.	Intake Gate Facilities		
	Gate Leaves	• Breakage of side guide rollers	Replace of side guide rollers
		• Damage on rubber seals	Replace of rubber seals
	Hoist	• Breakage of strand wires of wire ropes	Replace of wire ropes for hoist
	Stoplog	• Water leakage from bypass valves	Repair of bypass valves
	Local control panels	• Deterioration as a whole • Malfunction of measuring instruments and switches • Corrosion on terminal blocks • Deterioration of packings	Renewal of local control panels

Equipment		Results of Site Survey	Contents of Rehabilitation
	Remote control panes	• Common control panel for intake gates Units Nos. 1 to 4 • Deterioration of wiring cables (Chemical deterioration of sheath materials) • Deterioration of control switches for Units No. 1 and No. 2	Renewal of left side panel door for Units No. 1 and No. 2
18.	Gantry Cranes		
	Gantry crane for intake stoplog	• Deterioration of whole operator console in the cabin • Malfunction of measuring instruments and control switches • Corrosion on terminal blocks	Replace of operator console
	Gantry crane for tailrace stoplog	• Deterioration of whole operator console in the cabin • Malfunction of measuring instruments and control switches • Corrosion on terminal blocks	Replace of operator console

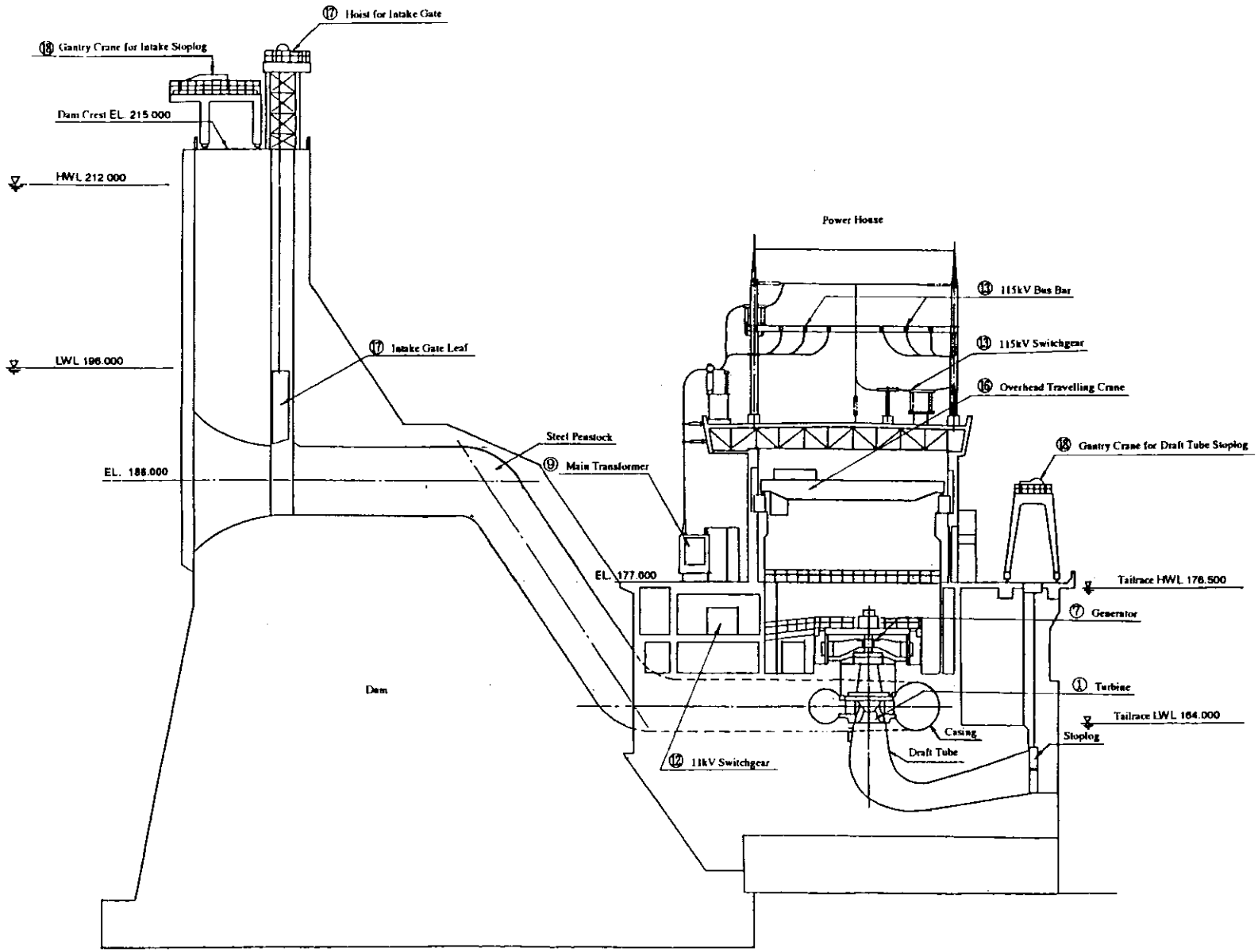


Fig. 2-2 Nam Ngum I Hydropower Station
Major Equipment for Rehabilitation

(2) Equipment Plan

The specifications of the major equipment for the Project are outlined in the tables below.

(a) Water Turbines

For Two Units

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) Spiral case	○			2 units	Surface preparation and coating
2) Stay ring	○			2 sets	Repair with overlay, surface preparation and coating
3) Stay vane	○			40 vanes	Repair with overlay, surface preparation and coating
4) Bottom ring	○			2 sets	Surface preparation and coating
5) Draft tube	○			2 units	Repair with steel plate lapping, surface preparation and coating
6) Runner and runner cone	○			2 units	Repair finishing by grinder, surface preparation and coating
7) Guide vane	○			40 panels	Repair finishing by grinder surface preparation and coating
8) Guide bearing		○		2 sets	Babbitt metal lining on SM400
9) Bearing oil reservoir		○		2 sets	
10) Bearing cooling coil		○		2 sets	Copper tube
11) Sealing box		○		2 sets	SM400

(b) Governors

For Two Units

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) Speed regulator			○	2 sets	Electronic type
2) Hydraulic actuator			○	2 panels	Oil pressure 30 kg/cm^2 with turbine control panel

(c) Pressure Oil System

For Two Units

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) Oil pressure tank	○			2 sets	Cleaning for internal, surface preparation and coating for external
2) Oil sump tank	○			2 sets	Cleaning for internal, surface preparation and coating for external
3) Pilot valve for unloader		○		4 pcs	

(d) Generators

For Two Units

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) Stator windings		○		2 units	F class insulation, one turn copper coil, 312pcs/unit
2) Stator core	○			2 units	Overhaul
3) Stator frame	○			2 units	Overhaul
4) Rotor	○			2 units	Overhaul
5) Air cooler		○		2 sets	Air-water heat exchanger 8 pcs/set
6) Thrust bearing		○		2 sets	12 pcs/set
7) Guide bearing		○		2 sets	16 pcs/set
8) Cooling coil for bearing		○		2 sets	Oil-water heat exchanger Separated in 2 parts

(e) Excitation Equipment

For Two Units

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) Excitation equipment			○	2 sets	Static type with automatic voltage regulator For 20 MVA generator
2) Excitation transformer			○	2 units	280 kVA, 11/0.27 kV, molded type transformer

(f) Main Transformers

For Two Units

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) Main transformer			○	2 units	20 MVA, 11/115 kV, 3-phase Oil immersed transformer

(g) House-Service Transformer

Common

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) House-service transformer			○	1 unit	1 MVA, 22/0.38 kV, 3-phase molded type transformer

(h) 11 kV Switchgear

Common

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) Neutral grounding transformer cubicle			○	2 panels	Transformer: single-phase, 70 kVA, 11/0.38 kV Resistor: 0.96Ω, 228 A Disconnector: single-pole, 12 kV, 400 A
2) Excitation transformer cubicle			○	2 panels	Transformer: 3-phase, 280 kVA, 11/0.27 kV CT: 1200/5 A VT: 11/0.11 kV
3) Generator circuit breaker cubicle			○	2 panels	CB: 12 kV, 1200 A, 25 kA CT: 1200/5 A
4) Disconnector and surge absorber cubicle			○	2 panels	DS: 3-pole, 12 kV, 600 A CT: 200/5 A Arrester: 14 kV, 10 kA Capacitor: 12 kV, 0.3 μF
5) House-service circuit breaker cubicle			○	1 panel	CB: 12 kV, 600 A, 25 kA

(i) 115 kV Switchyard Equipment

Common

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) Disconnector with earthing switch (#189-1)	○			1 set	120 kV, 800 A, manual operated type, mounted on supporting structure Replacement of: - Conducting parts - Operating mechanism - Earthing switch
2) Disconnector (#189P)			○	1 set	120 kV, 800 A, manual operated type, mounted on supporting structure
3) Disconnector (#189-2 #189B)	○			2 sets	120 kV, 800 A, manual operated type, mounted on supporting structure Replacement of: - Conducting parts - Operating mechanism
4) Disconnector (#189-T)	○			1 unit	120 kV, 800 A, manual operated type, mounted on beam structure Replacement of: - Conducting parts - Operating mechanism

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
5) Disconnector with earthing switch (#189-T1, #189-T2)	○			2 sets	120 kV, 800 A, pneumatic operated type, mounted on beam structure Replacement of: - Conducting parts - Operating mechanism - Earthing switch
6) Current transformer			○	1 set	Single-phase, 121 kV, 500-250/5 A, 40 VA, Class 0.2

(j) Control Boards

Common

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) Generator control panel	○			2 panels	Replacement of: (per panel) - Indicators: 10 pcs - Watt-hour meter: 1 pc - Watt-meter recorder: 1 pc - Switches: 6 pcs - Marking plates for operating status indicators
2) House-service control panel	○			1 panel	Replacement of: - Indicators: 4 pcs
3) Transmission line control panel	○			1 panel	Replacement of: - Indicators: 3 pcs - Watt-hour meter: 1 pc
4) Generator relay panel	○			2 panels	Removal of unnecessary relays and circuits Supply of spare relay: 1 pc
5) Automatic control board			○	1 panel	Floor-standing type metal enclosed panel of duplex construction To re-use existing automatic synchronizing device
6) AC control source distribution panel			○	1 panel	Floor-standing type metal enclosed panel, mounting - Indicators: 9 pcs - Circuit breakers: 15 pcs
7) Motor control center			○	2 sets	Floor-standing type metal enclosed panel for oil pump, generator space heaters, air compressor and cooling water pump

(k) DC Power Supply Equipment

Common

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) Storage battery			○	2 sets	Lead acid battery, 300AH, 53 cells/set, with steel racks
2) Battery charger			○	2 sets	Thyristor rectifier type Rated DC voltage: 140 V Rated DC current: 60 A
3) DC distribution panel			○	2 panels	Floor-standing, metal enclosed panel, mounting - Instruments: 4 pcs - Circuit breakers: 30 pcs

(l) Overhead Traveling Crane

Common

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) Overhead traveling crane	○			1 set	Adjustment of brake Adjustment of wire rope tension

(m) Intake Gate Facilities

For Two Units

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) Local control panel			○	2 panels	Outdoor installation, floor standing type metal enclosed panel
2) Remote control panel			○	1 set	Modification of existing panel for Units Nos. 1 to 4 (Renewal of left side panel)

(n) Gantry Cranes

For Two Units

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) Operator console for intake stoplog gantry crane			○	1 panel	Installed in the existing cabin
2) Operator console for tailrace stoplog gantry crane			○	1 panel	Installed in the existing cabin

By the way, the main transformers are planned to be purchased from Japan or Thailand for the following reasons.

i) Each main transformer will have a transportation weight of about 30 tons. If the main transformer is purchased form Japan, the price will be much expensive because of high transportation cost.

ii) Among the Southeast Asian countries, the transformer manufacturers to be qualified for the said main transformers are available in Thailand and Indonesia. Thailand has an advantage in transportation cost because it is accessible to the Project site by land.

iii) Thai manufacturers can take quick action in case of the transformer trouble.

The specifications of the main transformers are outlined as follows:

For Two Units

Equipment	Classification			Q'ty	Outline of Specifications
	Repair	Replace	Renewal		
1) Main transformer			○	2 units	20 MVA, 11/115 kV, 3-phase Oil immersed transformer

(3) List of Spare Parts, Maintenance Tools and Testing Instruments

The spare parts, maintenance tools and testing instruments to be supplied under this Project are listed in the tables below.

Table 2-5 List of Spare Parts to be Supplied

Spare Parts	Q'ty
1. Spare Parts for Turbines	
(a) Shear pins	8 pcs
(b) Shaft sealing boxes	2 sets
2. Spare Parts for Governors	
(a) Fuses	100 % of actual use
(b) Bulbs for indicating lamps	100 % of actual use
(c) Auxiliary relays	1 pc of each type
3. Spare Parts for Excitation Equipment	
(a) Fuses	100 % of actual use
(b) Bulbs for indicating lamps	100 % of actual use
(c) Auxiliary relays	1 pc of each type
(d) Cooling fans	100 % of actual use in one unit
4. Spare Parts for Relay Boards	
(a) Over current relay for generator protection	1 pc

Table 2-6 List of Maintenance Tools to be Supplied

Tools		Q'ty
Maintenance Tools for Generators		
(a)	Tools for wedge insertion	5 pcs
(b)	Spatula for wedge insertion	60 pcs
(c)	Skin hammers	10 pcs
(d)	Chisel for wedge removal	5 pcs
(e)	Chisel for wedge insertion	5 pcs
(f)	Chisel for stator core repair	5 pcs

Table 2-7 List of Testing Instruments to be Supplied

Testing Instruments			Q'ty
1.	Instruments for Field Tests of Governors		
	(a)	Digital oscillogram for load rejection test	1 set
	(b)	Pressure transducers for pressure measurement 50 kg	4 sets
	(c)	Pressure transducers for pressure measurement 10 kg	2 pcs
	(d)	Strain meter for signal converter	1 pc
	(e)	Extension cables, 30 m for measuring data	6 pcs
	(f)	Stroke detector for servomotor stroke measurement, 500 mm	1 set
	(g)	AC-DC converter for measurement of generator voltage and speed	2 sets
	(h)	Shunt for measurement of generator current	1 pc
	(i)	Digital multi-meter	1 pc
	(j)	Gauge tester for calibration of pressure gauges	1 set
	(k)	Signal conditioner for calibration of converters	1 set
	(l)	Dial gauges, 0.01 - 10 mm with magnetic block base	4 sets
	(m)	Power drum, 50 m, 4 taps	1 pc
2.	Instruments for Field Tests of Generators		
	(a)	Insulation resistance tester	2 pcs
	(b)	AC voltmeter, Class 0.5	3 pcs
	(c)	AC ammeter, Class 0.5	3 pcs
	(d)	DC voltmeter/ammeter, Class 0.5	1 pc
	(e)	Double bridge	1 set
	(f)	Oscillograph with 8 channels	1 set
	(g)	Digital multi-meter, basic accuracy 0.05 %	1 pc
	(h)	Phase rotation meter	1 pc
	(i)	Anemometer	1 pc
	(j)	Withstand voltage equipment (DC)	1 set
	(k)	Stop watch	1 pcs
	(l)	Handy vibration meter	1 pc
	(m)	Three-phase short bar	1 set
	(n)	Digital tachometer	1 set
	(o)	Portable balancer	1 set
	(p)	Standard voltage transformer	1 pc
	(q)	Standard current transformer	1 pc
	(r)	Vibration meter	1 set

2.2.3 Basic Design Drawing

Basic design drawings for the Project are shown as listed below.

No.	Drawing No.	Title
1	JCOP106-1	Power Station System Diagram
2	JCOP106-2	Single Line Diagram - Units No. 1 and No. 2
3	JCOP106-3	Single Line Diagram – DC Distribution Circuit
4	JCOP106-4	Single Line Diagram – AC Distribution Circuit
5	JCOP106-5	Nam Ngum I Power Station - Plan
6	JCOP106-6	Nam Ngum I Power Station - Elevation
7	JCOP106-7	Nam Ngum I Power Station - Section
8	JCOP106-8	115kV Outdoor Switchyard for Units No. 1 and No. 2 - Plan
9	JCOP106-9	115kV Outdoor Switchyard for Units No. 1 and No. 2 - Section
10	JCOP106-10	115kV Outdoor Switchyard for Units No. 1 and No. 2 - Section
11	JCOP106-11	11 kV Switchgear for Units No. 1 and No. 2, Layout Drawing
12	JCOP106-12	Main Transformer Connection, Outline Drawing
13	JCOP106-13	Control Room, Control Panel Layout Drawing
14	JCOP106-14	Existing Main Control Board
15	JCOP106-15	Stator Assembly
16	JCOP106-16	Foundation for Existing Main Transformer
17	JCOP106-17	Piping Diagram for Generator Air Coolers
18	JCOP106-18	Arrangement of 115 kV Busbars and Fittings
19	JCOP106-21	Sectional View of Water Turbine
20	JCOP106-22	Turbine Floor Plan (EL. 168.50)
21	JCOP106-23	Turbine Floor Plan (EL. 161.50)
22	JCOP106-24	Transverse Section of Units 1 and 2
23	JCOP106-25	Piping Diagram for Oil-Air pressure System
24	JCOP106-26	Outline of Oil Pressure Tank
25	JCOP106-27	Piping for Cooling Water (1)
26	JCOP106-28	Piping for Cooling Water (2)
27	JCOP106-29	General Assembly of Gate Leaf
28	JCOP106-30	Details of Side Guide Roller
29	JCOP106-31	Details of Seal Rubber
30	JCOP106-32	Outline of Local Control Panel
31	JCOP106-33	Outline of Remote Control Panel
32	JCOP106-34	Sequence Diagram of Intake Gate (1)
33	JCOP106-35	Sequence Diagram of Intake Gate (2)
34	JCOP106-36	Sequence Diagram of Intake Gantry Crane (1)
35	JCOP106-37	Sequence Diagram of Intake Gantry Crane (2)
36	JCOP106-38	Sequence Diagram of Tailrace Gantry Crane (1)
37	JCOP106-39	Sequence Diagram of Tailrace Gantry Crane (2)

2.2.4 Implementation Plan

2.2.4.1 Procurement Plan

(1) Procurement of Equipment and Materials

This Project is to rehabilitate the existing equipment that was supplied by Japanese manufacturers. Therefore, the equipment and parts thereof to be supplied under this Project are required to completely make a technical interface with the existing equipment from both structural and functional point of view.

Such equipment and materials are not available in Lao P.D.R. Accordingly, the equipment and materials for this Project are to be purchased from Japan.

However, the main transformers are to be purchased from Japan or Thailand.

(2) Bidding and Contract Method with the Contractor

All components of the existing Units No. 1 and No. 2 were supplied and installed by Japanese manufacturers. The turbines and generators will be restored to the original performance and conditions by repairs and/or replacement of defective parts.

The goods and services for the rehabilitation of the turbines and generators will be procured by direct negotiation with the original manufacturer for the following reasons:

(a) The equipment and parts for the rehabilitation cannot be designed without detailed data and information on the existing equipment such as design drawings, specifications, performances, materials and detailed dimensions. These detailed data are possessed by the original manufacturer only.

(b) These detailed data will not be disclosed or given to the third parties because they include the manufacturer's own technical know-how.

(c) The third party has no way of collecting such detailed data other than an extra field investigation on the turbines and generators. This investigation will be carried out by disassembling the turbines and generators, so it will require stopping the Units No. 1 and No. 2 for about 40 days in total. During this period, the Units cannot be operated for power generation. Thus, the extra field investigation by the third party will cause great inconvenience to the Lao side.

(d) The third party is requested to prepare various design drawings subsequently to the extra field investigation. This will be expensive in extra cost as well as in loss of time for delivery of the equipment. Accordingly, the equipment cost of the third party will be higher than that of the original manufacturer.

(e) Japanese manufacturers will not repair the equipment supplied by the third parties from his business practice except in special circumstances. This is because they cannot take responsibility on the performances of the equipment rehabilitated by them and they cannot indemnify any loss caused by their rehabilitation works.

(f) No manufacturer other than the original manufacturer can take over the responsibility of the existing equipment after the rehabilitation works.

(g) No manufacturer other than the original manufacturer can make successful and reliable coordination for the desired performances with the existing parts to be re-used.

The equipment and facilities associated with the turbines and generators will also be procured through the direct negotiation as far as their design require good coordination with the turbines and/or generators of the Units No. 1 and No. 2.

In the following cases, the equipment and facilities are planned

Besides, the equipment and facilities of which the design has no direct relation with the turbines and the generators will be procured under competitive bidding procedure.

Accordingly, the procurement of the goods for this Project will be carried out by the two contract packages for direct negotiation and competitive bidding. The equipment and facilities will be grouped into two package contracts as shown in Table 2-8.

(3) Policy of Spare Parts Supply

The implementation of this Project will much improve the operational reliability of the Units No. 1 and No. 2. Therefore, the replacement of the spare parts will be not necessary by next overhaul that should be done ten years after the completion of the Project, except the replacement of consumables.

Accordingly, the spare parts to be supplied under the Project will be limited to the consumables and parts of which frequent replacement is expected and to the parts that can be replaced by EDL personnel. The quantity of the spare parts will be sufficient for two years' operation. However, the consumables, which are usually procured by EDL until now, will be excluded from the scope of supply of this Project.

Table 2-8 Grouping of Equipment in Two Contract Packages

Equipment	Work	Lot 1	Lot 2	Remarks
		Direct	Bidding	
1) Turbines	Repair	○		Partial rehabilitation of the existing turbines
2) Governors	Renewal	○		Essential equipment to control turbine speed and output Close coordination with turbines is required
3) Pressure oil system	Repair	○		Close coordination with existing system equipment is required
4) Air compressors	Repair	○		Close coordination with existing system equipment is required
5) Water supply system	Repair	○		Close coordination with existing system equipment is required
6) Drainage system	Repair	○		Close coordination with existing system equipment is required
7) Generators	Repair	○		Partial rehabilitation of the existing generators
8) Excitation equipment	Renewal	○		Essential equipment to control generator voltage Close coordination with generators is required
9) Main transformers	Renewal		○	No coordination with turbines and generators is required
10) Fire extinguishing system for main transformers	Repair		○	Associated facilities for main transformers
11) House-service transformer	Renewal		○	No coordination with turbines and generators is required
12) 11 kV Switchgear	Renewal	○		Close coordination with generators is required
13) 115 kV switchyard equipment and busbars	Repair Renewal		○	No coordination with turbines and generators is required
14) Control and protective relaying equipment	Repair Renewal	○		Close coordination with governors and excitation equipment is required
15) DC power supply equipment	Renewal	○		Essential equipment to supply control source to turbines and generators
16) Overhead traveling crane	Repair	○		To use for rehabilitation of turbines and generators
17) Intake gate facilities	Repair Renewal		○	No coordination with turbines and generators is required
18) Gantry cranes	Repair		○	No coordination with turbines and generators is required

2.2.4.2 Implementation Policy

This Project is to rehabilitate the Units No. 1 and No. 2 under the condition that the other units are kept running. The extent of rehabilitation works covers almost all the equipment related to Units No. 1 and No. 2. Accordingly, appropriate rehabilitation methods and work procedures will be examined prior to the commencement of the works to carry out the rehabilitation works smoothly and effectively without interference with the continuous operation of the other units.

The basic concept and important notice for implementation of the Project are as shown below.

(1) Executive Agency

The executive agency of Lao side is the Ministry of Industries and Handicrafts (hereinafter referred to as "MIH)" and Electricite du Laos (hereinafter referred to as "EDL"). MIH is responsible for the administrative and supervision of the Project, and EDL is the actual agency in charge of the Project operation and execution.

For implementation of the Project, the Lao side is requested to pay careful attention to the following three items and to assign the person in charge of the Project for smooth execution.

(a) Coordination and arrangements for unit shutdown during the rehabilitation works

In implementation of this Project, the Units No. 1 and No. 2 are requested to stop their operations for five (5) months for each unit. The operation of the other units should be arranged so that the shutdown of the Units No. 1 and No. 2 will not interfere with continuous power supply to both domestic and Thai markets.

EDL is requested to make necessary coordination with Electricity Generating Authority of Thailand (EGAT) in time to stop the associated Units for successful and smooth implementation of the Project.

(b) Preparation of budget and assignment of personnel for proper execution of the works allocated to the Lao side

The Lao side is requested to take a share in the site rehabilitation works. The works shared to the Lao side should be carried out timely in close coordination with the implementation schedule of the Project. Necessary budget and personnel should be allocated for smooth and efficient execution of the shared works.

(c) Transfer of Technology

At least ten (10) personnel are requested to participate directly in the site rehabilitation works of the turbines and generators. The prime objective of their participation in the site works is to transfer to them technical skills for dismantling and reassembling of the turbines and generators through on-the-job-training so that periodical overhaul can be managed by them.

(2) Consultant

In accordance with Japan's Grant Aid procedure, the Government of Lao P.D.R. will make a contract with Japanese consultant firm for construction supervision. The Consultant will work for preparation of the bid documents for procurement of the goods and services, and supervision of the site rehabilitation works.

The major work items for the Consultant to be responsible are listed below.

Pre-Construction Stage (Home Work)

(a) Preparation of bid documents for procurement of the goods and services for the rehabilitation works

(b) Bidding and evaluation of bids

(c) Contract negotiation

(d) Approval of drawings/documents

(e) Witnessing of factory inspection before shipment of the goods

(f) Issue of inspection certificate

(g) Reporting and explanation to the parties concerned

Construction Stage (Field Work)

(a) Progress control of transportation, rehabilitation works, site inspections and tests, etc.

(b) Coordination of work schedule among the work lots

(c) Safety control at site

(d) Witnessing of site inspections and tests

(e) Evaluation of site test results

(f) Technical guidance for improvements in recording of operation data and events

(g) Preparation of monthly report regarding the transportation, rehabilitation works, site inspections and tests

(h) Issue of payment certificate

(i) Preparation of completion report on site works such as transportation, rehabilitation works, site inspections and tests

(j) Final Inspection one year after taking over (Before the expiry of guarantee period)

(k) Periodical reporting to the parties concerned

(3) Contractor

The rehabilitation of the turbines and generators is carried out on site. Each unit will be shut down for five (5) months and all the works including site tests will be completed within this period. Many items of the equipment are installed in the powerhouse, so some works will be inevitably carried out in parallel at the same time. Since the various works are related to each other, proper coordination is essentially required among all the works and the schedule and method of the other works should be confirmed prior to the execution of the works.

All the rehabilitation works will be carried out by the Japanese contractor in consideration of quality control, performance guarantees, defects liabilities and progress control.

The contractor is requested to design, execute and complete the works in accordance with the specifications prepared by the Consultant. When completed, the works will be inspected for proper installation and the equipment will be tested to demonstrate their performances. All site tests will be completed before Taking Over. The contractor is requested to carry out transfer of technology to the EDL's personnel during the period of the rehabilitation works.

(4) Necessity to Dispatch Specialists

Professional and practical experiences are essential to the site rehabilitation works and site tests of the generating equipment. Therefore, experienced and qualified engineers will be assigned for supervision, technical instructions, quality control and progress control of the site works and tests.

Repairs of the turbines and replacement of the generator stator windings cannot be done without special skills and high working qualities. Therefore, welders, mechanics and electricians qualified for those works need to be dispatched to the site.

Scope of the rehabilitation covers almost all components of the Units No. 1 and No. 2 and it is extended to various special fields. Accordingly, the following specialists will be dispatched to site for successful and smooth execution of the Project.

(a) Supervisor: Six (6) persons for turbines, generators, control system, electrical equipment, switchyard equipment and intake gate facilities

(b) Testing engineer: Eight (8) persons for governors, excitation equipment, indoor switchgear, control system, electrical equipment, transformers, outdoor switchgear and intake gate facilities

(c) Technicians: Nine (9) persons for turbine welding work, turbine finishing work, generator rewinding work (2 persons), piping work and cabling works (3 persons)

2.2.4.3 Implementation Conditions

(1) Coordination with Existing Facilities and Civil Structures

The equipment and parts for the rehabilitation works should be designed to coordinate structurally and functionally with the existing equipment. In case the new equipment and parts for replacement are different in size from the existing ones, suitable adapters or other means will be provided to fit exactly on the designated places. In case the new equipment for renewal is installed at the same place as the existing one, its construction will be designed to use the existing foundation and floor openings.

(2) Punctual Delivery of Goods

Punctual delivery of the goods is critical to completion of the Project within the scheduled time for completion. Therefore, the progress of procurement and manufacturing needs to be monitored for progress control.

(3) Safety Control

Safety is essential to the site works especially when handling heavy equipment, working at high ground, working at narrow space and working together with different groups.

Prior to the execution of the work, de-energized condition and safety measure for the equipment and circuits should be checked carefully to avoid danger of the workers. When working on the electrical circuits, the associated switchgear should be locked electrically and mechanically and the de-energized circuits should be grounded to avoid an accident due to careless operation.

(4) Preparation Works

The rehabilitation works for all items of the equipment will be executed within the same period of the unit shutdown. The access route, handling method and work procedure for all the items of the equipment should be studied carefully prior to the unit shutdown for the rehabilitation work. Any temporary works, which may be necessary, should be provided as far as possible in advance of the unit shutdown.

(5) Attention to Operation of the Other Units

The site rehabilitation works will be carried out while the other four units are kept running. Therefore, the rehabilitation works need to be programmed so as not to interfere with continuous operation of the other units.

When the 115 kV busbars and DC power supply equipment are rehabilitated, a complete shutdown of the power station may be unavoidable. In such case, necessary temporary measures should be taken to minimize the period of the complete shutdown.

(6) Coordination between the Works

Almost all items of the equipment are installed in the powerhouse, so various works

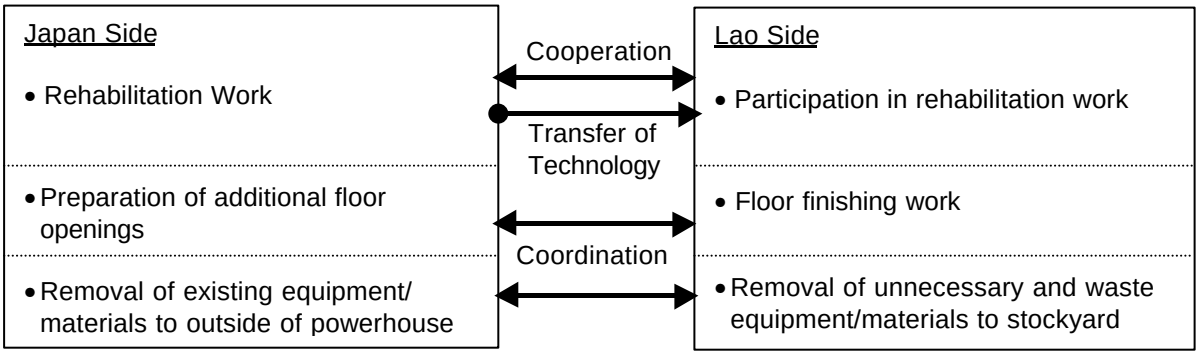
such as dismantling, removal, handling, assembling, painting and tests will be carried out in parallel at the same time.

All the works will be carried out under close coordination between various work groups for assignment of a responsible person to take care for the safety of all persons entitled to be on site.

2.2.4.5 Scope of Works

Japan side will be responsible for the rehabilitation of the equipment in accordance with the Basic Plan described in Sub-Clause 2.2.2. On the other hand, Lao side will be responsible for proper storage and disposal of unnecessary and waste equipment/materials as well as floor finishing work.

The works by both parties should be carried out in close coordination with each other as shown below.



2.2.4.6 Consultant Supervision

Under the Japan's Grant Aid scheme, the Consultant shall execute smoothly the consulting services by organizing a project team for construction supervision, with a full understanding of the Basic Design.

(1) Procurement Control Plan

The Consultant shall monitor the progress of procurement and manufacturing so that the goods for the Project can be delivered to site in time. The procurement control will be carried out in accordance with the following basic policy.

(a) Contractor's work program

Within 30 days after the contract signing, the contractor is requested to prepare his overall work program covering the design, manufacture, factory testing, delivery, site rehabilitation work, site training and commissioning of all items of the major equipment.

The procurement control and construction supervision will be carried out based on the approved overall work program.

(b) Monitoring of drawing submissions

The contractor will be obliged to prepare necessary design drawings for the equipment for the purpose of quality control.

The review results of the design drawings will affect the contractor's manufacturing design of the equipment. As for the major equipment, the contractor will be requested to submit the drawings for approval within 3 months from the contract signing and the approved drawings for work within 9 months.

Within 30 days after the contract signing, the contractor will submit a list of key drawings showing the contractor's target date for the first submission of each drawing. The progress of the drawing submission will be monitored based on the list of key drawings.

(2) Basic Policy for Construction Supervision

The Consultant is requested to give to the Contractor at any time instructions, which may be necessary, for the execution of the Works and to manage the Contractor's activities to finish all the Works safely and positively within the scheduled time for completion. The basic policy for construction supervision is the following three items.

(a) Progress control

i) To monitor the progress of manufacturing, transportation and site works for each item of equipment as well as progress of the works undertaken by the Lao side.

ii) To coordinate the work schedules for both the contractor and the Lao side.

iii) To arrange a coordination meeting for project management and progress control, from time to time during the implementation of the Project. Such a coordination meeting will be held weekly during the period of the site rehabilitation works and daily during the period of commissioning.

(b) Safety control

i) To enforce a safety check before setting out the works

ii) To avoid complication of some works at a place

iii) To provide a safety man at handling equipment and at working near the energized parts

iv) To take possible measures to avoid any accident due to careless operation at working in the waterway or on the electrical circuit

v) To take necessary safety precaution at working near the floor openings or the energized parts

(3) Consultant Engineers in Charge

To smoothly execute all different types of consultant services, it is required to assign a competent Project Manager who has ample experience in similar projects and fully understand the contents of the Project. At the same time, the Consultant establish a competent organization by appointing proper staff in charge for preparation of the Bid Documents, technical review of the Contractor's drawings, factory inspection, construction supervision and commissioning tests.

(a) Project Manager（1 person）

The Project Manager will manage overall implementation of the Project. He will give instructions, suggestions and necessary advice to other engineers in charge.

In the site construction stage, he will check working methods, safety, progress control of the whole works and to formulate site organization for construction supervision. He will also be responsible for evaluation of the Project effect.

(b) Engineers in Charge of Bid Documents（2 persons）

The engineers are responsible for preparation of the Bid Documents, bidding procedures including bid announcement, attendance to Bid Opening, Bid evaluation, assistance to the Contract Negotiation and the conclusion of the Contract.

Considering the specialties required for these activities, two engineers; one is an electrical engineer and another is a mechanical engineer, are required for this assignment.

(c) Engineers in Charge of Drawing Review and Factory Inspection (2 persons)

The engineers are responsible for technical review of the contractor's drawings for approval and witnessing the factory tests for the purpose of quality control of the equipment and materials to be supplied under this Project.

Considering the specialties required for these activities, two engineers; one is an electrical engineer and another is a mechanical engineer, are required for this assignment.

(d) Engineers in Charge of Construction Supervision (2 persons)

The resident engineers at site will be in charge of progress control and safety control in the whole period of the site rehabilitation works.

Considering the specialties required for these activities, two engineers; one is an electrical engineer and another is a mechanical engineer, are required for this assignment.

(e) Commissioning Engineer（1 person）

The commissioning engineer will witness the individual tests and comprehensive tests necessary for the quality control purpose, and he is also responsible for analysis and evaluation of the site test results.

2.2.4.7 Quality Control Plan

The quality control of the goods and the site works will be carried out in the following manner:

(1) Review of Contractor's Design Drawings

The contractor's design drawings submitted for approval will be reviewed to check the conformity with the requirements specified in the contract specifications.

(2) Factory Tests

In principle, all the goods will be subject to tests at the manufacturer's factory before shipment.

The factory tests for the major equipment will be witnessed to check whether the equipment is manufactured in compliance with the approved drawings and the specifications.

(3) Site Tests

The results of the rehabilitation works will be verified by site tests. The site tests will be carried out in the following two test stages:

(a) Pre-commissioning test to check individual function of the equipment in dry condition

(b) Commissioning test to check operating performance of the equipment and to demonstrate performance guarantees and technical particulars

(4) Concept of Defects Liability and Performance Guarantees

The defects liability will be applied only to the equipment, materials and/or their parts that will be supplied and worked under the Project. The defects on the parts beyond the scope of the Project will also be liable in case such defects are caused by the contractor. The defect liability period is one (1) year after Taking Over.

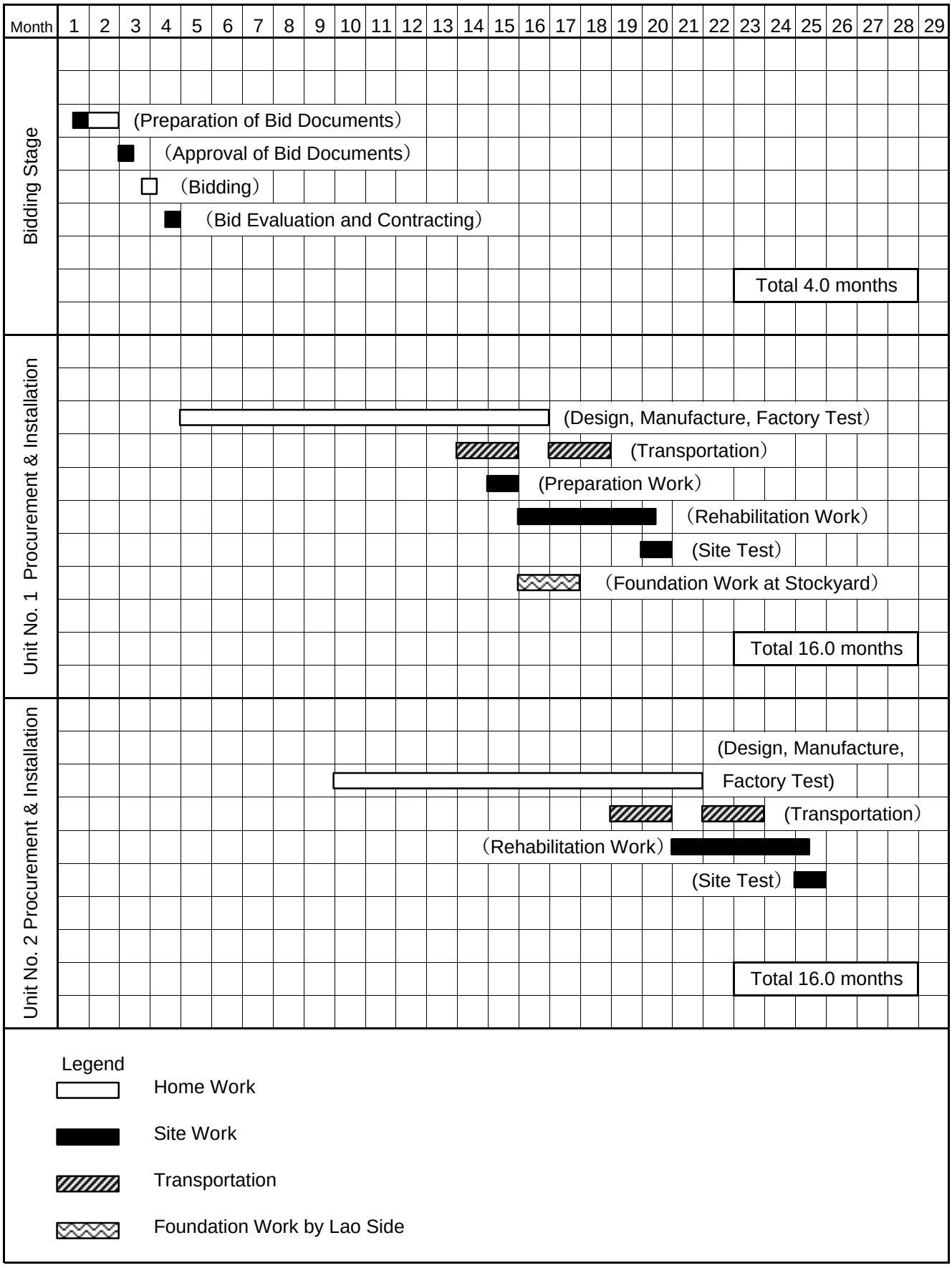
The equipment to be renewed and the replacement parts of which the performance can be measured will be subject to the performance guarantees. Their performance will be verified by site tests.

2.2.4.8 Implementation Schedule

This Project will be completed in twenty-five (25) months calculated from the conclusion of the Exchange of Notes (E/N) by both Governments. This schedule includes four (4) months for bidding and conclusion of the contract(s), and twenty (21) months for manufacturing, transportation, site rehabilitation works, site tests and transfer of technology.

The implementation schedule is shown in Table 2-9.

Table 2-9 Implementation Schedule



2.3 Obligations of Recipient Country

2.3.1 Works to be Executed by Lao Side

In the implementation of this Project, the Lao side is requested to execute the following works in addition to the services and works listed in Annex-3 and Annex-4 of the Minutes of Discussions on January 31, 2001 as the obligations of the recipient country.

(1) Participation in Rehabilitation Works of Turbines and Generators

The site rehabilitation works of the turbines and generators shall be carried out in active collaboration with the Lao side.

The Lao side shall provide at least ten (10) personnel of the maintenance crews of the Nam Ngum I Power Station to participate directly in the site rehabilitation works of the turbines and the generators during the period of the site rehabilitation works. These personnel is requested not only to be actively engaged in the rehabilitation works but also to improve and master a practical technique for dismantling and re-assembling the turbines and the generators in close collaboration with Japanese technicians.

(2) Proper Storage and Disposal of Unnecessary and Waste Articles of the Existing Plant

The Lao side shall be responsible for proper storage and disposal of all unnecessary and waste articles of the existing plant. The Lao side plans to store such unnecessary articles at the EDL's stockyard, which is about 600 m distant from the powerhouse.

The following works shall be borne by the Lao side.

(a) Preparation of land and space for storage of unnecessary articles

The land and space for temporary storage of the unnecessary articles shall be prepared by the Lao side prior to the implementation of the Project. The following facilities, which may be necessary for the storage purpose, shall also be prepared by the Lao side.

i) Foundation work for the relocated existing main transformers

Appropriate foundations are required to place the existing main transformers at the EDL's stockyard. The design and preparation of these foundations shall be carried out by the Lao side.

The foundation works shall be completed one month before the new main transformers arrive at the site.

ii) Oil fence at storage space for electrical equipment containing toxic chemicals

It was found that the existing excitation transformers, 11 kV voltage transformers and 11 kV capacitors use the insulating oils containing toxic chemicals. These items will be removed from the 11 kV switchgear cubicles and stored securely at a specially designated place in the powerhouse for

safekeeping.

The required space for safekeeping of these items is 2 m x 6 m and it shall be surrounded by a suitable oil fence with a height of at least 20 cm.

The oil fence shall be prepared by the Lao side prior to the commencement of the replacement work of the 11 kV switchgear cubicles.

(b) Removal of unnecessary and waste articles of the existing plant

As for removal of unnecessary and waste articles, the boundary points for responsibility between Japan side and Lao side will be designated at the outside of the powerhouse.

The Japan side shall be responsible for removal of unnecessary and waste articles from the existing plant to the boundary points, while the Lao side shall be responsible for removal of them from the boundary points to the outside of the power station.

However, removal of the existing main transformers will be included in the scope of work for Japan side on condition that the existing main transformer should be relocated to the EDL's stockyard, which is about 600 m distant from the powerhouse.

(c) Emptying and re-filling work for insulating oil of the existing main transformers

The Lao side shall be responsible for oil emptying from the existing main transformer before the relocation work and oil refilling to the relocated main transformers.

(d) Disposal of existing lead acid batteries

The waste lead acid batteries consisting of 104 cells shall be carefully disposed at a factory of car battery in Laos.

(3) Floor Finishing Work

In relation to the removal of the existing equipment, floor finishing work will be required to repair the floor surfaces. Such finishing works shall be carried out by the Lao side as well as supply of necessary mortar cement and floor tiles.

(4) Cable Re-Connection Work for DC Supply to Units Nos. 3 to 5

When the DC distribution panels are rehabilitated, the DC power supply to the Units Nos. 3 to 5 needs to be secured by changing the cable connections so that the DC power can be supplied directly from the battery charger.

For this purpose, the existing power cables for the DC power supply to Units Nos. 3 to 5 is required to be disconnected from the existing DC distribution panel and to be re-connected to the battery charger.

This cable re-connection work shall be carried out by the Lao side.

(5) Temporary Connection for House-Service Power Supply

When the 115 kV busbars are rehabilitated, the house-service power supply needs to be secured by receiving power from the 22 kV distribution line. Necessary preparation and temporary connection works for this purpose shall be carried out by the Lao side.

(6) Removal and Re-Installation of Terminal Boxes in the AC/DC Distribution Panels

The existing terminal boxes, which were additionally installed in the existing AC/DC distribution panels, are required to be removed before the replacement of AC/DC distribution panels are carried out by the contractor and to be re-installed in the new AC/DC distribution panels after completion of the contractor's replacement work.

Such removal and re-installation works for the terminal boxes shall be carried out by the Lao side including their cable connections.

(7) Remake of Foundations for Fire Extinguishing System for Main Transformers

At the replacement of the main transformers, a part of the water pipes for the fire extinguishing system will be disassembled by the contractor including removal of the foundations for their supports.

The foundations removed need be remade after completion of the replacement of the main transformers.

Such remaking of the foundations shall be carried out by the Lao Side.

(8) Replacement of Air Compressor for Emergency Diesel Engine Generator

The existing air compressor, which is essential to starting-up of the diesel engine, has seriously deteriorated in its operating function. Therefore, the replacement of the air compressor is urgently required to ensure successful operation of the diesel engine generator at any time to secure the house-service power supply.

The replacement of the air compressor shall be undertaken by the Lao side as soon as possible prior to the implementation of the Project.

2.3.2 Project Cost Estimation

In order to execute all the above mentioned works as undertaking obligations by the Lao side, the cost to be borne by the Lao side is estimated as follows:

(a)	Personnel expense		Kip. 70,000,000
(b)	Civil and building works		US$ 2,000
	i)	Temporary foundations for existing main transformers	US$ 1,200
	ii)	Oil fence around storage area of harmful equipment	US$ 50
	iii)	Floor finishing work	US$ 300
	iv)	Remake of foundations for fire extinguishing system	US$ 50
	v)	Others	US$ 400
(c)	Air compressor for diesel engine generator		US$ 6,250

To smoothly implement this Project, the Lao side should have the necessary cost ready in advance.

2.4 Project Operation Plan

The Nam Ngum I Hydropower Station has been operated for over 30 years by the power station staffs. The power station has a sufficient number of operators and maintenance crews who have enough experience for operation and maintenance of the power station. Therefore, they can manage the customary operation and maintenance of the power station without the need of modification of their organization. In order to maintain the effectiveness of this Project and to achieve further long-term operation of the Units No. 1 and No. 2, the operation and maintenance of the power station need to be improved in the following manner.

(1) Improvement of Periodical Maintenance Works

(a) Ordinary inspection

The ordinary inspection has been carried out periodically to confirm and maintain the performance of the respective equipment. However, they cannot do satisfactory inspection and tests due to lack of maintenance tools and testing equipment. Therefore, essential additional maintenance tools and testing instruments will be supplied as listed in Table 2-6 and Table 2-7. The contractor will be entitled to use these tools and instruments for his site rehabilitation works and he will instruct the maintenance crews of the power station how to use these items in their works.

(b) Detailed inspection

The power station staffs have never carried out the detailed inspection, which is necessary to restore the performance of the respective equipment. This is because they have no technical skills for dismantling and re-assembling of the turbines and generators.

The detailed inspection is essentially required to achieve the long-term operation of the generating units in good conditions.

The technical skills for dismantling and re-assembling of the turbines and generators will be transferred to the maintenance crews through on-the-job-training so that they can manage periodical overhaul and occasional inspection in case of emergency.

(2) Improvements in Recording Operational Data and Events

The operation data have been recorded hourly or half-hourly. The event recording is limited to heavy faults/troubles and major maintenance works. However, there are no satisfactory records on light faults/events, replacement of spare parts and consumables.

These operation data, faults/troubles and maintenance results are essentially required to monitor the operating conditions of the respective equipment. Accordingly, these data and events should be recorded properly and compiled as a database for the operation management and scheduling of the future maintenance plans.

Therefore, the Consultant will provide the technical guidance for improvements in data recording to the operators and maintenance crews at site.

(3) Proper Replacement of Consumables and Wearing Parts

The extension of the service life of the Units No. 1 and No. 2 is expected for at least 20 years after completion of this Project. The extension of the service life can be achieved on assumption that the consumables and wearing parts should be replaced properly and timely in accordance with maintenance schedule to be formulated carefully. Necessary budget should be prepared for proper replacement of these items.

(4) Supplement of Spare Parts

The minimum necessary spare parts and consumables required for two years' operation will be supplied under this Project as listed in Table 2-5. The following spare parts need to be supplemented for satisfactory operation of the Units No. 1 and No. 2.

(Unit: ¥1,000)

Items	Q'ty	Budget
1. Spare Parts for Governors		
(a) Fuse	50 % of actual use	1
(b) Bulbs for indicating lamps	50 % of actual use	49
2. Spare Parts for Excitation Equipment		
(a) Fuse	50 % of actual use	1
(b) Bulbs for indicating lamps	50 % of actual use	12
Total		63

The following replacement parts need to be supplemented at the overhaul of the turbines No. 1 and No. 2, which will be scheduled 10 years after completion of this Project.

(Unit: ¥1,000)

Items	Q'ty	Budget
Spare Parts for Turbines		
(a) Guide vane packings	40 sets	984
(b) Piston rings、∅400	16 pcs	1,088
(c) Servomotor packings、∅125	4 pcs	148
Total		2,220

In addition, the service life of the storage batteries, which will be renewed under this Project, is expected to be 10 to 15 years. Accordingly, the storage batteries need to be renewed again within 15 years. The budget for the storage batteries is estimated at ¥5,465,000.

CHAPTER 3

PROJECT EVALUATION AND RECOMMENDATIONS

CHAPTER 3 PROJECT EVALUATION AND RECOMMENDATIONS

3.1 Project Effect

The objective of this Project is to rehabilitate the Unit No. 1, Unit No. 2 for restoration of their technical performances, reliability and safety to the original conditions to realize a stable supply of electricity. The implementation of this Project will have the beneficial effects as shown in Table 3-1.

Table 3-1 Effects by Implementation of This Project

Present Issues	Measures by this Project	Effect after Implementation
1. The existing Units No. 1 and No. 2 have been operated for over 30 years since their commissioning in 1971. Their operating performances have deteriorated as a whole due to aging and corrosion.	The Units No. 1, No. 2 and the associated station common equipment will be rehabilitated to restore them to the original conditions.	The technical performance, reliability and safety of the Units No. 1 and No. 2 will be restored to the similar level as they were when installed in 1971 and their service life will be extended for further 20 years
2. Deterioration of the operating performance interferes with the continuous operation of the Units No. 1 and No. 2. If the Unit No. 1 and No. 2 are left as they are, it will have an adverse effect on stable power supply.		The Units No. 1 and No. 2 can be operated with high working ratio as they used to do before. This will come to restore and improve the reliability of power supply of the entire power station.
3. The Units No. 1 and No. 2 need frequent maintenance intervention and are often subject to faults and troubles. This results in increasing the maintenance cost. Especially, the 115 kV circuit breakers and low voltage cubicles had serious troubles due to aging. The renewal of these items resulted in a high rise of the maintenance cost.		The frequency of maintenance intervention and the possibility of faults and troubles on the Units No.1 and No. 2 will be reduced so that the maintenance cost will be greatly mitigated.
4. The turbine discharge has been currently decreased due to the elevated reservoir water level after completion of the Units No. 1 and No. 2.	The rated net head of the turbines No. 1 and No. 2 will be changed from 32 m to 37 m, according to present reservoir operation, and to recover the turbine discharge to the rated value originally designed for them.	The rated output of the Unit No. 1 and No. 2 will increase from 15 MW x 2 to 17.5 MW x 2 and the total installed capacity of the Nam Ngum I Hydropower Station will increase from 150 MW to 155 MW. This additional output will make some contribution to enhance revenues to the country from the power generation.
5. The turbine parts using grease lubricant are causing water pollution.	These parts will be renewed with grease-less construction to minimize adverse effect to the surrounding environment.	The water quality will be improved.

Present Issues	Measures by this Project	Effect after Implementation
6. The EDL's personnel have no technical skills for dismantling and reassembling of the turbines and generators.	The desired technical skills will be transferred to the maintenance crews of the power station through on-the-job-training.	They can manage periodical overhaul and occasional inspection in case of emergency of the turbines and generators. Especially, this Project will provide a greater opportunity for young engineers to learn the power station equipment.

The implementation of this Project will also have the following indirect effects:

(1) The implementation of the Project will reinforce the stable power supply to the consumers, which is essential to socio-economic development. This will lead to improvements in a living standard of the Lao nationals as well as in public services.

(2) The restoration and improvement the reliability of power supply will make a considerable contribution to progress of rural electrification program, which is one of the main objectives of the Government of Lao P.D.R.

(3) Similarly with the technology built up in the Nam Ngum I Hydropower Station to date, the technology provided by this Project will be transferred to the other power stations in the whole country. This will bring about the improvement of the technical level of the EDL.

3.2 Recommendations

A sufficient and proper maintenance is essentially required to maintain the effectiveness of this Project and to achieve further long-term operation of the Units No. 1 and No. 2. The maintenance works for the Nam Ngum I Hydropower Station need to be improved as described in Clause 2.4, Project Operation Plan. In particular, the following two items are the most important subjects to achieve successful long-term operation of the Units No. 1 and No. 2.

(1) Preparation of Necessary Budget

The extension of the service life can be achieved on assumption that the consumables and wearing parts should be replaced properly and timely in accordance with maintenance schedule to be formulated carefully. Therefore, EDL is recommended to prepare necessary budget for proper replacement of these items.

(2) Execution of Periodical Maintenance Works

EDL is recommended to execute the desired periodical maintenance works including overhaul to maintain the performance of equipment, to detect any trouble in its early stage and to prevent faults and accidents.

As aforesaid, the Lao engineers and technicians are requested to have technical skills for dismantling and re-assembling of the turbines and the generators through on-the-job-training during the site rehabilitation works. For this purpose, at least ten (10) personnel are requested to participate directly in the site rehabilitation works and to master a practical technique through on-the-job-training.

It is suggested that key persons of the maintenance crews in the Nam Ngum I Hydropower Station should have a technical training prior to the commencement of the site rehabilitation, in order to ensure that the transfer of technology at the site can be done successfully and efficiently. Technical training in Japan will give a lecture and practical training to them at the manufacturer's factory and at a training center of a Japanese electric power company.