No.

The Lao People's Democratic Republic

THE MASTER PLAN STUDY ON SMALL-HYDRO IN NORTHERN LAOS

Final Report: Volume 1

MAIN REPORT

December 2005

Japan International Cooperation Agency

Economic Development Department

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Japan International Cooperation Agency

Ministry of Industry and Handicrafts of Lao PDR

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NIPPON KOEI CO.,LTD.

KRI International Corporation

Preface

In response to a request from Lao People's Democratic Republic, the Government of Japan decided to conduct The Master Plan Study on Small Hydropower in Northern Laos and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent a study team led by Mr. Ichiro Araki, Nippon Koei Co., Ltd. and KRI International Corp., to Laos six times from February 2004 to November 2005.

The study team held discussions with the officials concerned of the government of Laos and conducted a series of field surveys. After returning to Japan, the study team carried out further studies and compiled the final results in this report.

I hope this report will be utilized for contributing to develop the small hydropower in Northern Laos and to the promotion of amity between our two countries.

I also express my sincere appreciation to the officials concerned of the government of Laos for their close cooperation throughout the study.

December 2005

Tadashi IZAWA
Vice President
Japan International Cooperation Agency

NIPPON KOEI CO.,LTD.
Consulting Engineers

December 2005

Mr. Tadashi IZAWA

Vice President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

LETTER OF TRANSMITTAL

We are pleased to submit herewith the Final Report of Master Plan Study on Small-Hydro in Northern Laos. We, Nippon Koei Co., Ltd. and KRI International Corp. had studied it for about two years from January 2004 to December 2005 under contract with your Agency.

The Final Report proposes the Government of Laos to utilize it for supporting tools with a master plan to achieve the Lao golden goal with 90% electrification until 2020. In addition, it comprehends the pre-feasibility study results for small-hydro potential sites executed by our Study Team supported by the Lao counterparts through comprehensive capacity building during whole study periods. We believe that the implementation of our proposed projects in the Study would contribute both to a rural development and a poverty reduction by electrification at the least-less developed area of remote villages in northern Laos. And, the Study had been carried out with three mottoes, Free access to information, Public involvement and Environmental friendly in line with JICA's own principles. Precisely, in consideration of the recent worldwide criticism on hydropower development, we have tried to investigate carefully for the negative impacts to the social/natural environments through a village socio-economic study and a public involvement at workshops showing our study results to the maximum extent.

Once again, we believe the Final Report would contribute both the smooth implementation of the Rural Electrification through the small-hydro projects and the good foot prints for future similar studies in other developing countries.

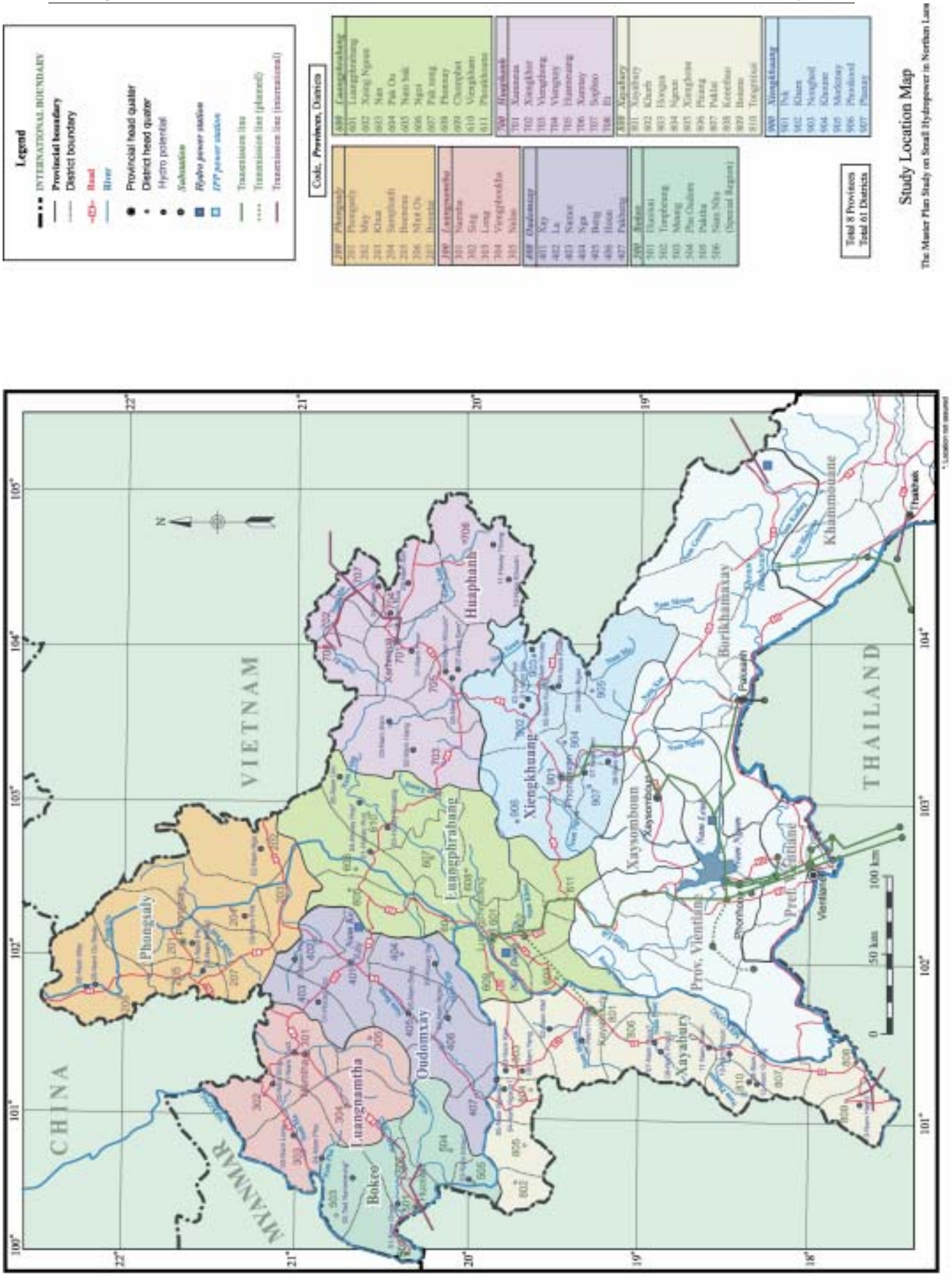
The Final Report consists of four volumes; Main Report, Executive Summary, Small-Hydro Manual and Small-Hydro Visual Guide. The main report covers all the study results including mainly the process of master plan study and Pre-F/S results on some small-hydro potential sites. The manual is expected for the Lao engineers to give a good valuable guidance for studying and designing of a small-hydro project. Especially, as the visual guide is translated into Lao language completely with full visual texts, it results in a unique beginner's book for the Lao local staff.

We wish to take this opportunity to express sincere gratitude to your Agency. We also wish to express our deep gratitude to the Ministry of Industry & Handicrafts of GOL, Electricite du Laos, Provincial Department of Industry & Handicrafts in northern eight provinces, the Embassy of Japan in Laos, the JICA Laos Office for close cooperation and assistance extended to our Study Team during field investigations and studies in Lao PDR.

Sincerely yours,

Ichiro ARAKI, Team Leader

The Master Plan Study on
Small-Hydro in Northern Laos


Legend
INTERNATIONAL BOUNDARY
Provincial boundary
District boundary
Road
River
Provincial head quater
District head quater
Hydro potential
Substation
Hydro power station
IPP power station
Transmission line
Transmission line (planned)
Transmission line (international)
Code, Province, District
Total 8 Provinces
Total 61 Districts
Study Location Map
The Master Plan Study on Small Hydropower in Northern Laos
CHINA
VIETNAM
MYANMAR
THAILAND
Phongsaly
Huaphanh
Xiengkhuang
Luangprabang
Oudomxay
Bokeo
Luangnamtha
Xayabury
Prov. Vientiane
Vientiane
Pref. Vientiane
Xaysomboun
Borikhamxay
Khammouane
0
50 km
100 km

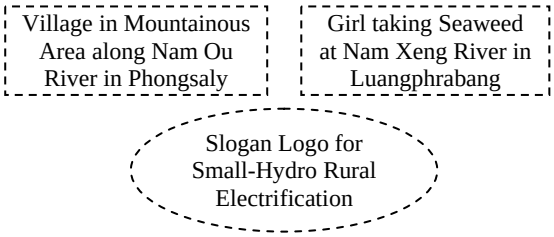
THE MASTER PLAN STUDY
ON
SMALL-HYDRO IN NORTHERN LAOS

FINAL REPORT

COMPOSITION OF REPORTS

Volume 1	Main Report	: English & Japanese
Volume 2	Executive Summary	: English & Japanese
Volume 3	Small-Hydro Manual	: English
Volume 4	Small-Hydro Visual Guide	: English & Lao
Volume 5	Supporting Data Files	: English

Front Cover Photo



VOLUME 1 : MAIN REPORT

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ABBREVIATIONS

ABBREVIATIONS		ABBREVIATIONS	
Lao PDR agencies		**Others (continued)**	
CDEP	Committee for Development of Electric Power	GHG	Green House Gas
CPI	Committee for Planning and Investment	GIS	Geographic Information System
DMH	Department of Meteorology and Hydrology	GMS	Greater Mekong Sub-region
DOE	Department of Electricity, MIH	GPS	Global Positioning System
EDL	Electricite du Laos	HPP	Hydropower Project
FIMC	Foreign Investment Management Committee	ICB	International Competitive Bidding
GOL	Government of Lao PDR	IEE	Initial Environmental Examination
LHSE	Lao Holding State Enterprise	IPDP	Indigenous Peoples Development Plan
LNCE	Lao National Committee for Energy	IPP	Independent Power Producer
LWU	Lao Women's Union	JI	Joint Implementation
MIH	Ministry of Industry and Handicrafts	LA	Loan Agreement
PDIH	Provincial Department of Industry & Handicrafts	LLDC	Least Less-Developed Countries
STEA	Science, Technology & Environment Agency	MOU	Memorandum of Understanding
Foreign organizations		M/P	Master Plan Study
ADB	Asian Development Bank	NBCA	National Biodiversity Conservation Area
EGAT	Electricity Generation Authority of Thailand	NEM	New Economic Mechanism
EVN	Electricity of Vietnam	NGOs	Non Governmental Organizations
IMF	International Monetary Fund	O&M	Operation and Maintenance
IUCN	World Conservation Union (Switzerland)	ODA	Official Development Assistance
JBIC	Japan Bank for International Cooperation	OPS	Off-grid Promotion & Support Program
JICA	Japan International Cooperation Agency (Japan)	PDA	Project Development Agreement
MOI	Ministry of Industry	PDP	Power Development Plan
MPI	Ministry of Planning and Investment	PPA	Power Purchase Agreement
NEPO	National Energy Policy Office	PPP	Public-Private Partnership
NTEC	Nam Theun 2(NT2) Electricity Company	PRF	Poverty Reduction Fund
NTPC	Nam Theun 2(NT2) Power Company	PTD	Power Transmission & Distribution Project
PEA	Provincial Electricity Authority in Thailand	PVP	Public-Village Partnership
UNDP	United Nations Development Program	SHS	Solar Home System
WB	World Bank	SIA	Social Impact Assessment
WCD	World Commission on Dams	SPC	Special Purpose Company
Others		SPP	Small Power Producer
AAU	Assigned Amount Unit	SPRE	Southern Province Rural Electrification Project
ATP	Ability to Pay	S/W	Scope of Works
B.	"Ban" Village in Laotian language	TOR	Terms of Reference
BOO	Build-Operate-Own	WTP	Willingness to Pay
BOT	Build-Operate-Transfer	**Unit and**	**Technical Terms**
CA	Concession Agreement	B-C, B/C	B: Benefit and C: Cost
CDM	Clean Development Mecah	EIRR, FIRR	Economic/Financial Internal Rate of Return
CER	Certified Emission Reduction	EL.( ) m	Meters above Sea level
COD	Commercial Operation Date	FSL	Full Supply Level of Reservoir
ECA	Export Credit Agencies	GDP	Gross Domestic Product
EIA	Environmental Impact Assessment	GWh	Giga Watt Hour (one billion watt hour)
EMMP	Environmental Management & Monitoring Plan	HH	Household
EPC	Engineering, Procurement and Construction	IRR	Internal Rate of Return
EPMs	Environmental Protection Measures	MAP	Mean Annual Precipitation
ERU	Emission Reduction Unit	MAR	Mean Annual Runoff
ESCO	Electricity Supply Company	MOL	Minimum Operation Level of Reservoir
ET	Emission Trading	MW	Mega Watt (one million watt)
F/S	Feasibility Study	PMF	Probable Maximum Flood
FARD	Focal Area for Rural Development	PMP	Probable Maximum Precipitation
GEF	Global Environmental Fund	US$	US Dollar

OUTLINE OF STUDY

CONCLUSION AND RECOMMENDATION

1. RURAL ELECTRIFICATION PROMOTION

The golden target of national electrification being raised up to a rate of 90% in 2020 is part of long-term national development planning to get out of being a Low Development Country by that year. The planning is to finally bring "Poverty Reduction through Fair Economic Growth".

In order to achieve the Golden Target of 90% electrification rate, a Master Plan of rural electrification is proposed by dividing it into the following four (4) project schemes with development scales appropriate to target households and budget. The schemes consist of (i): Electrification by grid extension nation wide (installed capacity more than 5 MW), (ii) Off-grid electrification to district centers (more than 100 kW below 5 MW), (iii) Mini-grid electrification by micro-hydro as village power (more than 50 kW below 10 kW), and (iv) Individual electrification by SHS (20-50W) and pico-hydro (100W-300W).

For establishment of an aggressive and sustainable organization for rural electrification promotion, it is recommended that the off-grid rural electrification projects are divorced from EDL's obligation and promoted by the central government, MIH. There are no more than obstacles for beneficial power development for EDL, under those difficult conditions. Accordingly, MIH should arrange both the technical and administrative staff to execute the off-grid rural electrification projects for the district centers. MIH should also manage mini-grid projects by micro-hydro (village hydro) and SHS projects by providing exclusive staff for the purpose. The responsibility and tasks of PDIH in providing assistant to MIH should be clarified.

2. SELECTION OF THE PRIORITY PROJECTS

Project Name	Grid Type	Off-grid Type
Priority Project	Nam Long (2,500 kW: Luang Namtha Province) Nam Ham 2 (1,000 kW: Bokeo Province)	Nam Ou Neua (260 kW: Phongsaly Province) Nam Likna (30 kW: Phongsaly Province)
Candidate Project	Nam Boung 2 (4,000 kW: Phongsaly Province) Nam Sim (8,000 kW: Huaphanh Province)	Nam Chong (50 kW: Bokeo Province) Nam Xeng (110 kW: Luangprabang Province)
Excluded Project	Nam Gnone (600 kW: Bokeo Province)	Nam Xan 3 (80 kW: Xiengkhuang Province) Nam Hat 2 (120 kW: Bokeo Province)

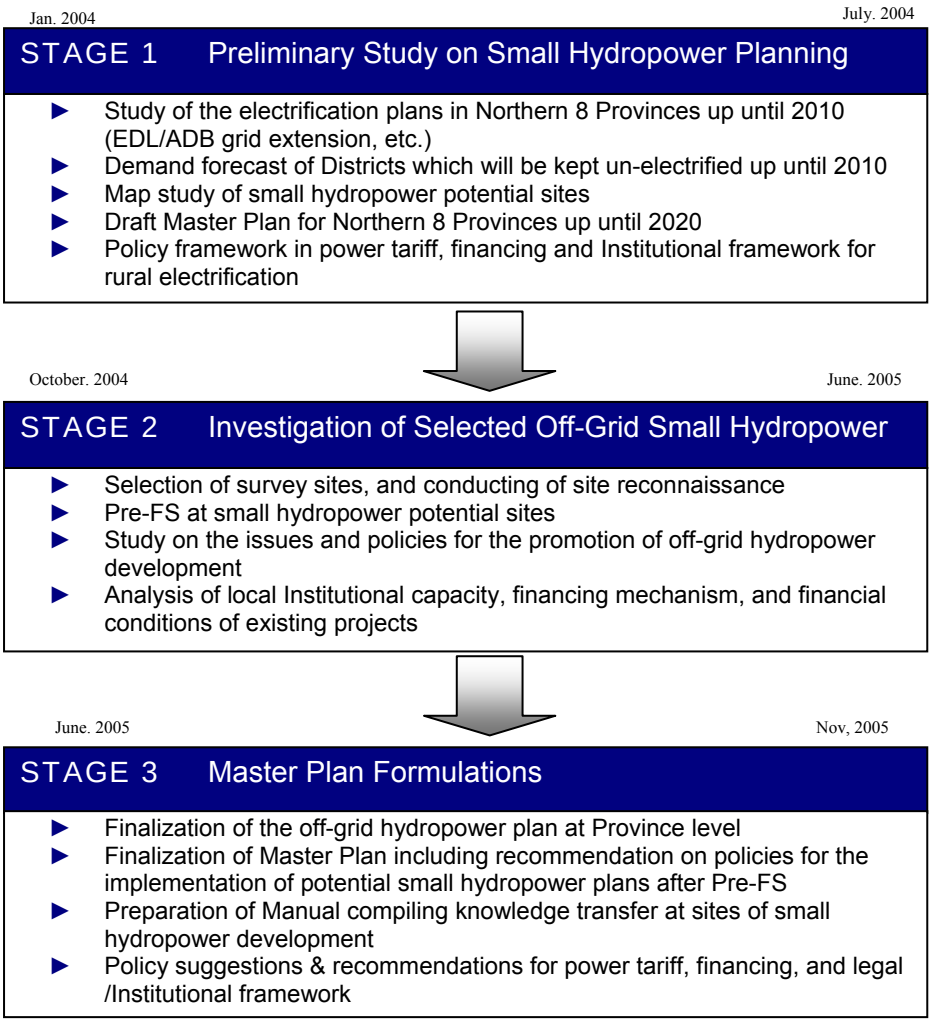
3. PURPOSE AND PROJECT BOUNDARY OF STUDY

The overall goal of the Study are improvement of the electrification rate, poverty alleviation, and economic growth targeting the northern eight (8) provinces; Phongsaly, Luangnamtha, Oudomxay, Bokeo, Luangphrabang, Huaphanh, Xayabury and Xiengkhuang in Northern Laos. Consequently, the purposes of the Study are; (i) promotion of electrification in unelectrified district centers, (ii) reduction of electricity import from neighboring countries, and (iii) achievement of the following study obligations by introduction of alternative power sources in areas depending on existing diesel generation:

- Preparation of master plan for off-grid small-hydro targeting the year 2020 based on the field reconnaissance results and implementation of Pre-FS,
- Policy suggestions and recommendations concerning the promotion of off-grid small hydropower schemes, and
- Execution of capacity building for the counterparts in small hydropower planning.

4. BACKGROUND AND ACTIVITIES OF STUDY

In July 2003, the Government of Lao PDR requested technical assistance of the master plan for small hydropower development less than 5 MW targeting northern eight (8) provinces. In reply, JICA dispatched the project formation study team in March 2003 and confirmed the detailed background of requirements for the Study. The team also discussed with both ADB and WB in Vientiane, agencies which have already studied the rural electrification in northern areas. In addition, when JICA dispatched the preliminary study team, the Lao side agreed to the S/W (Scope of Works) and signed the M/M (Minutes of Meeting) on September 18, 2003. The Study was carried out in accordance with the stages shown in the following flow chart:



POLICY RECOMMENDATION OF SMALL-HYDRO RURAL ELECTRIFICATION

5. BASIC STANCE OF POLICY RECOMMENDATION

Public bodies ranging from MIH to EDL as well as local government lack implementation capacity, especially in the field of finance. Despite their high potential for rural development, small-hydro projects inherently have high risks and low returns. In general the private sector in Lao PDR or neighboring countries would not be interested in small-hydro projects from pure business point of view. The only ways to promote small-hydro projects in Laos is with the leadership of the central government, using a combined approach of public-private partnership and community participation.

6. PRESENT CONDITIONS AND ISSUES OF RURAL ELECTRIFICATION POWER SECTOR

Power Supply Source

The domestic power is supplied by the national transmission line and the off-grid power supply in Lao PDR. The domestic power consists of the following power sources:

(i) National grid power supply from the power plants owned/operated by EDL (Small diesel generator and small-hydro),

(ii) National grid power supply from the export IPP plants (Large hydropower)

(iii) Small off-grid power supply imported from Thailand, Vietnam and China

(iv) Mini off-grid power supply from the power plants owned/operated by the provincial/district level and the private SPPs (Small diesel generator, Micro hydro and SHS)

Organization of Rural Electrification Sector

Under the electricity law, MIH has primary responsibility for policy formulation and strategic planning while EDL develops, owns and operates the country's main generation, transmission and distribution assets and manages electricity imports to its grid and exports from its stations. In the province where there is no EDL operation, the government of prefectures operates and maintains power generation facilities. Regardless of its size, Department of Electricity (DOE), one section of MIH, is responsible for technological aspects of the implementation of hydropower projects.

Legal, Institutional Regulatory Issues of Rural Electrification

The laws and regulations governing in Laos including IPP are (i) Foreign Investment Law, (ii) Electricity Law, (iii) Water and Water Resources Law, and (iv) Environmental Protection Law.

The Electricity Law became effective on August 29, 1997 has to be applied to generation projects

depending on which of the four categories the projects belong to (Article 9): (i) less then 100 kW, (ii) 100 kW-2MW, (iii) 2MW-50MW, (iv)greater than 50MW

Rural Electrification Projects and Development Models

The rural electrification projects include the Power Transmission and Distribution Project (PTD1), the Northern Area Rural Power Distribution: NARPD Phase 1 (PTD2) and NARPD Phase 2 (PTD3) financed by EDL/ADB.

SPRE implemented by EDL and WB consists of expansion project of transmission line in South under EDL and of SHS distribution project under MIH/DOE in whole country.

7. FINANCING FOR RURAL ELECTRIFICATION

The government of Laos has heavily depended on official assistance from international organizations which covers over 80% of whole budget deficit. The international donors for Laos are WB, ADB, IMF, UNDP, WFP, also the governments of Japan, Sweden, Germany, France, and Australia, and international NGOs. The amount of such assistance has been 15% to 18% of the GDP of Laos, which has been important financial source for capital expenditure. In terms of power sector, a budget has been allocated approximately US$ 16.3 million in average between 1997 and 2003. According to the estimate by WB, if the government intends to attain the 90% electrification ratio by 2020, it will need over US$421 million.

Under the tight fiscal condition mentioned above, it is indeed difficult to attain rural electrification only from the budget of the government of Laos including the ODA resource.

8. RECOMMENDATION FOR SMALL-HYDRO RURAL ELECTRIFICATION

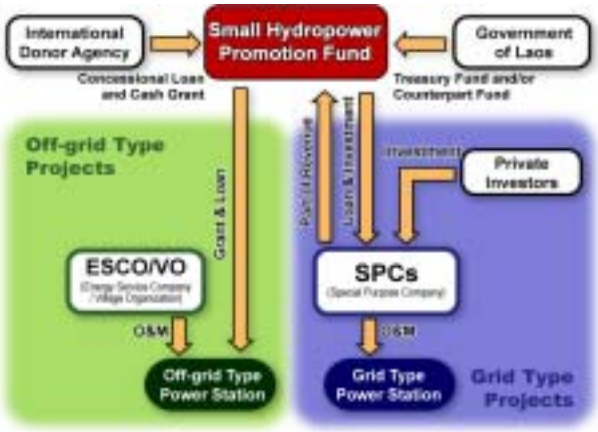
The ways to solve the issue of a high initial cost lies in the ways to reduce initial public investment or during the phase of operation. As shown in the conceptual scheme below, the public fund should be utilized as seed money to increase the coverage of electrification by small-hydro systems. World-wide experience in hydro power sector points to two (2) potential solutions of (i) Public-Private Partnership and (ii) Community Participation (Public-Village Partnership).

9. FUND FOR SMALL-HYDRO DEVELOPMENT

The basic concept of the Fund is to make up for the loss of the off-grid type projects, which contribute to poverty reduction in remote area, with the profits generated by the grid type projects. The Fund will be able to sustain profitability of on-grid type/off-grid type projects as a whole, and to assure sustainability of these projects (please refer to the figure below).

Envisaged income sources for the Fund are grant and concessional loan from the international donor agencies, treasury fund and counter fund of Laos Government, as well as revenue from other power projects.

Financial assistance would be made available for both the on-grid and off-grid type projects. Terms and condition of the assistance will be decided based on the profitability of each project.



Conceptual Diagram of the Fund

10. FINANCE PROCUREMENT USING CDM APPLICATION

Financial analysis was undertaken for two (2) options using CDM credit; one involves the application of 50% advance payment for the expected CER delivery over 21 years, and the other is without advance payment. As a result of financial analysis, Nam Ham 2 hydropower project improve its FIRR from 0.94% to 1.92%, and its NPV from US$115,154 to US$200,400. The profitability of Nam Ou Neua hydropower project increases with CDM application, but that of Nam Likna decreases due to the transaction cost of applying for CDM certification.

11. RECOMMENDATION FOR POVERTY REDUCTION THROUGH RURAL ELECTRIFICATION

Electrification is a necessary condition for village development but not a sufficient condition for its achievement. Electrification by itself does not lead to direct improvements in rural productivity, thereby resulting in increase in income. Productivity improves only after electricity is USED for productive activities as wells as lighting.

In preparing a guideline, WTP and ATP estimated by this project should serve as a benchmark reference for setting the electricity tariff in off-grid sites. In addition, the following issues should be considered in determining a tariff system.

- Formulation of Tariff Guideline for Off-grid Sites
- Payment of Connection Fee by Installation should be allowed for Poor Households
- Flat Rate System for Poor Consumers, and Metered Rate System for Non-poor Consumers
- Tariff for Commercial/Industrial Categories should be kept low.
- Tariff for Irrigation should also be kept low.
- Transport and Energy Infrastructure should be provided in order to achieve a Significant Synergy Effect on Poverty Reduction. And,
- Micro Credit should be offered for Entrepreneurs proposing commercial activities utilizing electricity.

MASTER PLAN OF SMALL-HYDRO RURAL ELECTRIFICATION

12. OUTLINE OF MASTER PLAN OF SMALL-HYDRO RURAL ELECTRIFICATION AT PROVINCE LEVEL

The Lao PDR aims at 90% electrification of the total number of households in 2020. For this reason, it is necessary to pull up the 31% rate of average electrification of the northern 8 provinces in 2003 to 77% in 2020. Therefore, after adding the electrification plan for district centers from the Pre-F/S of this master plan into the existing power development plan, further electrification is required of un-electrified villages that are not district centers.

Code	Province	Household Number	Electrified Household Number	Rate of Electrification %	Electricity Source of Electrified household					
					EDL Grid	Import electricity grid	Off-grid (small hydro)	Off-grid (Pico hydro)	Off-grid (diesel power)	Off-grid (SHS)
02	Phongsaly	27,410	3,938	14.4	0	0	2,179	641	1,118	0
03	Luangnamtha	25,168	8,839	35.3	0	6,232	228	192	889	1,298
04	Oudomxay	41,500	8,338	20.2	0	0	5,697	0	1,961	680
05	Bokeo	25,657	9,366	36.5	0	7,645	0	1,689	34	0
06	Luangphrabang	66,986	20,526	30.6	13,552	0	262	192	6,151	369
07	Huaphanh	41,621	21,664	52.1	0	8,485	3,272	9,723	184	0
08	Xayabury	61,370	18,961	30.9	6,978	10,892	0	0	202	889
09	Xiengkhuang	34,527	10,243	29.7	4,258	0	535	3,414	1,837	199
Total		324,239	101,875	31.4	24,788	33,252	12,173	15,851	12,376	3,435

Source: JICA Study Team

STEP 1

As shown in the table below, the present rates of electrification of the northern 8 provinces of 31% rises up to about 51% by adding i) electrification by the existing EDL grid extension plan, ii) the off-grid small-hydro plan of this master plan (projects for Pre-F/S only), iii) electrification of the village hydraulic power at potential sites found at the map study level in the master plan, and iv) the existing plan for Pico-hydro and SHS.

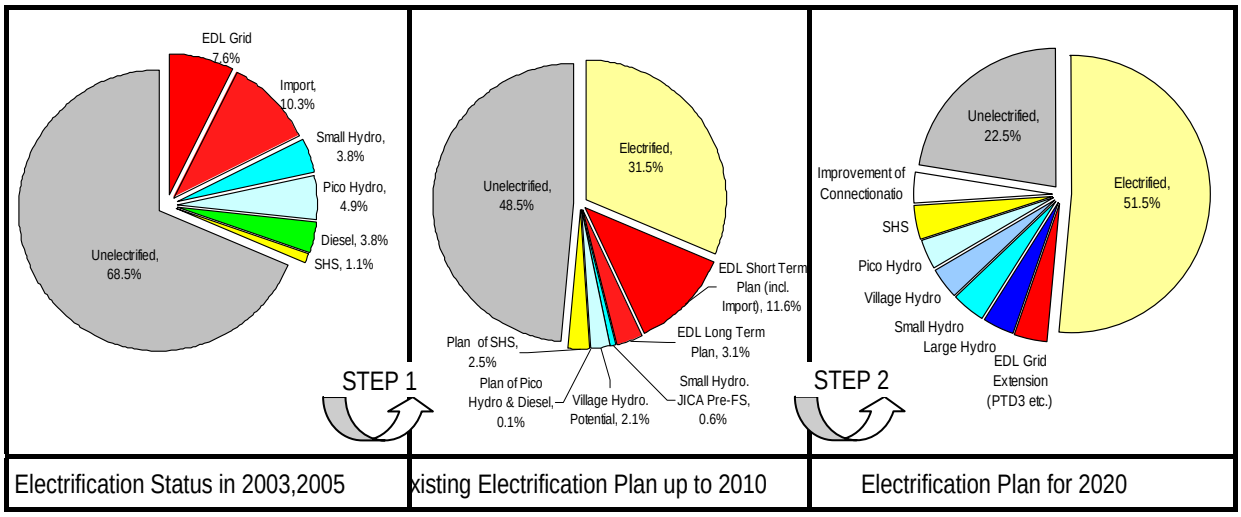
Code	Province	Household Number	Un-electrified Household Number	Rate of Electrif. after Implem. of Existing Electrif. Plan %	Existing Electrification Plan, Off-Grid Pre-FS Project and VH Potential Sites					
					EDL (short term plan)	EDL (Long term plan)	JICA Off-grid Pre-FS	VH Potential sites	Existing Pico hydro and diesel power	Existing plan of SHS
02	Phongsaly	27,410	8,451	30.8	2,951	0	527	1,035	0	0
03	Luangnamtha	25,168	9,966	39.7	912	0	0	215	0	0
04	Oudomxay	41,500	14,502	35.0	5,723	0	0	441	0	0
05	Bokeo	25,657	14,592	56.9	2,638	746	52	711	0	1,079
06	Luangphrabang	66,986	27,699	41.4	4,707	0	676	1,481	0	309
07	Huaphanh	41,621	25,354	60.9	1,932	572	0	1,186	0	0
08	Xayabury	61,370	42,234	68.8	7,418	8,524	0	489	415	6,427
09	Xiengkhuang	34,527	22,542	65.3	10,918	0	334	781	0	266
Total		324,239	165,340	50.9	37,199	9,842	1,589	6,339	415	8,081

STEP 2

By 2020, the electrification target of the Lao PDR is attaining a rate of 90% of household units having electricity. For attainment of this electrification target subsequent to STEP 1, it is necessary to increase the 51% average rate of electrification of the northern 8 provinces to 77% by 2020, and the following electricity sources have been considered for those northern 8 provinces: such as (i) EDL grid extension plan (PTD 3, provincial plan), (ii) Large hydropower project in northern 8

provinces and electrification of surrounding villages, (iii) Small-hydro project, (vi) Village-hydro project, (v) Pico-hydro project, (vi) SHS.

The existing electrification condition, existing electrification plan and requirement of electrification to attain the target in each province are shown in the following graphs.



13. ROUGH ESTIMATE OF COST FOR RURAL ELECTRIFICATION

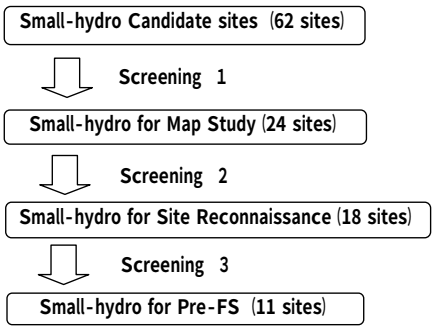
Case	Rough estimate of cost for rural Electrification
SHS of OPS program style by WB is adopted in STEP 2	The total cost for electrification of STEP 1 and STEP 2 is US$140 million. The electrification cost of STEP 2 was estimated about US$32 million.
EDL grid extension is adopted in STEP 2	The electrification cost of STEP 2, which is required to pull up 51% of rates of average electrification of northern 8 provinces to 77% in 2020 by EDL grid extension only, was estimated about US$186 million. This electrification cost is 6 times of Case 1.

14. NOTES ON SMALL-HYDRO RURAL ELECTRIFICATION

Items	Notes on Small-Hydro Rural Electrification
Planning based on Topographic Information at Site	When we proceed to the small-hydro planning, planning based on not only topographic maps but also the topographic information at site obtained from PDIH staff is required, because in small-hydro planning, the difference of head of 5m has a significant effect on the economic and financial analysis results.
Collaboration with EDL Grid Extension Plan	In 2006, the next grid extensions scheme, PTD3, is scheduled for formulation. It is important that the grid extension plan of PTD3 should be obtained and understood as soon as possible through confirmation with EDL planning section by DOE staff, and further off-grid small-hydro electrification plans should be implemented aiming at consistency with PTD3. For reference, the grid extension plans demanded at province level after PTD 2 were indicated in GIS maps as much as possible.
Small-Hydro Planning considering Local Hydrology and Topography	As shown in the specific discharge map in dry season in northern Laos, which was prepared in this Master Plan Study, small-hydro can be developed with high efficiency in the whole area of Huaphanh, Xiengkhuang, Phongsaly and the northern areas of Luangnamtha, Oudomxay and Luangphrabang. On the basis of this local characteristic, and considering topographical conditions, the electrification method for un-electrified villages in remote areas that will not receive EDL grid distribution, should be selected to achieve efficient electrification.

PRE-FEASIBILITY STUDIES ON SMALL-HYDRO

15. SMALL-HYDRO INVENTORY STUDY



In this Master Plan Study, a Pre-F/S was carried out for each of the eleven (11) small-hydro sites, which were selected from candidates sites (100kW~5MW) in the eight (8) provinces of northern Laos. The procedure leading to the Pre-F/S was as follows.

Selection of Small-hydro Candidate sites (62 sites)

A small-hydro inventory was prepared as the first step of the procedure mentioned above. It may be noted that the approach taken for the selection of the off-grid schemes was not based primarily on hydropower potential (supply) as in the conventional studies, but by first identifying the location and size of electricity demand at the load centers. Therefore, for example, in Bokeo Province where hydropower potential was not yet identified, an extensive map study was conducted for the areas near the load center to identify sites with hydropower potential that could satisfy the electricity demand of the load centers. Further, by referring to the existing report for small-hydro planning prepared previously, the potential sites for small-hydro aiming at the replacement of import electricity and the strengthening of the EDL grid were selected. The total number of these projects is 62 sites.

Screening 1 (Selection of Candidate sites for Map Study)

No.	Situation of the District in 2010	Province	District
1	No major power source.	Phongsaly	Nhot Ou, Samphan
		Bokeo	Meung, Pha Oudom
		Luangphrabang	Viengkhoune
		Xiengkhuang	Morkmay
2	Existing small-hydro only, and lacking potential.	Luangnamtha	Nalae
		Oudomxay	Nga, Pakbeng
		Huaphanh	Viengthong, Huameuang, Xamtay
3	Existing diesel power only, and lacking potential.	Phongsaly	May, Khua
		Luangnamtha	Viengphoukha

Screening 2 (Selection of Candidate sites for Site Recon. by Map Study)

Group	Characteristics of Small-hydro Planning	Number of Sites
Group 1	These are off-grid hydropower schemes for supplying to the load centers where EDL transmission lines are not planned.	15 sites
Group 2	These are grid hydropower schemes where sites with high hydropower potential are selected for the reinforcement of the EDL supply or the replacement of imported power from neighboring countries.	9 sites

Screening 3 (Selection of Pre-FS Sites by Site Reconnaissance)

As a result of the map study, 18 potential sites were selected for site reconnaissance. However, 24 sites were surveyed in total, because an additional 6 sites were identified at site.

A Pre-F/S was carried out on each of the 11 sites selected through the evaluation of the results of the EDL grid extension plan, demand forecast and the site reconnaissance from the use of the development priority criteria. It may be noted that although the quantity of the sites subject to the Pre-F/S was initially 10 sites, 11 sites were selected through discussion with DOE.

16. SMALL-HYDRO PLANNING

The sites selected for the Pre-F/S can be classified into two categories. As the planning processes of the two types are not identical, separate flowcharts were prepared.

No.	Grid Scheme	Description
1	Flowchart for the Off-Grid Scheme	The aim of the off-grid type hydropower system is to supply the power generated by the hydropower to the district center and the villages in the vicinity by constructing a mini-grid. Since the demand is limited in such a system, the optimum scale of development is governed by the balance between the peak load and the hydropower potential. For the planning of such a system, the benchmark for the hydropower potential is set at river discharge of 95% dependability, whilst the peak load per household is assumed at 190W/HH (peak hour = 4 hours) based on the load curve of the existing Nam Mong project. In addition, the ratio of base load to peak load is assumed at 40%, and the connection ratio is assumed at 80% of the total number of households, so that the scale of development does not become redundant.
2	Flowchart for the Grid Scheme	The grid type scheme is a relatively larger scale of development with the aim to reinforce the EDL grid. In this case, as all power generated by hydropower is consumed within the grid system, the optimum scale of development is not governed by demand. It was therefore necessary to plan and design several alternatives and to evaluate their unit generating costs, and the alternative with the lowest generating cost is obviously the optimum scale of development. This is to say that power generation simulation as well as design and cost estimate of all the alternatives considered are necessary at the Pre-F/S level in order to select the optimum installed capacity.

17. DESIGN AT PRE-F/S LEVEL

The design of the eleven (11) selected sites was conducted based on the results of the aforementioned planning process, of which 6 sites were designed by the Study Team and five (5) sites by DOE. The design follows the criteria mentioned in the Small-hydro Development Manual that has been prepared by the Study Team, while a program that calculated the basic dimensions of the civil structures was also prepared by the Study Team. As the use of the program is an important part of the capacity building of the DOE engineers, extensive explanation was given prior to its use.

18. COST ESTIMATE AT PRE-F/S LEVEL

Quantity calculations and cost estimates were conducted for the projects for which basic design was completed. The quantity was basically calculated based on the drawings, but a simple program was also prepared which calculates the quantities by use of formulae. Detailed explanation was given to the DOE engineers as this also serves as an important tool for capacity building.

The unit costs used in the cost estimate were derived based on those from previous projects implemented in Lao PDR and unit rates established in the Irrigation Department Office and the PDIH offices of the northern 8 provinces. The cost of electrical and mechanical equipment was estimated on the basis of the cost of previous projects obtained from EDL.

19. RESULTS OF PRE-F/S

Seq. No.	Project Name	Total No. of HH	Design Discharge (m^3/s)	Effec. Head (m)	Inst. Cap. (kW)	Effec.Ann. Energy (MWh)	Const. Cost (US$)	Gener. Cost (c/kWh)	Pre-F/S
4	N. Likna	154	0.37	12	30	106	198,273	24.70	S/T
5	N. Ou Neau	1,549	1.90	20	260	1,026	1,587,867	20.20	S/T
6	N. Boun 2	Grid	3.90	129	4,000	25,500	5,823,581	2.44	S/T
7	N. Long	Grid	1.35	238	2,500	15,269	3,515,003	2.48	S/T
15	N. Gnone	Grid	1.55	42	600	2,669	1,275,232	5.18	S/T
17	N. Chong	270	0.12	62	50	119	229,360	25.80	S/T
20	N. Hat 2	693	0.37	48	120	457	1,018,823	29.20	DOE
23	N. Xeng	629	1.64	10	110	416	859,392	29.80	S/T
27	N. Sim	Grid	6.71	148	8,000	31,673	6,502,610	2.20	DOE
31	N. Ham 2	Grid	0.78	170	1,000	5,794	1,888,824	3.53	DOE
32	N. Xan 3	431	0.41	29	80	293	462,633	20.80	DOE

20. FINANCIAL AND ECONOMIC ANALYSIS

Analysis	Grid Type Projects	Off-grid Type Projects
Financial Analysis	Project life is assumed to be 30 years after completion. Financial benefit is determined as the total expected energy sales to EDL at the end of a 22 kV line.	Project life is assumed to be 20 years after completion. Benefits of the Off-grid type projects are determined as the total expected revenue from sales of energy and revenue from connection fees.
Economic Analysis	Benefits of the Grid type projects have been determined as the replacement cost of alternative energy sources, substitutes for import energy cost and long-run marginal cost of generation, and 115 kV lines of the EDL grid.	Economic benefits of the Off-grid type projects are calculated using the consumer's average WTP for connection fees and electricity tariffs.

Summary of Financial and Economic Analysis

Project Name	Grid Type Projects					Off-grid Type Projects					
	Nam Boung 2	Nam Long	Nam Gnone	Nam Ham 2	Nam Sim	Nam Likna	N. Ou Neua	Nam Chong	Nam Xeng	Nam Xan 3	Nam Hat 2
Unit Cost (US¢/kWh)	2.44	2.48	5.18	3.53	2.20	24.7	20.2	25.8	29.8	20.8	29.2
FIRR	21.4%	18.9%	5.5%	11.4%	22.0%	-8.08	-6.9%	-10.8%	-11.3%	-7.5%	-12.8%
EIRR	24.9%	25.4%	7.9%	14.9%	28.1%	10.54	11.8%	9.4%	7.2%	10.8%	5.5%

21. COMPARISON OF SUPPLY COST BY ALTERNATIVES

Project(Unit:US¢/kWh)	Nam Likna	Nam Ou Neua	Nam Chong	Nam Xeng	Nam Xan 3	Nam Hat 2
Off-grid Type Projects	○ **24.74**	○ **20.15**	○ **25.82**	○ **29.83**	20.79	29.23
Diesel Mini Grid	35.29	41.67	40.77	37.64	35.67	39.44
Grid Extension	27.45	29.34	37.21	31.89	○ **17.17**	○ **17.55**

22. SELECTION OF THE PRIORITY PROJECTS

Project Name	Grid Type	Off-grid Type
Priority Project	Nam Long (2,500 kW: Luang Namtha Province) Nam Ham 2 (1,000 kW: Bokeo Province)	Nam Ou Neua (260 kW: Phongsaly Province) Nam Likna (30 kW: Phongsaly Province)
Candidate Project	Nam Boung 2 (4,000 kW: Phongsaly Province) Nam Sim (8,000 kW: Huaphanh Province)	Nam Chong (50 kW: Bokeo Province) Nam Xeng (110 kW: Luangprabang Province)
Excluded Project	Nam Gnone (600 kW: Bokeo Province)	Nam Xan 3 (80 kW: Xiengkhuang Province) Nam Hat 2 (120 kW: Bokeo Province)

23. FINANCIAL BENEFIT ON CDM APPLICATION

Items	Nam Ham 2		Nam Ou Neua		Nam Likna		Ou Neua + Likna	
	FIRR	NPV	FIRR	NPV	FIRR	NPV	FIRR	NPV
Base case, without CDM	11.44%	---	-6.87%	---	-8.08%	---	-7.00%	---
With CDM credit (w/o up-front payment)	12.38%	+115,154	-6.42%	+6,951	-9.33%	-19,695	-6.57%	+10,225
With CDM credit (w/ 50% up-front payment)	13.36%	+200,400	-6.59%	+24,996	-9.54%	-21,554	-6.70%	+30,128

Remarks : The analysis was carried out for the following three cases: (1) without CDM case, (2) with CDM and without up-front payment case, and (3) with CDM and with up-front payment case, on the assumption of 21 years as the project period. As for CDM application costs, validation cost, CDM registry cost, and verification/certification cost were taken into consideration.

24. VILLAGE SOCIO-ECONOMIC SURVEY

Outline of the Survey

The Village Socio-economic Survey was conducted in 8 candidate sites of the Off-grid type small-hydro projects, in order to clarify WTP and ATP for electricity, and energy demand in the project sites. Under the survey, 60 samples were collected in each site (8 sites x 60 samples = 480 samples).

Ability to Pay (ATP) for Electricity

Items	Pha Oudom	Meung	Vieng Phoukha	Nalae	Vieng Kham	Khoun	Sampanh	Gnot Ou	Average
Total Expenditure (Kip/month)	903,754	743,526	644,075	490,444	1,782,686	767,195	1,229,520	723,901	985,032
Ability to Pay (Kip/month)	45,188 90,375	37,176 74,353	32,204 64,408	24,522 49,044	89,134 178,269	38,360 76,720	61,476 122,952	36,195 72,390	49,252 98,503
Ability to Pay (US$/month)	4.35 8.71	3.58 7.17	3.10 6.21	2.36 4.73	8.59 17.18	3.70 7.39	5.92 11.85	3.49 6.98	4.75 9.49

Willingness to Pay (WTP) for Electricity

1. Estimated WTP for Connection Fee of Poor strata, Non-poor strata, and All

Items	Sample Size	Coefficient α (p-value)	Coefficient β (p-value)	Log Likelihood	WTP (US$)		
					Median (50% Yes)	Average	80% Yes
lAll Samples	479	13.85 (0.00)	0.33 (0.00)	-375.2	88.05	88.82	60.45
Poor Households	124	13.57 (0.00)	0.33 (0.00)	-92.6	68.84	69.82	45.98
Non-poor Households	355	13.94 (0.00)	0.30 (0.00)	-252.1	96.78	96.75	69.57

Source: JICA Study Team * Exchange Rate Used: U.S$ 1= Kip 10,376.5 (End of 2004, IMF International Financial Statistics)

2. Estimated WTP for Electricity Tariff of Poor strata, Non-poor strata, and Al

Items	Sample Size	Coefficient α (p-value)	Coefficient β (p-value)	Log Likelihood	WTP (US.¢ per kWh)		
					Median (50% Yes)	Average	80% Yes
All Samples	479	-17.07 (0.00)	2.29 (0.00)	-388.0	16.82	23.56	9.17
Poor Households	124	-17.61 (0.00)	2.42 (0.00)	-116.7	13.84	18.64	7.60
Non-poor Households	355	-17.17 (0.00)	2.24 (0.00)	-240.8	20.48	29.13	11.0

Source: JICA Study Team * Exchange Rate Used: U.S$ 1= 10,376.5 (End of 2004, IMF International Financial Statistics)

3. Estimated WTP for Connection Fee and Electricity Tariff by District Centers

Items		Pha Oudom	Meung	Vieng Phoukha	Nalae	Vieng Kham	Khoun	Sampanh	Gnot Ou
Poverty Ratio (%)		26.7%	28.3%	15.3%	38.3%	10.0%	33.3%	8.3%	31.7%
Connection Fee (US$)	Ave. WTP	89.6	89.1	92.6	86.4	94.1	87.8	94.5	88.2
	80% WTP	63.3	62.9	66.0	60.5	67.2	61.7	67.6	62.1
Electricity Tariff (US¢/kWh)	Ave. WTP	23.39	23.28	25.59	22.64	26.81	22.96	27.20	23.07
	80% WTP	9.12	9.08	9.84	8.88	10.24	8.98	10.36	9.01

Potential Electricity Demand for Business and Industries

A few households in the villages run businesses, such as a welding shop, motor bike repair shop or furniture making shop, using electricity from private diesel generators. These private diesel owners are, however, suffering from high fuel cost and frequent outage of the generators. Village heads in the surveyed sites expect that 24-hour electricity supply will provide a better chance to promote the establishment of small-scale industries, such as food processing, rice milling (there are 349 diesel powered machines in the surveyed sites), ice plants, furniture shops, repair shops, and grocery stores.

Out of 30 village heads interviewed, four (4) village heads in Gnot Ou district expressed interest in electrically pumped irrigation. They already have an irrigation plan (141 ha in the wet season and 181 ha in the dry season) using electricity.

25. SCREENING OF PRE-F/S PROJECTS FOR ENVIRONMENTAL IMPACT ASSESSMENT

The system of screening based on Environmental Impact Assessment in Laos PDR was conducted by DOE by reviewing the project description. It was judged that IEE is not required for the Pre-F/S

projects less than 500 kW; IEE for the Pre-F/S projects more than 500 kW only was required.

On the other hand, screening in accordance with JICA Guidelines for Environmental and Social Consideration was conducted based on project categorization judged by the JICA Environmental and Social Considerations Section. All projects were identified as requiring IEE-level environmental and social considerations studies, as they are all categorized as Category B.

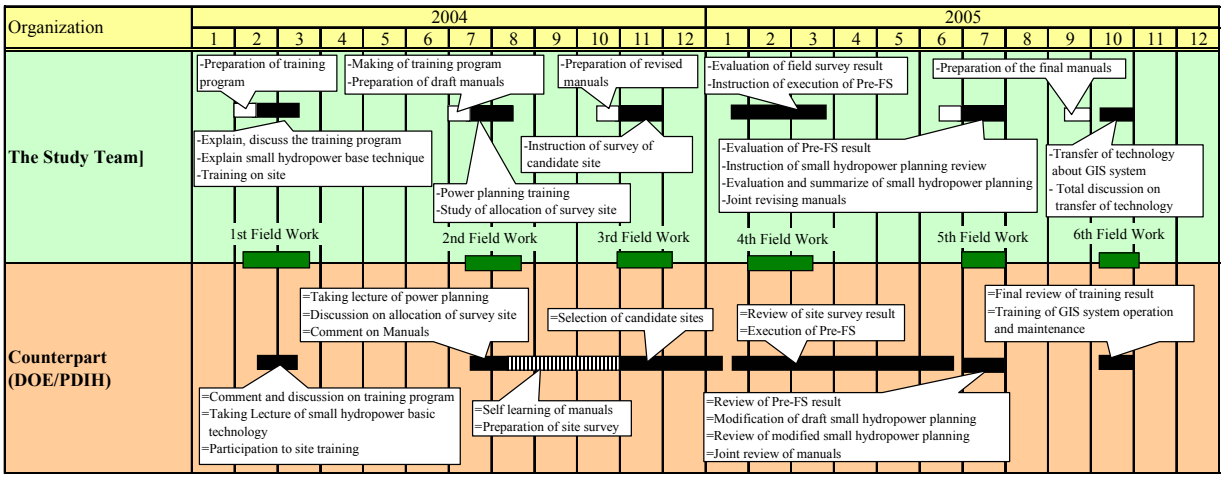
26. OUTLINE OF IEE RESULTS

No.	Items	Outline of IEE Results
1	Outline of the Projects	All proposed Pre-F/S projects are run-of-river schemes and small-hydro projects. The installed capacities range from 30 to 8,000 kW. Project components are the intake, waterway, power station, transmission line and access road. Nam Boun 2 project and Nam Sim project are river diversion schemes.
2	Overall Environmental and Social Conditions of the Project Area	All Pre-F/S projects are located in the mountain forests of northern Laos. There are many villages of ethnic minorities near the project areas. However, involuntary resettlement is not anticipated as a result of the projects. In addition, there are no protected areas in the project sites.
3	Adverse Environmental and Social Impacts	The adverse environmental and social impacts differ according to each project. However, the main and common impacts caused by the projects are impacts on water usage such as irrigation or sightseeing of waterfalls, impacts on aquatic biodiversity and disposed soil generation.
4	Evaluation of Alternatives	Four options were considered according to various criteria. A diesel power project is the most likely alternative against a small-hydro project. However, the project cost of diesel power is relatively more expensive than that of small-hydro due to the increasing oil price. Also, a diesel power project is less effective in respect of utilization of domestic resources. Therefore, the diesel power alternative was rejected. Solar power projects are superior to the proposed small-hydro projects in the sense that there is less environmental impact, but power generation is very low (20-40W). As this Study aims to raise the electrification ratio of the district center, the project cost would be highly expensive if the electricity demand of the district center were to be supplied solely by solar power. Therefore, the solar power alternative was rejected. The option of no project has no impact on the environment but does not contribute to the improvement of the electrification ratio. Therefore, this option was rejected.
5	Identification and Mitigation on Key Impacts	Since the adverse environmental and social impacts differ according to each project, the mitigation measures differ according to each project. However, the main mitigation measures are as follows. Riparian flow (maintenance flow) is required in order to ensure water usage such as irrigation or sightseeing of waterfalls. The muddy water during construction is to be treated accordingly to protect the aquatic biodiversity, while the disposal site for generated soil is to be established far from the residences and rivers.
6	Environmental Management Plan	In order to monitor the effectiveness of planned mitigation measures, environmental management plans are proposed. The main items of the environmental management plans are as follows: To monitor the effectiveness of the installation of the facility to protect against discharging of muddy water, (i) Inspection by DOE or an institution nominated by DOE and (ii) Implementation of water quality surveys by an institution for the operation once a year, are planned.
7	Public Consultations	Workshops were held on two occasions in Vientiane and one in Luanphrabang in order to explain to the stakeholders the project features and the possible environmental impacts foreseen, and to take note of the opinion of the stakeholders. These workshops were held at the EDL hall in Vientiane, inviting participants from DOE and PDIH of the northern provinces and other concerned parties.

CAPACITY BUILDING ON SMALL-HYDRO

27. INSTITUTIONAL FRAMEWORK AND SCHEDULE

The lectures were mainly held at the DOE meeting room in Vientiane. While the Hydropower Training Planner holds overall responsibility for the lectures, the other members of the Study Team assisted with the lectures in their respective fields of expertise. The counterparts attending the lectures were 2 engineers from PDIH from each of the 8 provinces in addition to the DOE engineers. The PDIH engineers attending the lecture were obliged to accompany the site reconnaissance in their respective provinces.



28. EXECUTED CONTENTS FOR TRANSFER OF TECHNOLOGY

FW	Item	Aim and Contents	Methodology
1st Field Work	Visit to 5 PDIH	Understanding on present status through visit to PDIH (Organization, Provincial electrification plan and technology), Programming of Lectures	Questionnaires and interviews
	1st Workshop	Sharing the contents of the Study through presentation of the Inception Report, sharing of electrification strategy and target through presentation by MIH/EDL/NGD, and understanding of the electrification status of the northern 8 provinces through presentation by PDIH.	Presentation by participants from each PDIH, questionnaires on capacity building.
		Site visit of construction site of Nam Mang 3 HP for study on hydropower equipment and civil structures.	Site visit to Nam Mang 3 HPP under construction.
	Discussion on Training Program	Understanding the present situation and identification of issues on capacity building.	Discussion for the workshop, implementation of questionnaires and conclusion.
	Procurement of Equipment	Installation of equipments and OA system.	Discussion on specifications of equipment and joint installation of OA system (LAN)
	Installation of the Staff Gauge	Transfer of discharge measurement method from DOE to PDIH.	Staff gauge installation at MW class potential sites conducted jointly between DOE and PDIH. Required materials was procured at sites.

FW	Item	Aim and Contents	Methodology
2nd Home Work	Preparation of the Training Program	Preparation of the Training Program.	Preparation of the Training Program based on discussions held in 1st Field Work.
	Drafting of the Small-hydro Development Manual	Drafting of the manual. Draft manual will be used for lectures.	-
2nd Field Work	Lectures on Basic Skills on Small-hydro Development (1st, 2nd Lecture)	Lectures on basic skills on small-hydro development for DOE/PDIH based on the lecture material.	Lectures combined with exercises. Lectures materials were translated by DOE and interpretation also made by DOE. Power point is used.
	Selection of Sites for Site Reconnaissance	Selection of priority sites for site reconnaissance for evaluation of feasibility.	Site selection made not only on hydropower potential but also appropriateness from the viewpoint of OJT. Various types and scales were selected, so that DOE/PDIH will be able to conduct reconnaissance by themselves in the future for the remaining 6 sites out of 24 sties selected through map study.
3rd Home Work	1st JICA C/P Training	Site Visit of Japanese Small-Hydro Projects and lecture and exercise for Small-Hydro using Computer. 2 DOE staff and 5 PDIH staff attended.	Visiting Existing Small-Hydro and the Factory for Small-Hydro Turbines and Generators, and lectures for Small-Hydro Planning Software using PCs.
3rd -4th Field Work	Site Reconnaissance	Site reconnaissance is carried out at selected small-hydro potential sites. Investigation on condition of sites for structures, river discharge, topography, geology, irrigation, condition of water usage and access, etc., which will become basis for the Pre-F/S planning and design.	Transfer of skills to DOE/PDIH through OJT, where discharge measurement, water use survey, head measurement, selection of sites for major structures, environmental evaluation, etc are taught. DOE/PDIH will conduct reconnaissance alone for 2 provinces where Study Team is not permitted to enter.
4th Home Work	2nd JICA C/P Training	The same as the 1st counterpart training, site visit of Japanese small-hydro and lecture and exercise for small-hydro using computer. 1 DOE staff and 3 PDIH staff attended. Also visiting "EXPO in Aichi"	Visiting existing Small-Hydro and the Factory for Small-Hydro Turbines and Generators, and lectures for Small-Hydro Planning Software using PC
4th Field Work	Pre-F/S	Transfer of skills on topographic survey, discharge measurement, meteo-hydrological analysis, optimum scale planning, power generation planning, preliminary design, economic/financial evaluation, initial environmental evaluation, etc.	Pre-F/S and site reconnaissance including topo survey and discharge measurement conducted jointly between Study Team and DOE, where the task is regarded as OJT for understanding of procedure and practical planning method.
	3rd Lecture	Training for the basic skills for small-hydro using draft manual. Review of the lecture and self-training using manual by counterpart staff.	Lectures combined with exercises. Lecture materials were translated by DOE and interpretation also made by DOE.
	2nd Workshop	Presentation of a progress report by DOE and study team.	Reporting Pre-F/S by DOE supported by study team.
5th Field Work	Evaluation of Pre-F/S	Enhance further understanding on basic concept, technical study results, drawings, calculation and reporting of Pre-F/S through revision made by Study Team on Pre-F/S conducted by DOE.	Revision of DOE Pre-F/S by Study Team and comparison with those conducted by Study Team aiming at further level up of DOE.
	4th Lecture	Reviewing 1st – 3rd Lecture, GIS Training, and Economic & Financial Lecture, which was requested by counterpart staff.	Lectures combined with exercises. Lecture materials were translated by DOE and interpretation also made by DOE.
	Transfer of Technology on GIS	Transfer of GIS technology and its maintenance.	Transfer of GIS technology made through review of data and operation manual.
5th Field Work	CDM Site Reconnaissance/ CDM Seminar	CDM Seminar subjected to the lecture on CDM theory and applicability to the small-hydro projects	Site Reconnaissance to a CDM applicable project site, and CDM Seminar for 2 days
	Revision of the Small-hydro Development Manual	Understanding of contents of the manual through joint revision by Study Team and DOE.	Translation by DOE, preparation of novice section for PDIH, customization according to Lao's unique conditions.
6th Field Work	3rd Workshop	Organizations related with rural electrification and JICA gathered at LPB to discuss about issues on rural electrification and promotion.	In the Workshop, there is presentation on study results by DOE including explanation of Pre-F/S results made by DOE.
	GIS System	Transfer of technology on effective use of GIS.	Transfer of technology on maintenance of system through review of GIS system data and operation manual. Technical lecture is held as required.

1. INTRODUCTION

1.1 CONCLUSION AND RECOMMENDATION

Lao Power Conditions

The hydropower plans in Laos are so famous that they are aptly referred to as “the batteries of Southeast Asia”. The hydropower development plans at the Mekong Basin started initially with the U.N. Technical Assistance Administration (the Gen. Wheeler Mission) in 1957 by ECAFE (Economic Commission for Asia and the Far East). They bloomed with the electricity export to Thailand from the Nam Ngum 1 Hydropower Project (HPP) in 1971 and many subsequent plans have been developed other than the Nam Theun 2 HPP to have started construction works this year.

It may “leave bitter taste” that the electrification rate of Laos is significantly lower than other Southeast Asia countries in spite of much hydro potential. This causes the slow economic growth as is well known by everybody. It is especially true in the northern area from the capital Vientiane, which has the borders with Thailand, Myanmar, China and Vietnam with steep mountains. The national grid of EDL is likely to reach those areas until very far into the future.

A quarter century has passed since the new Lao PDR, established its policies in December 1975. People in Laos worried about devastation of their land due to the large hydropower developments for export, which have been promoted for the convenience of developers in other countries. However, they are now trying to improve their own living standard using small-scale hydropower. The idea is to distribute electricity to each village forming an isolated mini-grid with an independent power source in each load center without EDL grid. It would be easy to get this accepted by northern mountain inhabitants, who have historically been governed regionally.

The reasons for this slow development are not only the topographic conditions but also the small population scattered in mountainous areas.

Rural Electrification Promotion

The golden target of national electrification being raised up to a rate of 90% in 2020 is part of long-term national development planning to get out of being a Low Development Country by that year. The planning is to finally bring “Poverty Reduction through Fair Economic Growth”.

In order to achieve the Golden Target of 90% electrification rate, a Master Plan of rural electrification

is proposed by dividing it into the following four (4) project schemes with development scales appropriate to target households and budget. The schemes consist of (i): Electrification by grid extension nation wide (installed capacity more than 5 MW), (ii) Off-grid electrification to district centers (more than 100 kW below 5 MW), (iii) Mini-grid electrification by micro-hydro as village power (more than 50 kW below 10 kW), and (iv) Individual electrification by SHS (20-50W) and pico-hydro (100W-300W).

For establishment of an aggressive and sustainable organization for rural electrification promotion, it is recommended that the off-grid rural electrification projects are divorced from EDL's obligation and promoted by the central government, MIH. There are no more than obstacles for beneficial power development for EDL, under those difficult conditions. Accordingly, MIH should arrange both the technical and administrative staff to execute the off-grid rural electrification projects for the district centers. MIH should also manage mini-grid projects by micro-hydro (village hydro) and SHS projects by providing exclusive staff for the purpose. The responsibility and tasks of PDIH in providing assistant to MIH should be clarified.

Electric facilities both for a national grid extension and an off-grid installation should be considered as a category of national infrastructure. Meanwhile, in regard to village electrification, consisting of both a mini-grid by micro-hydro and individual electrification by solar and pico-hydro, such electrification should be promoted as one of the means for Human Security.

Human Security

The 1994"Human Development Report "by the United Nations Development Programme (UNDP) was the first to mention human security publicly in the international community. The Concept of Human Security means a paradigm shift of "security" from staying on the narrow state security ideas to expanding its focus to include people's perspective. Threats including poverty, environmental degradation, conflicts, landmines, refugee problems, illicit drugs and infectious diseases such as HIV/AIDS, thus to secure people's lives, livelihoods and dignity in the real world.

1.2 CURRENT CIRCUMSTANCE OF RURAL ELECTRIFICATION AND SMALL-HYDRO

One of the reasons of the high poverty regions scattered in Northern Laos is assumed to be deterioration of inequality because of economic growth.

The policy to make imperatively settlement rural farmers on slash-and-burn culture has failed by the reasons of unfair land distribution and by insufficiency of the infrastructure with road and irrigation. It helped to spread slash-and-burn cultures disorderly and brought a vicious circle at difficulties of self-support. Consequently, GOL proceeds to begin power programs to achieve 90% electrification rate, since GOL makes a point of rural electrification in terms of improvement of living standard by encouragement of agriculture and industry.

It can be said that it is natural that hydro-power is chosen as a tool for electrification due to rich and rainy green forest covering whole of Laos, without considering worldwide recent coal and the oil price rise. Therefore, the expansion projects of off-grid connection area by small-hydro below 5MW are

expected to contribute directly the poverty reduction in addition to grid extension project and power supply projects by a medium-scale hydropower plant of 100MW or less.

The economic infrastructure projects depend on due international aid, for example, the dam and the road projects, has been reduced because of the environmental destruction and the resettlement issues. However, the indispensable access to a basic infrastructure, such as the road, water supply, and electricity was recognized again for accomplishment of a goal of Human Security.

Meanwhile, the power export by some large scale hydropower projects was progressed both by the foreign investors and the Lao national investment through EDL. The government proceeded to supply both rural electrification and grid extension by applying the budget from a part of power sales benefit. However, the balance of power export is not clear due to a repayment for Lao equity even enough income by domestic power sales. Under such situation, GOL established LHSE (Lao Holding State Enterprise) to invest the Lao portion of the power export exclusively in January 2005. LHSE shall be in charge of IPPs as Lao investor since Nam Theun 2 HPP as well as both existing IPPs of Theun Himboune HPP and Hoay Ho HPP. Accordingly, the Rural Electrification is apprehensive for less development due to the new EDL's policy to promote the priority grid extension by the commercial basis, even the balance sheet of EDL will be improved and transparent. Consequently, the rural electrification would be expected to promote by MIH/DOE with initiative instead of EDL.

Therefore, we would propose to construct both a grid connection and an off-grid system by small-hydro as well as to establish a management organization for a rural electrification being sustainable with economic and human resources mainly promoted by the self-help of GOL and partially by an effective found through international aid under consideration of the social and environment issues.

1.3 APPROACH FOR RURAL ELECTRIFICATION

Under the rapid progress of EDL unbundling, policy requires rural electrification to be developed with an enhanced sustainable operation and maintenance. In order to follow the policy, electrification by grid and off-grid should be developed under the following approaches:

No.	Items	Approach of Rural Electrification	Remarks
I	Rural Electrification focused on Sustainable Operation &Maintenance		
1	Task Demarcation	To train for basic capabilities to execute own required tasks.	To clarify task demarcation among central/local government, private companies and local peoples in order to effectively execute the rural electrification planning, its construction and operation & maintenance.
2	Tasks of Central Government	To pay attention to main tasks for rural electrification and to enhance planning ability.	To make proposals for rural electrification projects to be implemented independently by GOL, through capacity building for project finding, basic design & cost estimate of civil & electrical works for small-hydro.
3	Tasks of Local Government	To assist a project plan suggested by the central government and manage project execution.	To act as a "communication pipe" between local people and central government.

No.	Items	Approach of Rural Electrification	Remarks
4	Tasks of local peoples	To undertake training in the elementary technology, operation & maintenance, accounting system for tariff collection and saving of maintenance fees, as a responsibility of local people.	Understanding and cooperation of local people are required for sustainable O & M.
5	Project Economy	To check Lao legality and actual site conditions as well as project economy for study & suggestions for subsidy to provide for the primary cost for construction and O & M.	Generally, as grid power is costly by length of distribution line extension, it is not economical in the thinly populated regions and poor regions. On the other hand, the plant cost per kW of small-hydro is higher than that of a power station connected with grid.
6	Appropriate Purchase of Material & Equipment	Equipment supply from the neighboring countries at a low price can realize cost saving and sustainable operation in case of small-hydro under off-grid.	To study availability from local manufacturers in Thailand, China (Yun-nan), Viet-Nam, Myanmar and Indonesia.
7	Quantity of Power	To be acknowledged by local people that the power quality off-grid is lower than supply from the grid	As off-grid power has limitations on supply period and capacity, it can not satisfy demand requirements.
II	Issues of EDL Unbundling		
1	Application of Private Investment	The purpose of improvement of efficiency and transparency of power sales should be revealed by Power sector restructuring (privatization).	As the incentive for private investment for non-economical rural electrification is low, it is difficult to introduce it to private investment.
2	Transparency of Tariff System	Power sector restructuring aims to clarify the cost for power supply for end user by unbundling of tariff. Accordingly, it is recommended that cross subsidy be removed from the tariff system.	Rural electrification has been progressed conventionally under the national regulated tariff with a cross subsidy for the on-grid system. However, restructuring requires an abolition of the cross subsidy and a transparency of tariff system. On the other hand, it is recommended that the rural electrification with the off-grid system should proceed with the tariff at cost without subsidy during the initial stage
3	Investment	To establish a new financing scheme by PPP with enhancement of cooperation between the private sector (NGO, Cooperative and Community) and public sector for rural electrification promotion.	It is more difficult to find finance for rural electrification. It is necessary to apply a concession method to allow the inclusion of competition in the project by bidding and, at the same time, to introduce a subsidy supply system at approval of concession.
4	Organization	To execute capacity building for the government staff to promote rural electrification and to recommend power policy of rural electrification.	The main task for rural electrification promotion is to adjust its organization after achievement of successful power sector restructuring.

1.4 PURPOSE AND PROJECT BOUNDARY OF STUDY

The overall goal of the Study are improvement of the electrification rate, poverty alleviation, and economic growth targeting the northern eight (8) provinces; Phongsaly, Luangnamtha, Oudomxay, Bokeo, Luangphrabang, Huaphanh, Xayabury and Xiengkhuang in Northern Laos. Consequently, the purposes of the Study are; (i) promotion of electrification in unelectrified district centers, (ii) reduction of electricity import from neighboring countries, and (iii) achievement of the following study obligations by introduction of alternative power sources in areas depending on existing diesel generation:

While the rural electrification for the purpose of (i) above requires the international aids for development, the Government of Lao is requested independently to proceed the purposes of (ii) and (iii) above due to its his own national energy strategy. Consequently, the capacity buildings of a hydropower for the counterparts of DOE/PDIH are proposed to be executed during this master plan study.

- Preparation of master plan for off-grid small-hydro targeting the year 2020 based on the field reconnaissance results and implementation of Pre-FS,
- Policy suggestions and recommendations concerning the promotion of off-grid small hydropower schemes, and
- Execution of capacity building for the counterparts in small hydropower planning.

The work items to be conducted in the Study are as follows.

Study Objectives and Scope of Work

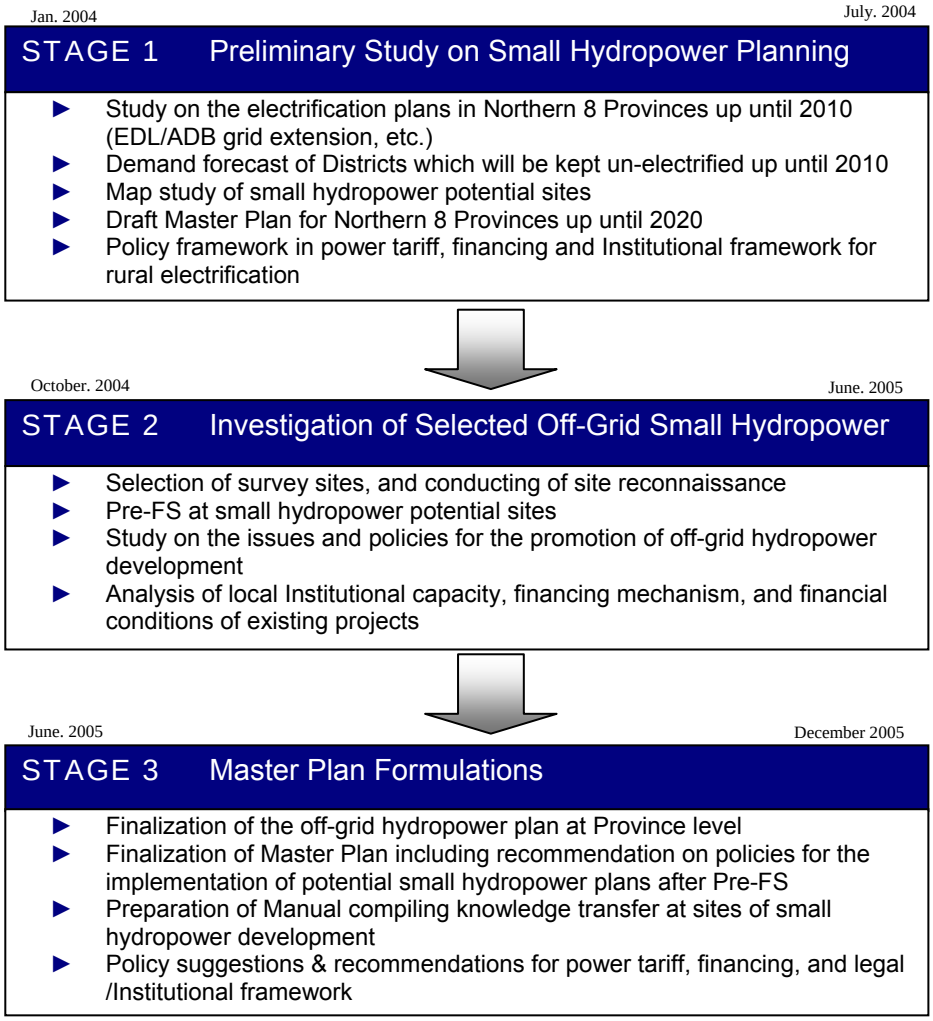
No.	Study Objectives	Scope of Work to achieve Objects
1	Master Plan of grid and off-grid small hydropower at province level	Confirming the issues and present situation of the off-grid electrification and the on-grid electrification plans by EDL and ADB
2		Planning of electrification scheme for the northern 8 provinces and districts by 2010
3		Selection of small hydropower plan candidate sites (18 sites out of about 24)
4		Carrying out Pre-FS (10 sites out of 18)
5		Master Plan formulation up to 2020
6	Policy suggestion and recommendation for the promotion of grid and off-grid small hydropower	Conforming of the financial plans and benefit assumption
7		Verifying the present issues and situation regarding electric power sector
8		Establishing policy measures for accelerating off-grid small hydropower projects
9		Financial potential study applying CDM
10		Application study on Public-Private Partnership (PPP) enterprise
11	Execution of capacity building for small hydropower plan development to DOE/ PDIH counterparts	Holding Workshops
12		Holding Coordination Meetings
13		Carrying out the Training Program
14		Preparing manuals for small hydropower plan
15		Formation of GIS System and transfer of technology
16		Methodology and Procedure of Clean Development Mechanics (CDM)

Note: DOE: Department of Electricity, **PDIH**: Provincial Department of Industry and Handicrfat, **EDL**: Eléctric du Laos, **ADB**: Asia Development Bank

This JICA Master Plan Study was originally aimed at executing off-grid rural electrification study by using small-hydro. However, as the Master Plan was established including rural electrification by grid extension, “Off-grid small hydropower“ is replaced by “Small-Hydro Rural Electrification”.

1.5 BACKGROUND AND ACTIVITIES OF STUDY

In July 2003, the Government of Lao PDR requested technical assistance of the master plan for small hydropower development less than 5 MW targeting northern eight (8) provinces. In reply, JICA dispatched the project formation study team in March 2003 and confirmed the detailed background of requirements for the Study. The team also discussed with both ADB and WB in Vientiane, agencies which have already studied the rural electrification in northern areas. In addition, when JICA dispatched the preliminary study team, the Lao side agreed to the S/W (Scope of Works) and signed the M/M (Minutes of Meeting) on September 18, 2003. The Study was carried out in accordance with the stages shown in the following flow chart:



Wording Definition in the Report

The technical terms shown in the table below are defined limited to this report only, because they are no terms acknowledged internationally and used commonly.

No.	Terms	Definition in this Report
1	Electrification Rate	This rate means a household electrification rate with a contract, especially as long as there is no proviso.
2	Grid	This indicates the national power grid system by EDL. EDL Grid.
3	Off-Grid	This indicates an isolated/individual small grid, not connected to EDL Grid. Basically it is electrified by 100kW-10MW generator(s). It has the possibility to be connected to EDL grid.
4	Mini-Grid	It is the same as "off-grid". However, it is specified as an off-grid covering one village only with 10kW-50kW capacity.
5	Small Power	It means a small hydropower and a small diesel plant with 100kW-10MW capacity to electrify several villages by off-grid.
6	Micro Power	It means a very small hydropower supply and a small diesel plant with 10kW-50kW capacity to electrify a village by off-grid. Namely, a village power.
7	Simple House Power Supply	This term refers to both SHS (20W-50W) and pico-hydro (100W-300W).
8	Small-Hydro Rural Electrification	It means the Rural Electrification with Grid, Off-Grid or Mini-Grid by means of the small hydropower with all kind of installed capacity.

2. POLICY RECOMMENDATION OF SMALL-HYDRO RURAL ELECTRIFICATION

2.1 BASIC STANCE OF POLICY RECOMMENDATION

For practical and sustainable small-hydro based rural electrification, it is important to understand the unique characteristics of small-hydro generation. The current policy should be altered by addressing the three such characteristics as follows;

(i) Public bodies ranging from MIH to EDL as well as local government lack implementation capacity, especially in the field of finance.

(ii) There are various kind of stakeholders such as the central government, local governments, an electric company, local residents, financial institutions, investors, equipment distributors, international aid organizations, NGO, and a private consultant, etc. Despite its high potentials for rural development, small-hydro projects inherently have high risks and low returns. In general the private sector would not be interested in small-hydro projects from pure business point of view.

(iii) There is lack of integrated policy for rural electrification in Lao PDR. The issues are addressed by loan financing by the World Bank or by ODA programs by the Japanese government on an ad hoc basis up to now.

Conventionally, small-hydro projects depend on a grant from donors from equipment to operation, but still often failing to maintain the operation in many cases. Despite its potential for rural development, neither the private sector nor public sector in Laos is too cash-strapped to finance small-hydro projects single-handedly which one can expect low return on investment for. Nation-wide propagation of small-hydro generation is far from reality if the government pursues a dichotomist approach of pure public or private business financing. With the leadership of the central government, combined approach of public-private partnership and community participation are the only ways to promote small-hydro projects in Laos.

On the grounds of social welfare and security, public support for the implementation of small-hydro projects is the core to the implementation. Nevertheless, it is important to garner managerial and financial resources from the private sector where the market mechanism functions. While it is important to provide incentives for the private sector participation in one hand, it is equally important to solicit community participation wherever there is lack of incentives for private participation to

avoid perpetual subsidization of the small-hydro project.

In particular, it is necessary to establish a system to obtain resources for O&M cost, such as a revolving fund during the initial period of planning and/or construction in order to secure commitment to a grant-based project by the donors. The system should address all the financial needs beforehand including the deficits during operation and the needs for replacement at the time of equipment retirement or damage.

For the sound operation of a rural electrification project, it is important to pay an equal attention to managerial aspects as well as technological aspects of planning, engineering and operation. Thus the capacity building of local governments and agencies is indispensable. Also it is important to involve NGOs and local communities to lead to a successful small-hydro project.

2.2 PRESENT CONDITIONS AND ISSUES OF RURAL ELECTRIFICATION POWER SECTOR

2.2.1 GENERAL

The domestic power is supplied by the national transmission line and the off-grid power supply in Lao PDR. The domestic power consists of the following power sources:

(i) National grid power supply from the power plants owned/operated by EDL (Small diesel generator and Small-hydro),

(ii) National grid power supply from the export IPP plants (Large hydropower)

(iii) Small off-grid power supply imported from Thailand, Vietnam and China

(iv) Mini off-grid power supply from the power plants owned/operated by the provincial/district level and the private SPPs (Small diesel generator, Micro hydro and SHS)

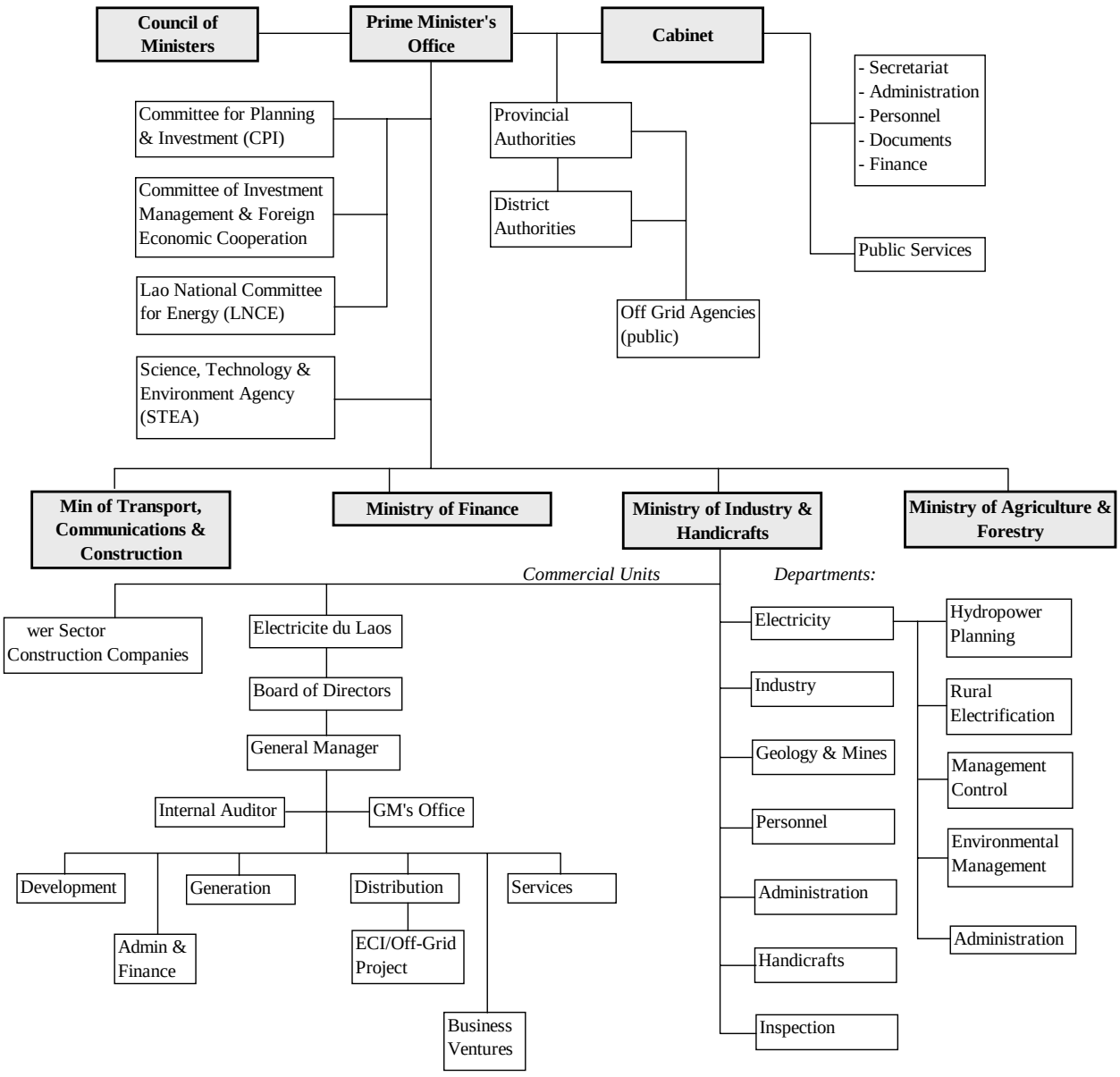
The national electrification rate stands at 34.7% on community basis and 42.9% on household basis in 2003. The map on the right shows the power source distributions in the Northern provinces in 2004 according to the Study Team surveys.

Present Electrification Status (2004)
Source: Prepared by JICA Study Team

2.2.2 ORGANIZATION OF RURAL ELECTRIFICATION SECTOR

(1) Lao Power Sector

The institutional makeup of the power sector in Lao PDR is shown below.



Under the electricity law, MIH has primary responsibility for policy formulation and strategic planning which is undertaken jointly with STEA, CPI and other agencies. MIH also has responsibility for preparing and implementing legislation and regulations and for overseeing the performance of electricity enterprises.

Department of Electricity (DOE) is one section of MIH. DOE's duties are mainly divided into (i) the Power System Planning Division responsible for generation, transmission planning and development, (ii) the Environmental Management Division for environmental issues on power system, (iii) the Rural

Electrification Division responsible for off-grid electrification and (iv) the Management & Control Division responsible for power standard and electrification data.

The Power System Planning Division has primary responsibility for strategic power planning, project identification and evaluation of IPP project proposals. It provides technical support for projects of 5 MW or less.

The Rural Electrification Division coordinates and implements projects generally not intended for connection to the main grids. It does this in accordance with jurisdiction of the Provincial and District Offices (PDIHs).

MIH has no direct responsibility for operating and maintaining the state-owned power plants. For projects connected to the main grid, this is borne by EDL. For the off-grid projects, they are the responsibility of provincial, district, prefectural, or special zone administrative authorities, as applicable, or of a concessionaire who is awarded a concession.

EDL develops, owns and operates the country's main generation, transmission and distribution assets, and manages electricity imports to its grids and exports from its stations. It is a state-owned corporation reporting through its own board of directors. Under GOL policy to date, EDL is the implementing agency for Government power projects.

GOL established the Lao Holding State Enterprise (LHSE) as a state-owned company in January 2005. It is the agency nominated by GOL as its shareholder where GOL participates in the ownership of export IPP projects.

All foreign investment in Lao PDR is channeled through and coordinated by the Committee for Planning and Investment (CPI) within the Prime Minister's Office. CPI provides a "one-stop shop" service for developers seeking a mandate to build power projects for both export and domestic in the country.

(2) Off-grid Agency

Private sector operations based on the Electricity Service Company (ESCO) approach is becoming an established model for delivering off-grid power through pilot programs set up under the MIH Off-Grid Rural Electrification Promotion and Support Program. These ESCOs are generally individual entrepreneurs or small businesses who have been trained in the promotion, support and maintenance of solar PV systems, village hydro and village diesel generator technologies. The majority of their business is in subsidized solar PV systems. The ESCO coverage under the MIH pilot program is limited to six provinces (Vientiane, Oudonxai, Luangnamtha, Champassak, Luang Prabang, Xieng Khouang and Sayaburi), and this provides the foundation for evaluating, adapting and sealing up the ESCO model.

Although the ESCO model is designed to fill an important gap in the power sector investment program,

an expansion of ESCO involvement in managing power supplies could be considered in situations where grid supplies are extended into remote villages. Moreover, the potential of such a model for mobilizing private capital was evaluated as part of the "Rural Electrification Frameworks Study".

2.2.3 LEGAL, INSTITUTIONAL REGULATORY ISSUES OF RURAL ELECTRIFICATION

(1) Foreign Investment Law

The Law on the Promotion and Management of Foreign Investment in Lao PDR (1994) came into force on 20 June 1994. The salient provisions of the Law are:

(i) Property and investments of foreign investors are protected by the laws of Lao PDR and cannot be requisitioned, confiscated or nationalized except for a public purpose and upon prompt and adequate compensation.

(ii) Foreign investors can invest either as a joint venture with local partners or as a wholly foreign-owned enterprise. Foreign ownership within a joint venture must be a minimum of 30%. Wholly owned enterprises may be either a new company or a branch office of a foreign company.

(iii) Foreign investors may lease land and transfer leasehold interests. They may own and transfer land improvements and other moveable property.

(iv) Foreign investors will give priority to Lao citizens in recruiting employees but will have the right to employ skilled foreign personnel when necessary.

(v) Foreign investors may repatriate earnings through a Lao bank or a foreign bank established in Lao PDR.

(vi) Disputes will be by arbitrated either through the economic arbitration authority of Lao PDR or through other international organizations agreed to by the parties.

Under consideration are further refinements of the law to take account of the rights of lenders in the event of default, foreign jurisdiction over offshore assets, assignment of debt, rights in respect of land and fixed assets, and the use of escrow accounts.

(2) Electricity Law

The Electricity Law became effective on August 29, 1997. It is understood that the regulations needed to give effect to the legislation are not yet complete and that a review of the legislation and the regulatory framework is proposed.

The application of the Law to generation projects depends on which of the four categories the projects belong to (Article 9):

(i) less then 100 kW: Approved by provincial, prefectural or special zone authorities

(ii) between 100 kW and 2,000 kW: Proposed by provincial, prefectural or special zone authorities and approved by MIH

(iii) between 2,000 kW and 50,000 kW: Approved by GOL

(iv) greater than 50,000 kW: Proposed by GOL to National Assembly for approval

With respect to concessions for electricity activities, it is stipulated that investment is by the state solely or with foreign parties. Co-operative investments are allowed. Modalities may be:

- Build, operate, own and transfer (BOOT),
- Build, operate, transfer (BOT),
- Build, transfer, and finance (BTF),
- Operation by the State Electricity Company, and
- Others.

Article 3 of the Electricity Law states "physical resources of electricity throughout the Lao PDR are the property of the national community and the State administers, preserves and conservatively uses such on a long term and productive basis."

Article 11 requires concessions to be sought by promoters of electricity enterprises, and requires the Government to "participate in the shareholding when there is a concession for an electricity enterprise". Neither minimum shareholding nor the type of share is prescribed. Article 11 also foreshadows the introduction of a licensing system for awarding and managing power concessions.

Article 12 deals with GOL equity in projects. The two English translations studied2 conflicted on this point. Advice was taken from an interpretation of the Lao language version and it is accepted that there must be GOL participation in equity but no limits are set and a nominal holding would satisfy the requirement.

The agency charged with administering the licensing procedures is MIH (Article 12). Features of the licensing system include:

(i) Conditions for approval of the license are (Article 15)

(ii) Sponsors should have access to finance and expertise in power projects

(iii) Sponsors should be of good repute and have a sound commercial background

(iv) Projects should provide demonstrable benefits to the economy and society

(v) Projects should be consistent with national planning

(vi) Projects should not adversely impact the environment

Term of a license is no more than 30 years from the date it was issued (Article 16). This would allow

a 25 year operating concession if the sponsor can finance and build its plant within five years. The license can be extended for up to 10 years subject to GOL approval. Article 16 provides that at the end of the period "the concessionaire must transfer the entire enterprise back to the Government in a good and operational condition without any compensation whatsoever".

Procedures and preconditions for awarding licenses are outlined in Articles 12-15. In broad terms the sponsor is required to submit economic and technical studies (Article 13): and social and environmental studies and action plans (Article 14).

The obligations of the licensee are specified in Article 18. These are expressed only in general terms (e.g. "to protect the environment"). Among them is the requirement to "pay taxes and charges in due time in full amount in accordance with the laws". For marginal projects to achieve debt service criteria of lenders, it is often necessary to relax the taxes levied on a project during the debt repayment years.

The introduction of the licensing system to replace the practice of negotiating widely varying concession agreements is an important step forward in introducing greater control over the IPP project implementation process. Injecting competition and transparency into the process of awarding licenses would further improve GOL control and increase its share of project benefits.

The Electricity Law also maps out the legal environment for transmission development. Article 29 of the Electricity Law contemplates the existence of the National Grid and requires all "electricity production plants" to interconnect with it. State ownership of the National Grid is implied but private sector capital could still be tapped through the use of Build-Transfer-Lease (BTL) or similar models that would leave ownership of assets in the hands of GOL.

Article 28 allows access of all generators to privately-owned transmission lines.

Under Article 37, regional transfers of electricity involving transmission through Lao PDR must also use the National Grid unless the grid has not been developed to facilitate such transfers, in which case private investment in transmission is permitted.

Articles 42-46 set out institutional responsibilities within the power sector. The legislation is silent on the roles of Government agencies such as CPI and LNCE.

(3) Water and Water Resources Law

The Water and Water Resources Law was adopted by the National Assembly on October 11, 1996 and became effective on March 3, 1997.

In the context of hydropower development, the Water and Water Resources Law seeks to ensure responsible and sustainable use of water. Water use is divided into small, medium and large scale (Article 14), and the legislation defines rights, obligations and procedures appropriate for each

category.

Mini-and micro-hydropower projects fall within the "medium" category provided that their structures do not seriously disrupt watercourses (Articles 16 and 27). Run-of-river projects involving no inter-basin diversion of water could be classified as medium scale use. Other hydro would be classified as 'large" (Article 17). Such projects must observe approval and implementation requirements specified elsewhere in the Law, including:

(i) The sponsor of the project shall submit a feasibility study, an EIA and action plans defining mitigations (Article 18);

(ii) The sponsor of the project shall obtain GOL approval (Article 19). The form of GOL approval is the License as defined in the Electricity Law;

(iii) Projects must be consistent with the "Socio-Economic and Environmental Development Plan, master plans and development plans from time to time" (Article 21);

(iv) Project sponsors are obliged to contribute to the cost of watershed management and protection (Article 24);

(v) Hydropower projects must be planned and built in a manner that protects the environment and the water resource and provides, where appropriate, for multipurpose use including flood mitigation, water supply, irrigation, water transportation and aquaculture (Article 25);

(vi) Project sponsors must assist in and must fund the effective resettlement of people displaced by the project.

(vii) Under Article 31, logging in catchments is "absolutely prohibited for any individual, juristic entity or organization".

(4) Environmental Protection Law

The Environmental Protection Law was passed into law in April 1999.

EIA procedures and responsibilities are defined in Article 8. STEA issues regulations setting out procedures and actions and the responsible line ministries, MIH in the case of hydropower, issue guidelines or regulations for EIA mechanisms based on the Environmental Protection Law. EIA regulations for hydropower projects are developed and implemented by MIH.

Hydropower projects are required to submit an EIA. This provision applies retrospectively with existing projects also obliged to submit an EIA to the relevant agency for issuance of an environment compliance certificate. Such projects must propose mitigation measures for impacts caused.

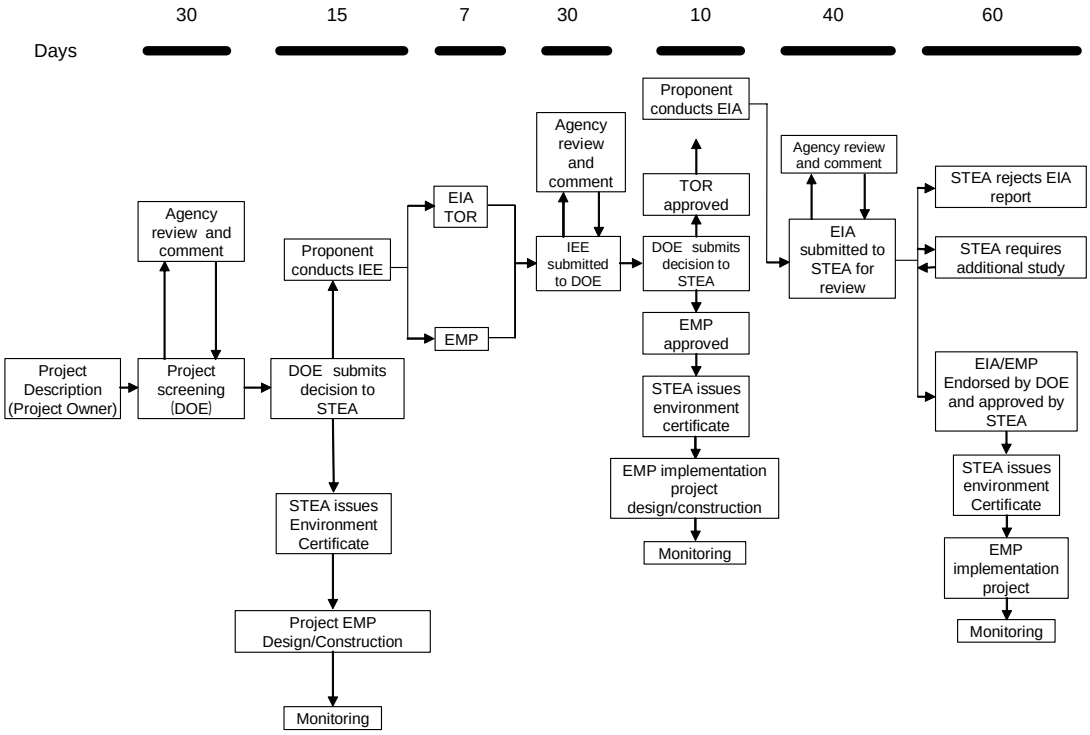
Article 15 addresses the issue of biodiversity. STEA is responsible for introducing legislation to establish biodiversity management measures.

Disaster protection and prevention is given prominence in the draft legislation (Article 19).

Depending on the final form of the Law, owners of dams and managers of reservoirs may have obligations to maintain safe structures and cooperate with the National Disaster Prevention Committee in planning and executing responses to disasters

Mitigation and restoration of the environment are the subjects of Articles 24-28. Environmental management and monitoring processes and responsibilities are described in Articles 35-41. The provisions lack detail and it is difficult to form a view about their effectiveness and application in the context of hydropower projects.

An Environment Protection Fund will be set up pursuant to Article 30 and under Article 31 "development projects" are nominated as a source of funds. Hydropower projects fall within the ambit of "development projects".



EIA Flowchart under Lao Legislation

2.2.4 CURRENT SITUATION OF RURAL ELECTRIFICATION

(1) PTD and NARPD by EDL/ADB

The Power Transmission and Distribution Project (PTD1), the Northern Area Rural Power Distribution: NARPD Phase 1 (PTD2) and NARPD Phase 2 (PTD3) financed by EDL/ADB are summarized as follows:

No.	Name	Constr. Period	Project Description
1	PTD1	2000-2003	Content: 115kV(325km), 22kV(70km) Target: 32,502HH(Vientiane, Xayabury, Xiengkuang) Budget: US$58 mil (ADB30, EDL18, Finland 6, France 4)
2	PTD2	2004-2007	Conten: 115kV(303km), 22kV(796km) Target: 33,800HH(Oudomxay, Luangnamtha, Xayabury, Xiengkuang) Budget: US$51 mil (ADB30, EDL11, NDF10)
3	PTD3	2007-2009	Content: 115kV(-), 22kV(-) Target: Unsettled (Phongsaly, Bokeo, Luangphrabang, Oudomxay, Luangnamtha, Xayabury, Xiengkuang) Budget: Unsettled

(2) Southern Province Rural Electrification Project (SPRE) by EDL/WB

SPRE consists of expansion project of transmission line in South under EDL and of SHS distribution project under MIH/DOE in whole country.

No.	Name	Constr. Period	Project Description
1	SPRE1	1997-2004	Contents: 115kV(53km), 22kV(1,200km), Off-Grid:5,300HH/700HH(2005) Target: 51,770HH(T/L at 7 southern provinces) Budget:US$36 mil (WB33、EDL3)
2	SPRE2 (Phase 1)	2005-2007	Contents: 115kV(?km), 22kV(?km), Off-Grid:10,000HH(National wide) Target: 93,000HH(T/L at 7 southern provinces) Budget: ?
3	SPRE2 (Phase 2)	2008-2010	Contents: SPP small-hydro pilot scheme (100kW～2MW) Target: 2 projects Budget: US$100,000~150,000/project

(3) Technical Assistance on Rural Electrification by WB

World Bank is proceeding efficiently the rural electrification projects of transmission line at South and off-grid both at South and North as well as technical assistance shown below:.

No.	Report Issue	Project Name of T/A	Project Description
1	Mar. 2004	Power System Development Plan	Long-term electrification plan targeting to set up 90% rate at 2020.
2	Sept. 2004	Power Sector Financing Strategy Study	Develop financing and procurement strategies for domestic generation expansion, export project, national & regional transmission development and grid extension.
3	Nov. 2004	Rural Electrification Framework Study	Pre-Study as framework on Off-Grid Rural Electrification Master Plan Study to be started at the end of 2005 for 2.5 years.
4	Jan. 2006 (Scheduled)	Off-Grid Rural Electrification Master Plan Study	Master plan to expedite electrification in rural area at national level mainly equipped with micro-power and SHS. Including GIS database and some green field hydro projects with 2MW～100kW to be developed by PDIH.

(4) Current Rural Small Hydro Electrification Model

Financially speaking rural power distribution is a money losing business except for some sales of stand-alone generation equipment such as PV or diesel engine generators. In consideration of poverty alleviation impacts, the tariff needs to be suppressed to a degree and thus the likelihood of financial balance further diminishes.

It is reported that 18 out of 39 small-hydro schemes implemented in the past are now out of operation.

Some of them were damaged severely by a flood and some of them are out of operation due to mismanagement.

According to the Maunsell Report on Rural Electrification Framework Study, as much as 5% of the rural electrification owes to individual purchase of pico-hydro system or diesel generator set or solar system while the official figure of rural electrification remains at about 40%. In other words more than 10% of electrification owes to individual initiatives. The Study Team's field observation reinforces this view. In some villages 30 out of 100 households were electrified by pico-hydro systems. For a country at the electrification level less than 40% nation-wide, this figure is quite large. In other words as much as 10% of households have electrified their own home on their own effort.

The electrification models in Laos are classified into the following three categories.

(i) Conventional Government-Owned Model by EDL

The government-owned electricity utility (EDL) has extended its grid to the rural area, and/or operates isolated grids with his own generation units. EDL has reasonable capability for management, operation and maintenance of small hydro. However, past experience has been that EDL is reluctant to engage in electrification of remote regions. Because, the national uniform tariff is not enough to compensate both the capital cost and the O&M cost. The Nam Ngai HPP in Phongsaly Province with installed capacity of 1.5MW is cited as one of the conventional government-owned models.

(ii) Conventional Government-Owned Model by PDIH

Local government agency (PDIH, such as provincial office of MIH or a district authority) owns and operates isolated grid systems and its generating plants. In Laos, most of isolated systems operated through the model are powered by a diesel power plant. O&M of the diesel unit is relatively easy. Capability for accounting and revenue collection is generally satisfactory. However, since knowledge and technique for O&M is not sufficient, external support is required. In most of case revenue is not enough to compensate both capital cost and O&M expense, operating loss is compensated from recurrent cost of local government. Many of these systems are inoperative, requiring refurbishment or repair.

(iii) Commercial Sales Model

In this model, both generation unit and storage system are sold to individual household by private venders. In Laos, several venders are a sold diesel generator, an automotive battery, and a pico-hydro without Government support. Solar house system (SHS) without subsidy is pretty expensive for rural residents. There is a wide spread use of pico-hydro in Lao PDR.

2.3 POLICY AND INSTITUTIONAL RELATED TO SMALL-HYDRO RURAL ELECTRIFICATION

2.3.1 CHARACTERISTICS OF SMALL-HYDRO SYSTEMS

Laos traditionally owes a large portion of its export to the sales of electricity. Laos is also known for its large untapped hydropower potentials. Therefore, hydropower generation offers great economic development potential in Laos. However, the circumstances surrounding the development of hydropower development, of particularly large scale in the past decade or so have been unfavorable. On the other; hand small-hydro projects have the advantages as follows;

(i) No need to have a reservoir thus little negative impacts on environment with a good possibility for CDM application;

(ii) Possibility to supply power to remote off-grid areas, thus having high potential for poverty alleviation.

Small-hydro projects usually have a run-of-river type of design, thus have less negative environmental impacts such as watershed modification, hydrological regime changes, reductions in river flow, methane production in the reservoir as seen in a large scale reservoir type of hydropower. In addition, small-hydro could replace the power generation by fossil fuel combustion power generation, thus an application of CDM is a possibility.

The areas that are select for a small-hydro project is often located in a remote area even without road access. Grid extension to these areas or diesel power generation poses great difficulties technically and economically. Therefore small-hydro project offers a great potential for providing economic access to energy in these areas. SHS does offer lighting in off-grid but is not practically capable of providing motive or heating power.

Rural electrification is closely related to poverty alleviation since large portion of the poor in the country are concentrated in the off grid rural areas. The people in the remote rural areas are deprived of their access to public and private facilities for sound socio-economic development. Solar systems that are currently promoted by DOE present the most efficient means of electrification in rural areas of Laos. However, solar system is limited in inducing economic development through electrification since the application of uses is limited compared to full grid or off grid small-hydro systems.

Even though the power tariff in Laos is far below the opportunity cost, the current uptake of the rural households in a grid-connected village is some 70% on the average and some 50% for PV system. This is because the initial connection fee is beyond the saving capacity of the rural poor, but at the same time because the poverty level in terms of cash income in rural area is that serious.

The majority of donors concur in the importance of electrification in rural areas for poverty alleviation. However, when an economic efficiency measurement such as IRR is applied to a specific project, the

majority of projects, especially small-hydro power projects fail to meet the economic efficiency criteria. Small-hydro project only is only economically justified when a least cost method is applied in such case the alternative is either grid extension or diesel power generation in the particular locality. The poverty stricken areas are poor for a reason. These areas are usually located in remote isolated areas where transport cost is highly inhibitive. Thus the financing these projects through loan scheme becomes difficult.

2.3.2 ISSUES IN SMALL-HYDRO BUSINESS

There are three issues that small-hydro projects need to overcome for realization in Lao PDR as follows;

- Constraints in Financing and Economic Viability
- Business Risks
- Lack in Institutional Capacity

(1) Constraints in Financing and Economic Viability

Having a large amount of external debt, Laos is under close scrutiny of IMF for borrowing. EDL also has a very limited borrowing capacity due to its financial difficulties.

After the Asian Currency Crisis, the EDL's debt mushroomed while the tariff level from its domestic customers did not increase to offset the decline its repayment capacity. The balance sheet of EDL deteriorated quickly and under the guidance of IFI's the Lao government had to provide a rescue such as conversion of the debt to the equity. Although the financial standing of the EDL has improved since then, the borrowing capacity of the EDL is still limited. Thus this limitation presents a major obstacle to rural electrification in Laos.

Our economic analyses suggest that economically feasible small-hydro development for dispersed rural populations is limited to a class of power generation schemes over 1 MW with grid connection. A larger than 1.0MW class has a good chance of achieving less than US$ 2,000/kW and also connecting to the grid to boost the voltage at the periphery. A small-hydro class between 50 -100 kW is typically suitable to electrify a cluster of villages of around 500 households, the investment cost tends to be relatively high. However, the middle range of small-hydro power between 100 kW to 1 MW is even less cost effective as it requires an extensive distribution network and operation presents a major problem.

Compared to solar or grid extension, the investment cost for small-hydro (more than 100kW) is quite high, nearly US$ 10,000/kW for the target district centers. However, a small-hydro system could provide the full benefits of electrification commensurate with a full grid extension. For the poor remote region, the benefits for the electrification of its district center goes beyond the number of households at the district center. Since the district center serves as commercial and political hub for

the district, electrification will enhance the productivities for the whole spectrum of communication, trade, manufacturing, services and local administration for the entire population of the district. However, the investment cost for a small-hydro project comprises 90% of its total life-cycle cost. In other words, it is a project that requires a long duration for investment recovery.

Settlement patterns in Laos are unique. The population density is 21 persons per hectare, only one tenth that of Vietnam. Moreover, communities of about 100 households are spread throughout low lying hill areas homogeneously. Aside from a population of 600 thousand in Vientiane, there is no large agglomeration of population in the country. The district centers provide for basic social and economic needs in trades, public administration, education and public health. The electrification of the district centers directly leads to an increase in productivity in the service area as a whole covered by the center.

The current district center electrification comprises of a small portion numerical goal of achieving 90% in rural electrification by the year 2020 for the country. However, the electrification of district centers is urgent economic development goal in order to gain more equitable regional development and poverty alleviation in northern region of Laos where the higher percentage of the poor resides.

(2) Project Risks

The risks involved with small-hydro projects are threefold, (i) cost, (ii) hydrology, and (iii) accidents. A risk that accompany any construction project is cost-overrun. Since a small-hydro project does not have much of underground structure or foundation requirement, the possibility of cost overrun is relatively small. A hydrological risk associated with any hydropower project includes (i) flooding during construction, (ii) inaccuracy in the estimated average discharge volume due to miscalculation or long-term climatic variation, and (iii) a short-term drop caused by draughts.

Damages associated during the operation are attributed either to natural or to artificial causes. The former cause includes physical damages caused by natural forces such as floods and lightening. It is possible to avoid the damage partially by incorporating the advent of events into the design such as the location of facilities above the expected flood level. However, when the disaster beyond the planned limit takes place, the damage is inevitable. Artificial accidents may occur when there is negligence in the maintenance of sedimentation ponds or in take channels. The damages usually lead to the loss of revenue, thus the business as a whole in some cases.

As described above, there are many risks that are associated with the business of small-hydro generation. Without considering country risk typically associated with developing countries, there is very little incentive for the private sector to invest in most small-hydro projects.

(3) Lack in Institutional Capacity

In terms of an institution for off-grid electrification promotion, World Bank's SPREII initiated the

promotion of SHS as part of the program. The institutional setup is well in motion for widespread propagation of the systems. In the program, the government assumes the responsibilities of financing and procurement of the required equipment and wholesale them to the private sector for marketing and installation. The program has all the components typical to a PPP scheme such as community participation, marketing, and revolving fund mechanism etc. There is a substantial experience and know-how accumulated in terms of organization, cost recovery, and subsidization. Nevertheless, the government agency in charge will have to increase its level of commitment and organizational skills in order to undertake PPP's for small-hydro projects in addition to more traditional requirement in technological issues.

Currently there are around thirty (30) numbers of engineers and planner within MIH/DOE who oversees the coordination of numerous donor projects to IPP projects. Yet their capacity in terms of financing, organization, and engineering is still limited in developing a comprehensive plan for a hydropower project. The development of local capacity which was an integral part of the Study is an important task to realize a vast hydropower potential that exists in Lao PDR.

As the off-grid system consists of many small scaled isolated generating systems, it is impossible for the central government to make planning, operation and maintenance of all projects because of geophysical and financial difficulties. In addition, as a hydropower requires general skills and knowledge of civil, mechanical and electrical technology, active participation of MIH/DOE/EDL together with the technical assistance of foreign consultants is indispensable for a construction and an operation of hydropower.

It is necessary to enhance the technical skills of PDIH for promotion of a small-hydro rural electrification. Consequently, the purpose of training/capacity building, which consists of main parts of the Study, is to enhance capability of local government starting at the planning stage, and to operate and maintain by local staff finally.

The current capacity building program for PDIH by the Study Team is an effort that should look beyond the immediate study goals of electrifying five district centers in the northern region. One of the bottlenecks in the widespread realization of small-hydro schemes is the lack of local planning capacities. There is a huge need for the technological expertise in the field of off-grid power systems at local levels.

A large untapped hydro potential in the country and nearly 1 million households to electrify, a logical solution is to utilize locally available resource to the extent possible. However, there is no comprehensive survey of hydro power potentials of less 1 MW, to say the least of ones with a capacity below 100 kW. There would be literally hundreds or promising sites but utilizing external experts for small scale projects itself defeats the economic viability of the projects since every hydro power project requires a location specific design.

2.3.3 POLICY OPTION OF SMALL-HYDRO RURAL ELECTRIFICATION: IMPROVEMENT OF ECONOMIC EFFICIENCY

There are policy options to improve economic efficiency of off grid power systems which include;

(i) Revision of Tariff Structure, and

(ii) Revision of Institutional Framework

Since the second part is discussed in Chapter 2.4 extensively, main focus here is the issue of tariff structure.

In the past isolated grid systems charged a different tariff, usually higher than EDL tariff to the consumers. The promotion of independent private participation could lead to local monopoly with high tariffs. However, the larger concern is a possibility of little interest by the private sector in rural electrification, especially in the case of small-hydro systems which requires an integrated skills and technologies to operate and there is a large risks and uncertainty associated. Without the public cause to provide the benefits of power to the local people, there will be no interest in undertaking a small-hydro power business. Thus what is required for the government is to remove the risks and uncertainties in addition to eliminating the obligations to recover the full upfront investment costs for the construction of the small-hydro. Only then it would become possible for any entity to take part in the operation of the small-hydro power business. As suggested in Chapter 2.5.1, the financial and tariff analysis show that possible tariff scheme is to cover only the cost for operation and maintenance.

2.3.4 FINANCE SOURCE FOR RURAL ELECTRIFICATION

(1) Capital Expenditure in Budget of the Government of Laos

The budget expenditure of the government of Laos consists of current expenditure for mainly administrative expenses including wages for public servants, and for capital expenditure to develop social infrastructures and other public development works. The current expenditure, accounting for 43.7% of total expenditure is finalized by Ministry of Finance, considering budgetary requests from the provincial governments.

Regarding the capital expenditure, the budgetary requests made by provincial governments are assessed by Committee for Planning and Investment (CPI) placed in Ministry of Finance and then are officially included in the Public Investment Program (PIP). In case of the least developed countries, social infrastructure is less developed in general. Therefore the capital expenditure tends to become a huge amount. In Laos, the capital expenditure amounted to US$165.3 million in 2002, which accounted for 56.3% of the entire budget.

Overall budgets in Laos have shown continuous heavy deficits in the past as indicated in the table below. In 2001, the deficit reached US$120 million while the revenue was US$ 211 million and the

expenditure was US$331 million. With a large external debt and strict scrutiny by IMF, the government of Laos faces difficulty in spending its fiscal expenditure on rural electrification.

Government Budget of Laos **(Unit: US$ Million)**

Budget	1997	1998	1999	2000	2001	2002
Revenue	86.66	85.87	122.26	205.80	210.79	218.07
Tax	71.96	67.92	98.09	166.33	171.64	176.30
Non-tax	14.70	17.94	24.18	39.47	39.15	41.77
Expenditure	156.48	198.09	226.19	335.19	330.96	293.63
Current	72.97	62.60	59.12	127.78	129.54	128.35
Capital	83.51	135.48	167.06	207.40	201.41	165.29
Overall Balance	-69.82	-112.22	-103.92	-129.39	-120.17	-75.56

Source: ADB, Key Indicators of Developing Asian and Pacific Countries
Exchange Rate Used: annual average exchange rate quoted from the IMF International Financial Statistics

(2) Budget Support from International Donors

The government of Laos has heavily depended on the official assistance from international organizations which covers over 80 % of whole budget deficit. The international donors for Laos are WB, ADB, IMF, UNDP, WFP, also the governments of Japan, Sweden, Germany, France, and Australia, and international NGOs. The amount of such assistance has been 15% to 18% of GDP of Laos, which has been important financial source for capital expenditures. Rural electrification is being implemented on a project base with the assistance from international organizations like WB and ADB.

ODA to Laos extended by donors is shown in the table below. ODA to Laos reached to the highest amount of US$ 329 million in 1997. However, after Asian Crisis, ODA has declined and then has hovered in the range between 245 million US$ and 295 million US$.

ODA Amount to Laos by Country **(Unit: US$ Million)**

Country/Year	1997	1998	1999	2000	2001	2002
Japan	78.60	85.57	132.54	114.87	75.47	90.09
EU	57.87	53.25	54.11	54.43	51.96	60.52
ADB	85.55	63.50	43.79	47.28	40.21	43.72
WB	40.90	23.68	18.52	16.73	26.86	27.20
Sweden	15.48	11.99	11.56	14.56	12.10	15.38
France	14.75	11.66	10.68	12.78	10.73	14.85
Germany	16.63	18.38	21.66	13.29	13.64	11.97
ODA Amount	329.10	276.24	295.47	281.79	245.17	278.25

Source: Organization of Economic Cooperation and Development, International Development Statistics Online Database

According to sectors, the assistance for social infrastructure has been decreased since the latter of 1990's, while the assistant for social sector such as for medical and health, education, sanitation, water, and governance have been increased. In terms of power sector, the budget for it has been allocated approximately US$ 16.3 million in average between 1997 and 2003. According to the estimate by

WB, if the government intends to attain the 90% electrification ratio by 2020, it will need over US$421 million.

(3) Necessity of Introducing PPP Model for Rural Electrification

Under those tight fiscal condition mentioned above, it is indeed difficult to attain rural electrification only from the budget of the government of Laos including the ODA resource. Therefore, it is necessary to introduce private participation for it. In addition, it is also understood private participation can bring efficiency, particularly in the operation & maintenance of public facilities built under ODA.

However, it would be difficult for private sector to operate power business in the local area, where there is less power demand and low affordability to pay for electricity bill. To let private enterprise participate in rural power, it is expected for the government of Laos adopt PPP (Public-Private Partnership) scheme where government role and function are clearly determined regarding sharing investment fund, subsidy setting, deregulation, risk sharing, tax exemption and so on.

2.4 RECOMMENDATION FOR SMALL-HYDRO RURAL ELECTRIFICATION

2.4.1 OUTLINE

Although small-hydro project is environmentally friendly and if successfully implemented, it serves as catalyst to trigger rural economic development, a large initial cost required to build the structure and powerhouse at the outset makes it financially very difficult to attract private capital for the development or make the tariff acceptable to the people. Moreover, in the past the JICA provided some grants for small-hydro project through its grant scheme on a turn-key basis. Although the quality of the project achieved has been excellent in general, the cost of using Japanese firms from design to construction culminated in a high cost. Given the financial limitation for small-hydro development, a turn key approach due to time and cost factors restricted a wider propagation of small-hydro systems.

2.4.2 PROMOTION POLICY FOR SMALL-HYDRO RURAL ELECTRIFICATION

The way to solve the issue of a high initial cost lies in the way to reduce initial public investment or during the phase of operation. As shown in the conceptual scheme below, public funds should be utilized as seed money to increase the coverage of electrification by small-hydro systems. World-wide experience in hydro power sector points to two (2) potential solutions: (i) Public-Private Partnership and (ii) Community Participation (Public-Village Partnership).

The aim is to diversify the source of financing from sole reliance on public money to other sources including private firms and community participation in kind. By inducing the private sector and/or community participation in money, management, or in kind, the motivation is to increase the impact of limited public fund for small-hydro development.

Regardless of the size of the hydropower projects, it is crucial to remove the risks associated with the projects in order to promote the participation of the private sector. Small-hydro inherently possesses natural risks related to geology and hydrology in addition to the management risks. These risks are the largest deterrent to private sector participation. It is necessary to conduct thorough surveys and planning to reduce these risks. However, private firms cannot afford to invest too much at planning stage since an initial investment would worsen the investment return. Therefore it is mandatory to reinforce the public sector, namely MIH/PDIH in Laos

2.4.3 MANAGEMENT ISSUES IN SMALL-HYDRO RURAL ELECTRIFICATION PROJECTS

There are four steps to the improvement of financial viabilities of rural power supply businesses by small-hydro in Laos. Based on this stepwise planning, the public-private participants to a particular project need to come to an agreement on the ways to share the costs and risks related to the project.

- Power tariff,
- Subsidy,
- Business risks, and
- Integration of rural development and power supply.

(1) Electricity Tariff

In Laos, usually off-grid rural power supply schemes charge higher tariffs than those set by EDL. Although there is some possibility of local monopoly charging higher than normal price on the consumer, usually lack of financial incentive for the private sector participation is the problem in rural electrification.

As examined in Chapter 2.7.3 (1), the tariff should be set according to the affordability to pay and willingness to pay of the local residents. In view of poverty reduction, the tariff should be set so as to enable 80-90% of the residents afford the connection to power supply.

(2) Introduction of Subsidy

After setting the appropriate level of tariff, it is necessary to set the subsidy requirement based on the expected level of revenue based on the set tariff. Subsidy to the power supplier may be variable or fixed sum. Fixed sum based approach may avoid moral hazard in reporting and self-auditing.

(3) Reduction of Business Risks

Another big obstacle in inducing private sector participation is the existence of risks and uncertainties associated with the project. The biggest risk associated with hydropower projects regardless of size is the ones that stem from variation in discharge volume. If a PPP scheme is designed to have the private partner carry all the responsibilities for the risk, there may not be any interest from the private sector at all. A basic approach is to establish a clear-cut responsibility for MIH/DOE to develop the plan for a project and announce the planning parameters at the time of the tender. In this way, if the project fails to achieve the announced planning parameters such as discharge volume, it is the responsibility of the public sector. On the other hand, any deficits incurred by a shortfall in number of customers or revenue due to lack of marketing and management effort falls on the shoulders of the private sector. Clear indication of division of responsibilities is the key to a successful partnership.

What is necessary for the PPP is first to reduce the burden on the private sector in investment cost recovery and then to remove various risks associated with the project. After all these are accomplished, the private sector will be induced to take part in the project.

(4) Integration of rural development and power supply

Electrification is a necessary condition of village development but not a sufficient condition for its achievement. Electrification by itself does nod lead to direct improvements in rural productivity, thereby resulting in increase in income. Productivity improves only after the utilization of electricity to productive activities come into life as wells as lighting.

The power generation capacity is designed by the peak power demand of the service area, which appears at the dinner time usually in an independent rural mini grid. A load factor, i.e., an average utilization level of the capacity typically hovers about 20% in rural area. It is necessary to increase day time demand by inducing productive activities to increase the level of utilization. In other words, improvement of hydropower economy and economic development are the both sides of the same coin.

Accordingly, one of methodology for promotion of electrification is to integrate a small-hydro project with rural development project as shown below:

- Integrated project with an irrigation project, and
- Integrated project with rural road project.

2.5 SMALL-HYDRO RURAL ELECTRIFICATION SCHEME

2.5.1 POSSIBILITY OF APPLICATION OF PPP SCHEME TO SMALL-HYDRO BUSINESS

(1) Outline

In Laos, electricity business had been completely monopolized by public sector and financing relied 100% on public finance. To resolve crunch in financing hydropower development, the Government of Laos decided to introduce private finance to the sector in 1990. Since then, foreign-financed Independent Power Producers (IPPs) supported by ADB and World Bank started to participate in large-scale hydropower projects.

In the case of small-hydro development and management, it was often the case of the government owned and managed. The reason for this extreme case was not only because of social welfare standpoint but rather of lack of financial incentives for the private sector management. As a result, there were many instances of poorly managed projects. However, there are various degrees of private sector involvement In the case of small-scale full government ownership is likely to lead to lack of security on efficiency and rigor in management nor the accumulation of technologies. On the other hand full private ownership may not be lucrative either due to low purchasing powers of rural residents without government assistance.

(2) PPP Scheme in Small-hydro Project

The next table shows an overall classification of public private partnership for small-hydro projects.

Type of PPP Models in Laos

No.	Model	Application in Laos	Application in Laos
1	Management Contract Model	Transfer only limited risks and responsibilities to the private sector. The contract could cover billing and tariff collection, operation and maintenance of generator and/or part of distribution system. Owner ship of asset remained with public sector. The private sector is not involved in the investment, including capital expenditure, cost for modernization and rehabilitation, for the assets.	In Laos, EDL routinely contract out engineering and financial service of various types including billing and collections in remote area.
2	Lease Contract Model	Some or all of the operational activities in the Government owned facility or a part of it are leased to the private sector for an agreed period. More risk is transferred to the private sector than management contract model. In this model, the private sector has to pay a fee for the lease to the public sector, and usually needs to procure working capital and maintenance cost. Instead, the private sector has a right to send the invoices to their consumers and to collect electricity tariff. Public sector preserves the possession of the assets, and is responsible for financing capacity/net work expansion.	This model is not common in Laos.

No.	Model	Application in Laos	Application in Laos
3	Concession Model	Under this model, much of the development and operating risk is transferred to the private sector, and all or a majority of he financing required for the development is provided from private sector sources. Most common model is BOT (build, operate, and transfer). Under this model, a concession is given to the private sector to build new generation or distribution system and operate them for an agreed period. The private sector pays a concession fee. In return, the private sector has a right to collect money from their customers. Ownership reverts to the Government at the end of the concession period.	All of major power stations developed in the country recently have been carried out on this model (mainly BOT). Concession contracts also include Built Own Operate and Transfer (BOOT) and Rehabilitation Own and Transfer (ROT). In case of ROT, the private sector responsible for repair and refurbishment of existing unserviceable power station, then subsequently concession is given to the private sector for agreed period.
4	ESCO Model	ESCO (electricity service company) refers to private companies or individuals, who construct a small network, install generators and supply electricity to consumers. In Cambodia, a similar model is called REE (Rural Electricity Enterprise). Most of REEs employ diesel generators for power source.	There are 6 ESCOs in Laos as of the end of 2003. They contract with MIH and supply electricity for 4,691 households in 125 villages. While major power source of ESCO is SHS, which is not required to develop distribution system, some ESCO employ small hydro with installed capacity of about 75 kW and mini grid. These schemes are currently supported by DOE's OPS (Off-grid Promotion and Support Program) Program. While part of capital cost is subsidized by GEF (Global Environment Fund), recurrent cost for operation and maintenances covered by revenue form monthly electricity tariff. World Bank financed SPRE I project has demonstrated viability of ESCO model in Laos. However, there are only few applications for 100 kW-class hydropower project, and no application of MW-class hydropower project.
5	Village Organization/ Cooperative Model)	In this model, village organization (VO) or customers group (cooperative) raise 5 – 10% of the capital cost of establishing the system (through cash contributions, materials and/or labor), the remainder having to be funded by a capital grant from the Government or donor agencies. The model allows greater consumer participation in design and operation helps to improve sustainability. On the other hand, management and technical expertise are generally not adequate. However, since the complexity of operation and maintenance of community electrification grid is usually beyond the capability of community-based organization/ cooperative, frequent external support will be indispensable.	In Laos, community based approaches to development are becoming more common, mainly in the development of rural water supply and sanitation an in other activities supported by the Poverty Reduction Fund.

Source: Rural Electrification Frameworks Study, November 2004, Maunsell

According to the current the Law of Electricity in Laos, the extreme case of BOO is not legally possible. BOT is possible but this will further undermines the financial incentives while all the risks involved in construction and operation are shouldered by the private participant of the scheme.

In the cases of lease contract scheme and management contract scheme, the ownership of assets belongs to the government therefore the risks of construction properly are borne by the government while the risks of management are borne by the private sector participant. In the case of small-hydro

generation/distribution schemes, instead of monopolistic outcomes, the immediate concern is the financial sustainability of the operation. Without financial incentives, the private participation is no more than a fiction. The separation of asset ownership and management allows the clear distinction for the needs of subsidy. The combination of exclusive contract and subsidy could lead to inefficient management outcome not any different from the public ownership but given a possibility of contract termination, some improved efficiency can be anticipated.

The advantage of lease or management contract system is incentives created for the private sector by eliminating the large risks of cost-overrun and accidents at the time of construction and of disasters such as floods while retaining the opportunity to make a profit. For the central government, it is too costly to maintain the decentralized small systems in remote areas while the provincial government lacks in financial resources for the required maintenance.

An additional advantage lies in the ability to raise finance from various sources including grants and loans from various donors. While BOO or BOT system will foreclose possibilities of ODA soft loans and grants, the separation of ownership and management makes it possible for the entity to form a contract with a private partner for the operation of the systems.

In general community owned system has advantages in accountability, efficiency and flexibility in management while the government owned system has an advantage in potential large pool of resources. However, in the small hydro case of Laos, the government does not have resources in finance or expertise to respond to the needs for regular maintenance or repairs. Thus a community based system needs to be further explored as well as the private sector participation.

(3) Possible Application of PPP Scheme for Small-Hydro Projects

Out of the five models shown above, (3) concession model" would have applicability for the on-grid type small hydro projects, which have proven to have enough profitability (see the section 4.9). It is anticipated that generated electricity can be sold to EDL at the rate of US¢ 4.0-4.5/kWh. Excluding Nam Gnone, four (4) on-grid type projects (Nam Long, Nam Boung 2, Nam Sim, and Nam Ham 2) have unit generation costs within the range from US¢/2.20-3.53/kWh. It is would be possible for the private investor to gain a reasonable return on investment from these four projects, and thus said projects are considered to have potential to attract the private investors.

On the other hand, unit generation costs of the off-grid type projects well exceed US¢ 20.0/kWh (20.2-29.2). Accordingly, it must be difficult for these projects to attract the private investors without subsidy from the government and/or some kind of funding. Since the scale of operation is considerably smaller than the on-grid type projects, (4) ESCO Model" and (5) Village Organization (VO)/ Cooperative Model" would have applicability for the executing of the off-grid type projects. Since we can't expect technical capability and financial affordability for VO and Cooperative, application of VO/ Cooperative model will be limited only for quite small-hydro project, such as Nam Likna (30 kW) and Nam Chong (50 kW).

In the case of ”a. Management Contract Model” and “b. Lease Contract Model”, private investor is not responsible for capital investment, but responsible only for management, operation and maintenance for completed facilities. As mentioned, primal object of the application of PPP model in this study is to introduce private finance for capital investment for rural electrification project. Thus, these models are not applicable.

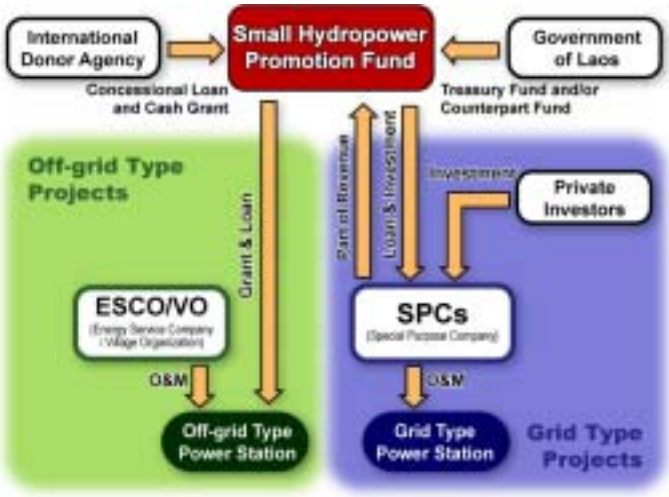
2.5.2 FUND FOR SMALL-HYDRO DEVELOPMENT

(1) Basic Concept of the Proposed Small-hydro Promotion Fund

Basic concept of the Fund is to make up for the loss of the off-grid type projects, which contribute for poverty reduction in remote area, with the profits generated by the-grid type projects. The Fund will be able to sustain profitability of on-grid type/off-grid type projects as a whole, and to assure sustainability of these projects (please refer to the figure below).

Envisaged income sources for the Fund are grant and concessional loan from the international donor agencies, treasury fund and counter fund of Laos Government, as well as revenue from other power projects.

Financial assistance would be made available for both the on-grid and off-grid type projects. Terms and condition of the assistance will be decided based on the profitability of each project.



Conceptual Diagram of the Fund

Revenue from the profitable projects would be collected by the Fund, and then part of it distributed to the non-profitable off-grid projects to compensate for the loss. The accumulated deposits in the Fund would also be utilized to provide for capital cost of some new projects.

The Fund would facilitate, not only financial assistance but also technical assistance for small-hydro projects. This assistance would be made for responsible organization of the projects. In the case of the on-grid type projects, a SPC (Special Purpose Company) is a likely candidate for managing the projects. On the other hand, the ESCO or village organization is regarded as a likely candidate for managing the off-grid type projects.

(2) Relation between the Proposed Fund and the World Bank’s REF

World Bank is currently establishing the Rural Electrification Fund (REF) to promote rural electrification in Laos, and has already provided about US$ one million of grant for the pilot project in

off-grid area. The Government of Laos has approved the fund officially in August 2005, and will go into full scale operation officially in the near future.

REF mainly aims to promote SHS (solar house system) to provide a lighting source for rural households. REF has provided about SHS for 4,000 households on the pilot projects so far. REF also plans to electrify rural villages by using other new and renewable energy sources. However, small-hydro station needs sizable investment than SHS. Given the limited REF's budget scale, it is difficult for REF to assist small-hydro project (e.g. capacity above 100 kW). According to the discussion with World Bank, they saw complementary relation between REF and the Fund for small-hydro, which would contribute for the common goal of promoting rural electrification.

(3) Envisaged Organization and Monetary Flow of the Fund

On-grid Type Project

Since some of the on-grid type projects show promising profitability, concession type contract (such as Build Operate and Transfer: BOT) is deemed suitable for these projects. Capital investment of these projects will be covered by concessional loan from international donor agencies, equity participation by private investors and government of Laos. Concessional loan from international donors would provide for the Fund, and then the Fund will on-lend to a Special Purpose Company (SPC) with some additional interest rate. A SPC will own and operate the project facilities during concession period (e.g. 25 - 30 years). During this concession period, a SPC will gain the revenue from sale of electricity to EDL. A SPC have to cover the expenditures such as operation and maintenance costs, interest and principal repayment of on-lending loan to the Fund, a concession fee to the Government, and dividends to investors.

Off-grid Type Project

Initial investment costs of the off-grid type projects would to be covered by cash grant/concessional loan from international donor agencies, treasury fund and/or counter fund from the Government of Laos. When a reserve in the Fund adequately accumulates, the Fund would provide capital grant subsidy for the initial investment of some new projects.

After the commissioning of the project, the Fund will own the project facilities. While the Fund will be responsible for operation and maintenance of the project facilities, actual works would be contracted out to ESCO and/or village organization.

Role of the Government of Laos

The Government of Laos is responsible for providing concession of power generating business to SPC's, and is expected to provide money for the Fund with using treasury fund or counter fund of non-project grant aid. The Government receives the dividend from SPC's for the on-grid type projects. The fund will be allocated to finance the investment of new off-grid type projects.

Role of the Small-hydro Promotion Fund

The Fund will receive part of profit from the on-grid type projects. Then the Fund utilizes such money to compensate for the loss from the operation of the off-grid type projects. When the reserve in the Fund adequately accumulates, the Fund is expected to provide a grant subsidy for the initial investment of new projects.

2.6 FINANCE PROCUREMENT USING CDM APPLICATION

2.6.1 BACKGROUND

One of main problems that hinder the implementation of hydropower project is financing the initial project cost and then operation and maintenance cost. Previous small-hydro projects supported by international organization only funded the initial construction cost. Then, most of the projects were spoilt due to the breakdown of equipment.

A small-hydro with least possibility without CDM application as an ODA project is deemed applicable for CDM since CDM only has added value. It is also expected that CDM applicability may facilitate Small Power Producer (SPP) who takes investment initiatives.

CDM is however an evolving scheme, it is necessary to take suitable process such as approval of CDM Executive Board, CER issuance and so on. On the other hand, the government of Japan is under pressure to reduce GHG emissions and/or acquire CERs in accordance with the effectuation of the Kyoto Protocol from February 16, 2005. It is possible to apply CDM to hydropower projects accordingly.

2.6.2 CDM APPLICATION IN ODA SCHEME

In the international understanding, ODA diversion for CDM project is not an appropriate or admitted action. To this matter, the government of Japan interprets that CER from ODA project can be purchased by independent funds set up apart from ODA funds. On the other hand, most of CDM projects funded by the private sector naturally are based on profit-seeking motivation, thus will look for investment opportunities with a large amount of GHG emission reduction and will not extend to small scale rural electrification projects. This study proposes a new project formation approach, utilizing the feature of small scale CDM on ODA project and also proved that ODA project with CDM contributes not only to GHG emission reduction but also to poverty reduction.

2.6.3 CDM APPLICATION ON SUSTAINABLE LOCAL PARTICIPATION

ODA project assists the development of social infrastructures with grants or low interest loans in order to accomplish poverty reduction and sustainable development. Some facilities provided with ODA fund does not have enough budget for operation and maintenance, often the facility are left unused. Success of an ODA project depends on sustainable operation by local community.

It is proposed that with CDM application on hydropower project, the CER will provide an incentive for improved sustainability in small-hydro projects.

2.6.4 CDM CASH FLOW AND CDM FINANCIAL ANALYSIS

(1) CDM Cash Flow

After commencement of the CDM project, CER will be issued in accordance with GHG emission reduction. There are two methods of financial arrangement using CER: one is up-front payment, another is payment on CER delivery.

Up-front payment is valued on the prospective CER's in the future. The upfront payment is possible from Japan Carbon Fund established in December 2004. With this fund, the project profitability is expected to improve and reduce investors' risk.

If a CDM project does not apply for the up-front payment, the project can get CDM income as a regular payment on CER delivery. In this case, financial analysis is carried out with the assumption that average CER will continue every year over the period of 21 years as CDM benefit.

(2) Financial Analysis

Financial analysis was undertaken for two (2) options using CDM credit; one involves the application of 50% advance payment for the expected CER delivery over 21 years, and the other is without advance payment. As a result of financial analysis, Nam Ham 2 hydropower project improve its FIRR from 0.94% to 1.92%, and its NPV from US$115,154 to US$200,400. The profitability of Nam Ou Neua hydropower project increases with CDM application, but that of Nam Likna decreases due to the transaction cost of applying for CDM certification.

Present CDM Situation of Lao PDR

Kyoto Protocol

Lao PDR ratified Kyoto Protocol on February 6, 2003 and is categorized non-Annex I country in the Protocol, which imposes on GHG emission reduction by 1st commitment period (2008-2012). Degree of ratification of Lao PDR is "Accession" which is the lowest commitment of Kyoto Protocol among four levels, such as "Ratification", "Acceptance", "Approval" and "Accession".

Designated National Authority (DNA)

Science Technology and Environment Agency (STEA) is in charge of CDM operation concerned under president's office in Lao PDR and is appointed as DNA. Concerns of GHG emission reduction has been started since "World Summit on Sustainable Development in Rio 1992". Lao GHG study project was established, then national GHG research committee was also established in STEA. The committee consists of representatives from relating ministry. Policy and program in terms of global warming is prepared based on the decision of the said committee.

GHG Mitigation Plan in Lao

Currently, detailed guideline of GHG mitigation in Lao is based on UNFCCC. The guideline is mentioned the following contents.

(i) Publicity activities on climate change

(ii) Implementation of GHG mitigation plan

(iii) Periodical measurement of weather data, such as temperature, rainfall, river flow and so on

(iv) Cooperation with international organization on climate change

Criteria for project selection on GHG mitigation is based on the cost performance, namely there is no effect on Lao economic.

CDM Application on Power Sector

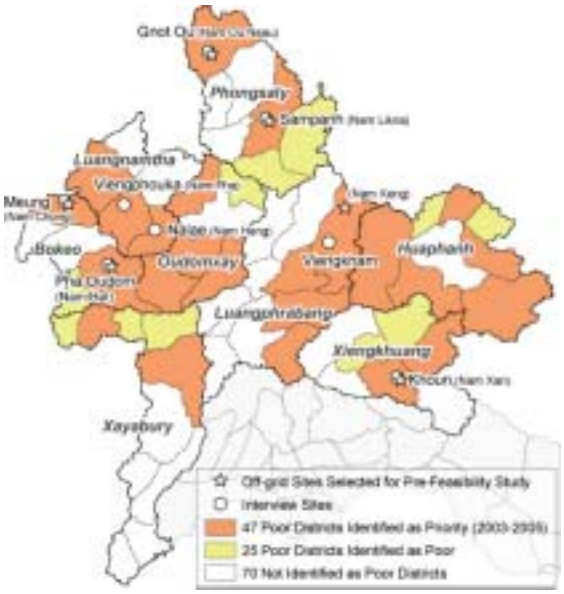
Ministry of Industry and Handicraft (MIH) is in charge of supervision of power sector, and EDL is in charge of implementation of power sector. Also Committee for Planning and Cooperation (CPC) is in charge of investment and promotion of foreign fund.

MIH, EDL and other ministries are welcome to CDM application because CDM bring the foreign investment, however CDM system is not completed yet. STEA also does not have enough understanding of CDM and human resource and budget to facilitate.

2.7 RECOMMENDATION FOR POVERTY REDUCTION THROUGH RURAL ELECTRIFICATION

2.7.1 POLICY TOWARDS POVERTY REDUCTION

The Government of Laos has placed great emphasis on poverty reduction, particularly in rural area and among ethnic minorities. The National Poverty Eradication Program (NPEP) was prepared in September 2003, and is central to the national development agenda. The NPEP identified 72 poor districts in the country, and out of these districts, 45 districts were selected for priority intervention during 2003- 2005.



Poor Districts in Northern 8 Provinces

The figure to the right illustrates the districts in the Northern 8 provinces designated as poverty areas. All of the off-grid sites and interviewed sites are falls into the priority intervention areas. Thus the six off-grid projects identified by this master plan are consistent with national development plan, and are expected to contribute to reducing poverty in the region.

2.7.2 LIVING STANDARD AND POVERTY IN TARGETED VILLAGES

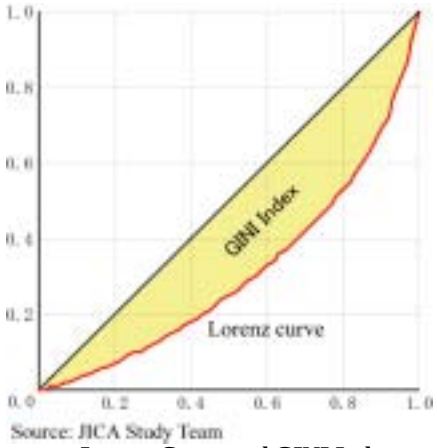
Under the socio-economic survey conducted, both household consumption and expenditure data were collected to verify living standard and situation of poverty of the targeted villages. Goods and services purchased make up household expenditure, while household consumption is defined as household expenditure plus the value of goods consumed from household's own production. The in-house consumption is largely made up from own produced rice and other crops, and meat/egg of house-owned domesticated livestock. Consumption is more indicative for the living standard of a household, and is utilized for judging poor and non-poor household in Laos (detail of consumption and expenditure in the targeted villages are mentioned in Chapter 4.6.3 and Supporting Data Files (Part-B), respectively).

The poverty threshold of Laos*1 in 2004 was estimated Kip 116,517 (US$11.23) per month per person, based on the poverty threshold in 1997/98 of Kip 20,417 and consumer price indexes in the subsequent years. When using the estimated poverty threshold, the poverty ratio (number of poor households ÷ number of households) in each district center can be used to provide a relative priority and has been calculated. The poverty ratios across the eight (8) sites are

[1] Poverty threshold in urban area (according to the National Statistics Center's definitions, surveyed district centers are classified as urban)

significantly diverse. The poverty ratio is lower at Sampanh (8.3%) and Viengkham (10.0%), and higher at Khoun (33.3%) and Nalae (38.3%).

In addition, Gini Index of each site was calculated based on consumption to measure degree of inequity. Gini Index is a standard economic measurement of income inequality. A society that scores 0.0 on the Gini scale has perfect equality. A score of 1.0 means that only one person earns all the income. The higher is the index, the worse is the inequality. As the figure shown right, Gini Index can be calculated as the ratio of the area between the 45 degree line depicting complete equality and a Lorenz curve to the entire area of the triangle below the 45 degree line.



Lorenz Curve and GINI Index

Compared to national average and other Asian countries*2, inequity in the surveyed 8 sites are lower (inequity between rich household and poor household is narrow). While the gap is narrow in the district center of Viengphouka (0.236) and Nalae (0.256), the gap is wider in Viengkham (0.383).

Poverty Ratio and Gini Index at the 8 Sites

	Sample Size	Consumption per Capita (Kip 1,000)*	No. of Poor Households	Poverty Ratio	Gini Index
Pha Oudom	60	1,157.9 ± 41.1	16	26.7%	0.305
Meung	60	1,113.7 ± 33.9	17	28.3%	0.348
Viengphouka	59	1,059.0 ± 18.0	9	15.3%	0.236
Nalae	60	0,868.6 ± 15.5	23	38.3%	0.256
Viengkham	60	1,985.3 ± 95.7	6	10.0%	0.383
Khoun	60	1,047.4 ± 34.5	25	33.3%	0.330
Sampanh	60	1,485.7 ± 83.7	5	8.3%	0.359
Gnot Ou	60	1,236.1 ± 27.7	19	31.7%	0.332
Study Area Total	479	1,244.6 ± 87.6	124	25.9%	0.351
National Average**		1,292.1 ± 59.8	-	-	0.371

* Figures indicate 95.0% confidential interval (margin error 5.0%)

** National average consumption per capita is quoted from LECS 2002/03, Gini Index is quoted from East Asia Update 2005, World Bank

Source: JICA Study Team

[2] Indonesia 35.4% in 2004, Malaysia 49.1% in 2004, Philippines 46.2% in 2000, Vietnam 37.5% in 2004, Cambodia 46.0% in 2004 and Thailand 41.4% in 2004. Source: World Bank

2.7.3 RECOMMENDATIONS FOR POVERTY REDUCTION AND RURAL DEVELOPMENT THROUGH RURAL ELECTRIFICATION

(1) Recommendation for Tariff Setting in Off-grid Sites

Formulation of Tariff Guideline in Off-grid Sites

While a unique tariff system is adopted for consumers receiving electricity from the national grid, tariff in off-grid sites are not regulated. Each off-grid operator (including a local government) sets an individual tariff system, but these tariffs differ widely according to localities. In the future, private operators may enter into off-grid power supply business. And if they determine tariff only to pursue their profitability without considering social impacts, the poor might be excluded from the access to electricity service. Actuary, in the case of Cambodia, a neighboring country to the south, high electricity tariffs of private small power companies using diesel generator (REE: Rural Electricity Enterprise) are becoming a social problem.

Viewed in this light, tariffs in the off-grid sites should also be regulated by the government to some extent. In preparing a guideline, WTP and ATP estimated by this project should serve as a benchmark reference for setting an electricity tariff in off-grid sites. In addition, the following issues should be considered in determining a tariff system.

Install Payment of Connection Fee Should be Allowed for Poor Households

Though in general, people in rural area having enough capability for paying monthly electricity tariff, it is difficult for them to pay a connection fee in a lump sum at the outset. The village socio-economic survey conducted also revealed that a gap of WTP for a connection fee between the poor and the non-poor is wider than that for a monthly tariff. This means that although the poor households have a relatively similar WTP to that of the non-poor household for a monthly tariff, it is difficult for the poor households to pay a sizable amount of money for a connection fee in lump sum (please refer to Chapter 4.6.4).

Accordingly, to facilitate poor household in applying electricity service and to reduce poverty, the installment of a connection fee should be allowed for the poor households.

Flat Rate System for Poor Consumers, and Metered Rate System for Non-poor Consumers

For a household using various electric appliances (including TV set, electric fan, electric iron, and refrigerator) electric meter need to be installed, and tariff will be charged at a metered rate. On the other hand, for a household using electricity only for lighting purpose, installment of electric meter is deemed not required, and fixed tariff (US$1-2/month) is more appropriate for these consumers *3. Such arrangements will eliminate meter reading and tariff calculation. In addition, a connection fee

[3] According to the village socio-economic survey, ability to pay (ATP) for electricity tariff of poor strata is estimated to US$ 1.3 – 2.6 per month.

for a poor household using only lighting can be reduced to a great extent because an electric meter is not required*4 for them.

Tariff for Commercial/Industrial Categories Should be Kept Low

In the most developing countries, while a tariff for residential categories is kept low due to political pressure, tariff for commercial and industrial categories are sometimes set higher. A similar policy seems to be adopted for the EDL tariff system. However, tariffs for industrial/commercial categories in rural area should be attractive enough to induce income generation activities using electricity. Especially, in the case of the small-hydro project, in order to fully capture the under-utilized energy generation capacity during an off-peak time, a tariff for commercial/industrial consumers in the off-peak should be kept at a minimum.

Tariff for Irrigation Should Also be Kept Low

Self-sufficient agriculture is a predominant mode in the project sites. Surplus in rice production in mountainous areas in Laos is relatively difficult because of topographical constraints. Limited accessibility to the market also makes the village people reluctant to grow surplus rice. Thus, most of villages surveyed are not interested in introducing electric pumping for irrigation (please refer to the section 4.6). Most of interviewed village chiefs think electric pumping too costly.

However, unlike a diesel generator, small-hydro station (especially run-off river type) needs no additional expense (such as fuel) for electric generation during off-peak times. Accordingly, in order to promote pumping irrigation and to utilize electricity during daytime, an electricity tariff for irrigation purpose in off-peak time should be kept low*5.

(2) Recommendations for Income Generation and Rural Development through Rural Electrification

Transport and Energy Infrastructure For Significant Synergy Effect on Poverty Reduction

In the surveyed sites, raising livestock and trading non-timber forest products (NTFPs) are more important cash income sources apart from agriculture. In the case of villages having good accessibility to the market, people earn their cash income by selling NTFPs to a middle man (mainly Chinese and Vietnamese). The living standard of these villages is relatively higher than that of the villages having less accessibility.

For example, district center of Viengkham (the only site having paved access road among surveyed

[4] An electric meter calibrated by EDL costs about US$ 50.

[5] In the case of part of India and Pakistan, an electricity tariff for irrigation purpose is heavily subsidized. In Baluchistan province, western part of Pakistan, tariff for irrigation purpose is heavily subsidized and is charged at fixed rate. Such tariff system resulted in massive electric consumption (accounted for about 40% of total consumption), over use of groundwater, and subsequent decrease in ground water level. In northern Laos, since large irrigation scheme is difficult due to topographical constraint, and the area is rich in water resources, similar problem is unlikely to happen. If need arises, establishment of village water association is required for efficient use of electricity and water resources.

sites) and that of Sampanh (accessible by boat along the Nam Ou River and functioned as a local trading center) benefit a great deal from trade of NTFPs. According to the socio-economic survey conducted, a poverty ratio is lower in these sites, and wiliness and ability to pay for electricity are higher than other surveyed district centers. In addition, in the villages with a good access, many households earn their living by running a furniture shop, repair shop, eatery by using diesel generators (detail will be mentioned in the section 4.6 and Supporting Data File(Part-B)).

In selecting target site for electrification, a site having good accessibility, higher wiliness to pay, and higher potential for income generation by using electricity should be given high priority for project implementation. On the other hand, in the case of villages without good accessibility, transport and energy infrastructure should be developed in an integrated manner, to realize synergy effect in reducing poverty.

Offering Micro Credit for Entrepreneur of Commercial Activities Utilizing Electricity

In Laos, Agricultural Promotion Bank (APB) provides micro-credit and technical assistance in rural area. In the case of Vang Sae village in Luangphrabang province, APB provides micro-credit for groups of women for buying material and equipment for weaving. APB also provides advices to these groups about design and techniques of production.

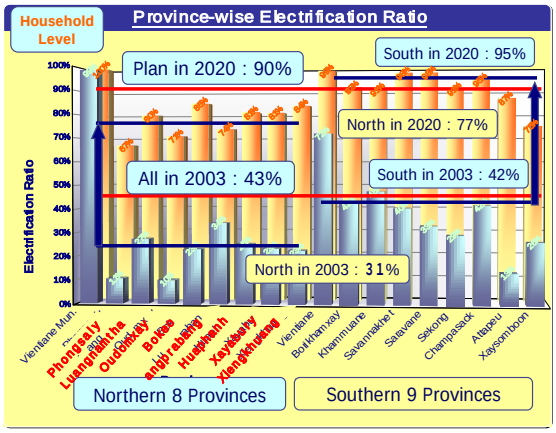
The establishment of an organization and system which provide micro-credits and technical advisory services for entrepreneurs and/or village organization wishing to start pumping irrigation or business activity using electricity will be expected. Financial source and technical assistance for pumping irrigation and agro-processing industry should be developed by the MIH in partnership with the Agriculture Promotion Bank. Also, the small-hydro promotion fund (please refer to Chapter 2.5.2) might be solicited for cooperation for providing same services.

3. MASTER PLAN OF SMALL-HYDRO RURAL ELECTRIFICATION

3.1 Outline of Master Plan of Small-Hydro Rural Electrification at Province Level

3.1.1 BASIC POLICY OF RURAL ELECTRIFICAITON

The Lao PDR aims at 90% electrification of the total number of households in 2020. For this reason, it is necessary to pull up the 31% rate of average electrification of the northern 8 provinces in 2003 to 77% in 2020. Therefore, after adding the electrification plan for district centers from the Pre-F/S of this master plan into the existing power development plan, further electrification is required of un-electrified villages that are not district centers.



It is necessary to examine the present electrification situation and future electrification plans for villages other than district centers in order to attain embodiment of the promotion of village electrification towards target achievement. On the basis of the results of the questionnaire of the village electrification situation, obtained through PDIH staff in the 4th field survey, the households of each village were classified into the following categories, and the totals calculated.

Condition of Electrification	No.	Electricity Source
Electrified district	1	EDL grid
	2	Imported electricity grid
	3	Off-grid (small-hydro)
	4	Off-grid (Pico-hydro)
	5	Off-grid (diesel power)
	6	Off-grid (SHS)
Un-electrified district	7	Existing EDL plan (short term plan)
	8	Existing EDL plan (long term plan)
	9	Off-grid small-hydro of Pre-F/S Project in this Master Plan Study
	10	Village-hydro (10kW~20kW) potential sites
	11	Existing plan for Pico-hydro and diesel power generation
	12	Existing plan for SHS

On the basis of the categories above, the household numbers were accumulated by district and province, and the results are summarized as follows. For this accumulation of Oudomxay, Luangphrabang, Huaphanh and Xiengphuang provincial households, data for electrified household numbers and electricity source as of 2003 were adopted. On the other hand, for the accumulation of Phongsaly, Luangnamtha, Bokeo and Xayabury provincial households, the same data as of 2005 were

adopted, which were obtained through PDIH staff in 2005.

Electricity Source of Electrified Households

Code	Province	Household Numbers	Electrified Household Numbers	Rate of Electrification %	Electricity Source of Electrified households					
					EDL Grid	Import electricity grid	Off-grid (small hydro)	Off-grid (Pico hydro)	Off-grid (diesel power)	Off-grid (SHS)
02	Phongsaly	27,410	3,938	14.4	0	0	2,179	641	1,118	0
03	Luangnamtha	25,168	8,839	35.3	0	6,232	228	192	889	1,298
04	Oudomxay	41,500	8,338	20.2	0	0	5,697	0	1,961	680
05	Bokeo	25,657	9,366	36.5	0	7,643	0	1,689	34	0
06	Luangphrabang	66,986	20,526	30.6	13,552	0	262	192	6,151	369
07	Huaphanh	41,621	21,664	52.1	0	8,485	3,272	9,723	184	0
08	Xayabury	61,370	18,961	30.9	6,978	10,892	0	0	202	889
09	Xiengkhuang	34,527	10,243	29.7	4,258	0	535	3,414	1,837	199
Total		324,239	101,875	31.4	24,788	33,252	12,173	15,851	12,376	3,435

Source: JICA Study Team

STEP 1

As shown in the table below, the present rates of electrification of the northern 8 provinces of 31% rises up to about 51% by adding i) electrification by the existing EDL grid extension plan, ii) the off-grid small-hydro plan of this master plan (projects for the Pre-F/S only), iii) electrification of the village hydraulic power at potential sites found at the map study level in the master plan, and iv) the existing plan for Pico-hydro and SHS.

Electrification Plan of Un-electrified Households and Electricity Source

Code	Province	Household Numbers	Un-electrified Household Numbers	Rate of Electrif. after Implem. of Existing Electrif. Plan %	Existing Electrification Plan, Off-Grid Pre-F/S Projects and VH Potential Sites					
					EDL (short term plan)	EDL (Long term plan)	JICA Off-grid Pre-F/S	VH Potential sites	Existing Pico hydro and diesel power	Existing plan for SHS
02	Phongsaly	27,410	8,451	30.8	2,951	0	527	1,035	0	0
03	Luangnamtha	25,168	9,966	39.7	912	0	0	215	0	0
04	Oudomxay	41,500	14,502	35.0	5,723	0	0	441	0	0
05	Bokeo	25,657	14,592	56.9	2,638	746	52	711	0	1,079
06	Luangphrabang	66,986	27,699	41.4	4,707	0	676	1,481	0	309
07	Huaphanh	41,621	25,354	60.9	1,932	572	0	1,186	0	0
08	Xayabury	61,370	42,234	68.8	7,418	8,524	0	489	415	6,427
09	Xiengkhuang	34,527	22,542	65.3	10,918	0	334	781	0	266
Total		324,239	165,340	50.9	37,199	9,842	1,589	6,339	415	8,081

Source: JICA Study Team

STEP 2

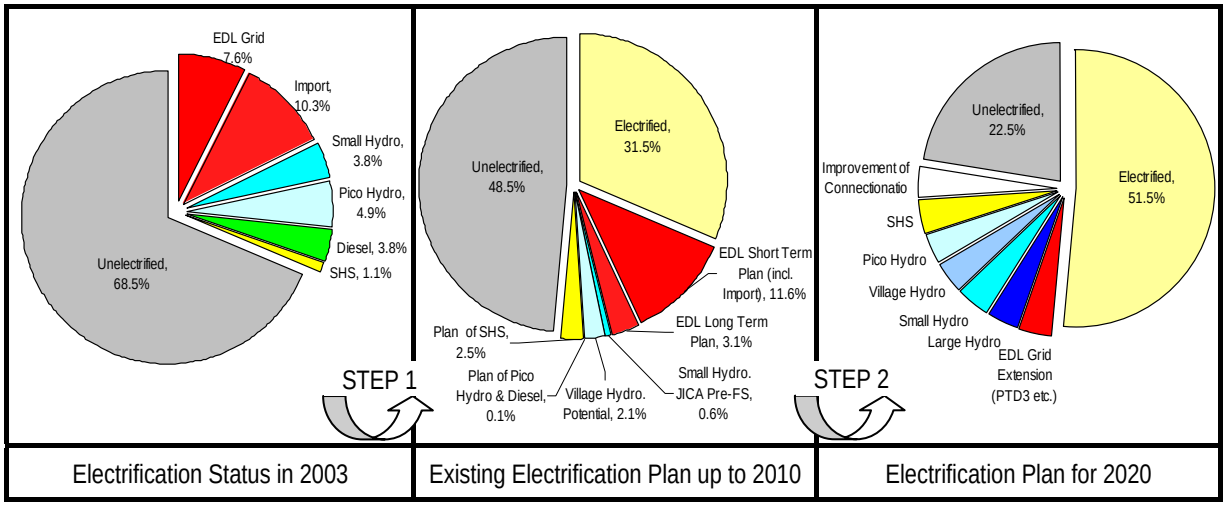
By 2020, the electrification target of the Lao PDR is attaining a rate of 90% of household units having electricity. For attainment of this electrification target subsequent to STEP 1, it is necessary to increase the 51% average rate of electrification of the northern 8 provinces to 77% by 2020, and the following electricity sources have been considered for those northern 8 provinces:

(i) EDL grid extension plan (PTD 3, provincial plan)
(ii) Large hydropower project in the northern 8 provinces and electrification of surrounding villages
(iii) Small-hydro project
(iv) Village-hydro project
(v) Pico-hydro project
(vi) SHS

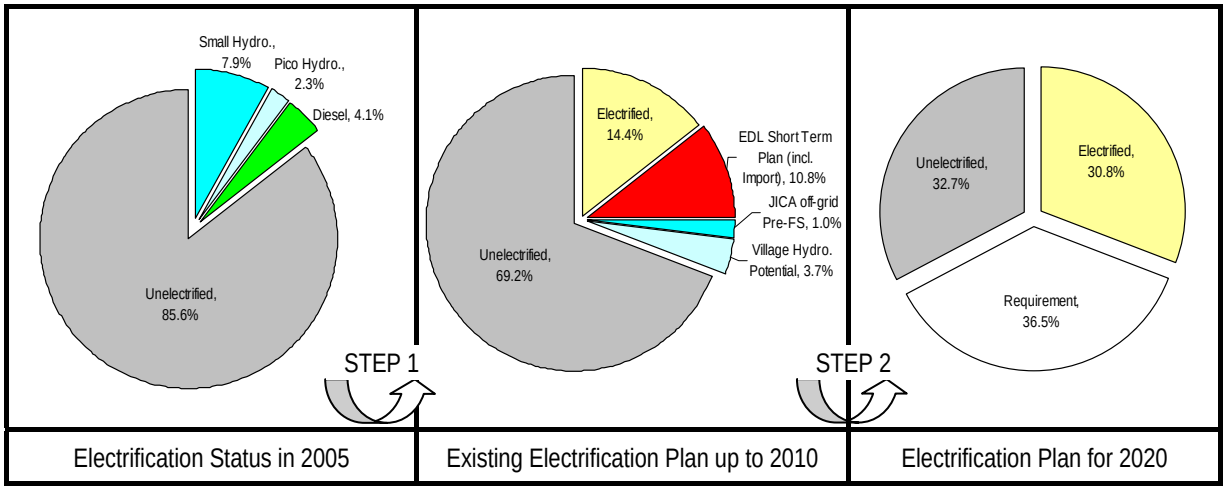
Though the electricity sources of a. and b. shown above will contribute to raise the electrification ratio considerably, the scale and timing of development can not be estimated since those plans depend on the national plan of Lao PDR, international donor and other developer. The existing electrification

condition, existing electrification plan and requirement of electrification to attain the target in each province are shown in the following graphs. Further, the electrification policy for attainment of target of each province and district are shown in Chapter 3.4.

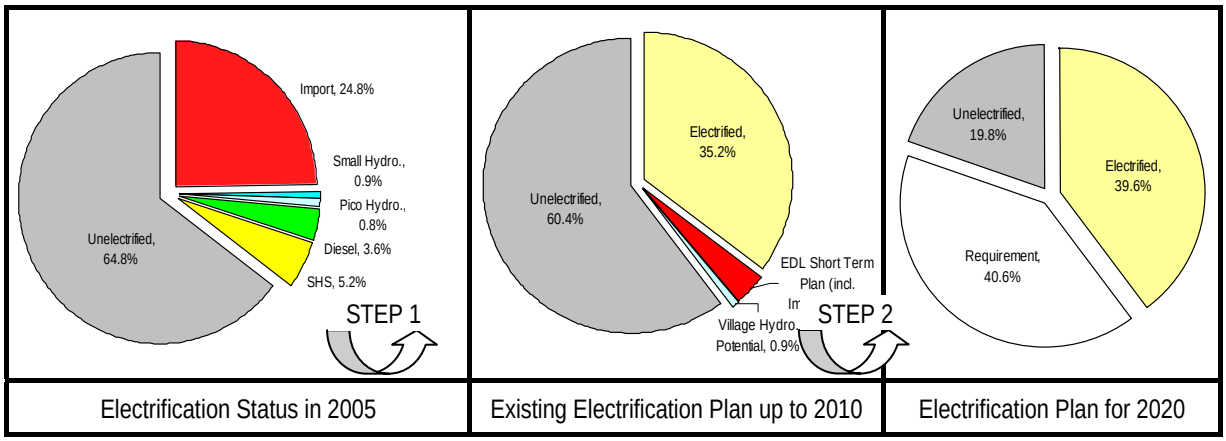
Total of Northern 8 Provinces



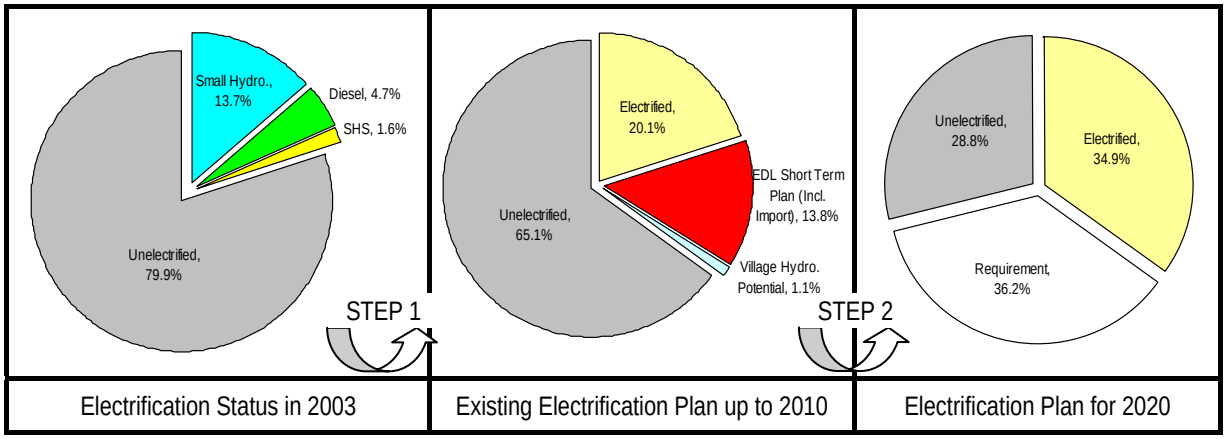
1. Phongsaly Province



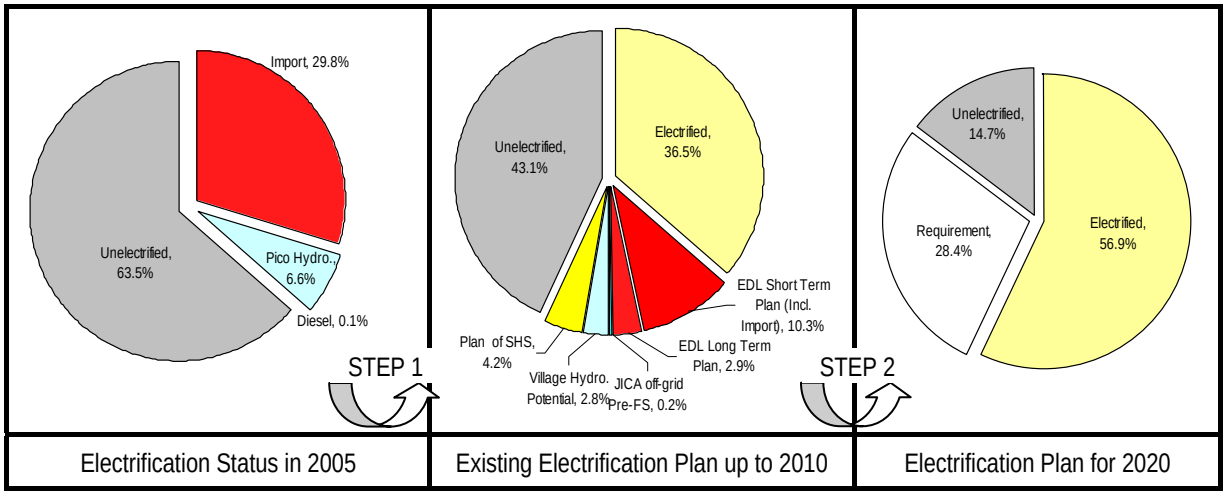
2. Luangnamtha Province



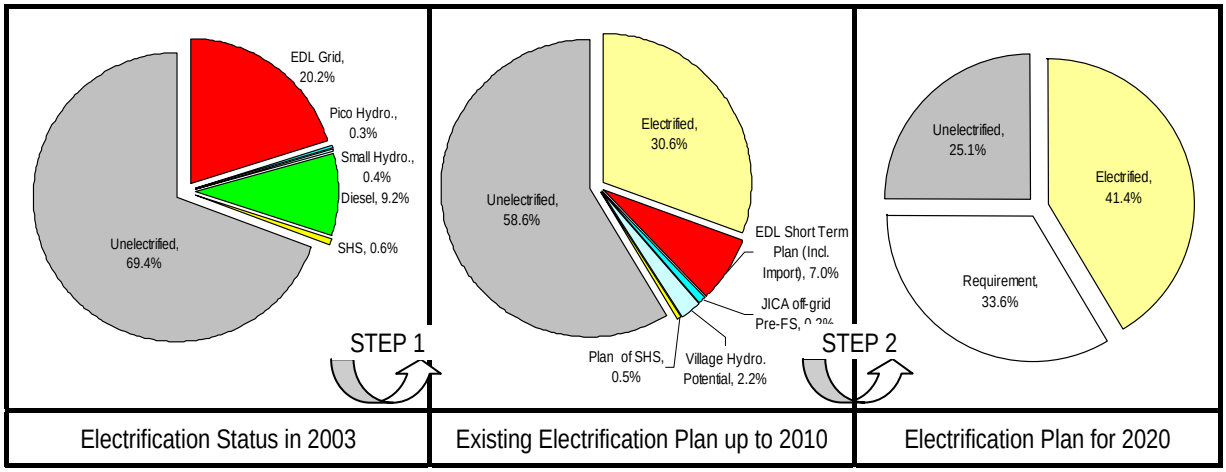
3. Oudomxay Province



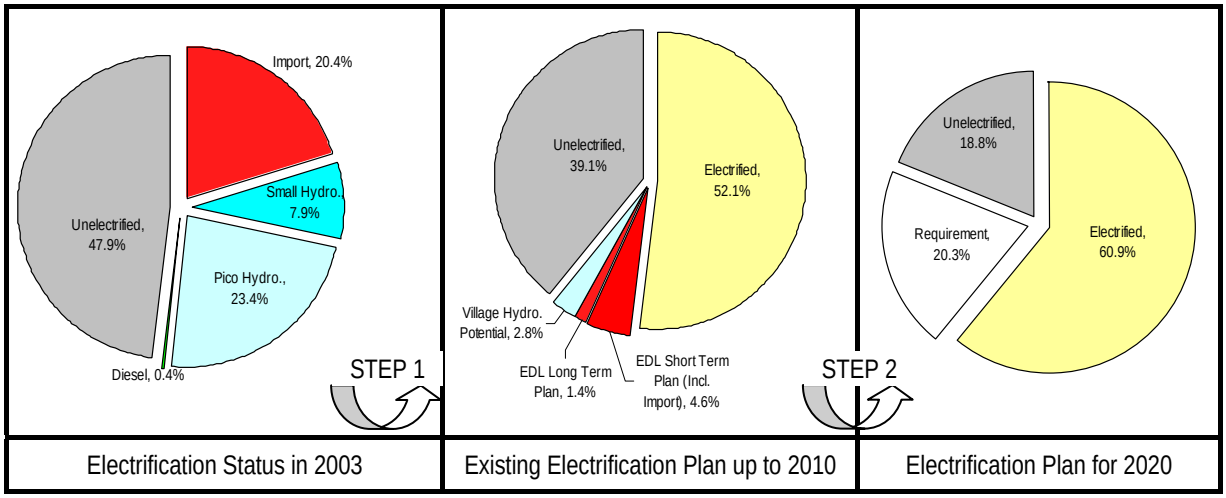
4. Bokeo Province



5. Luangphrabang Province

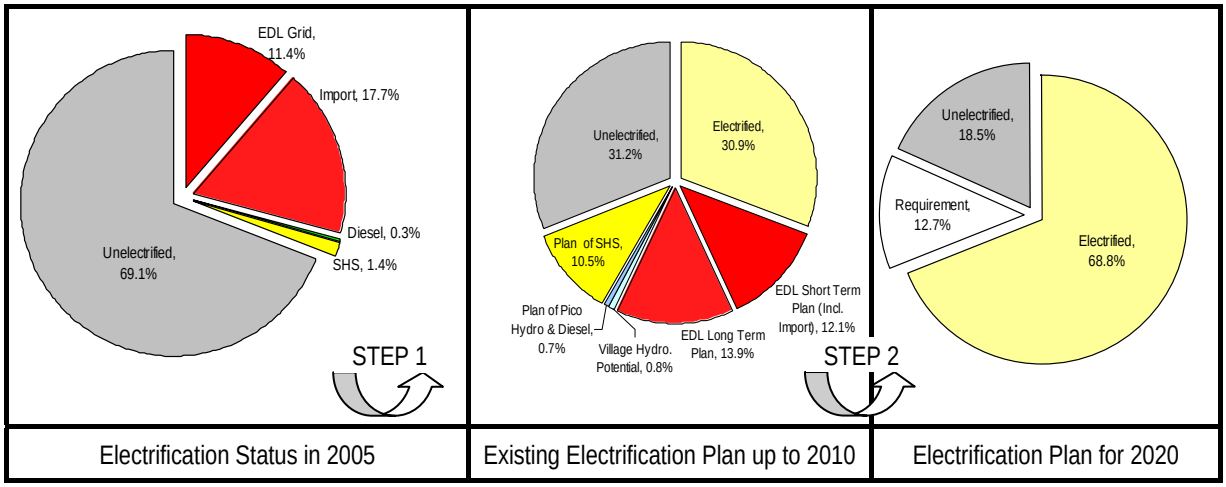


6. Huaphanh Province



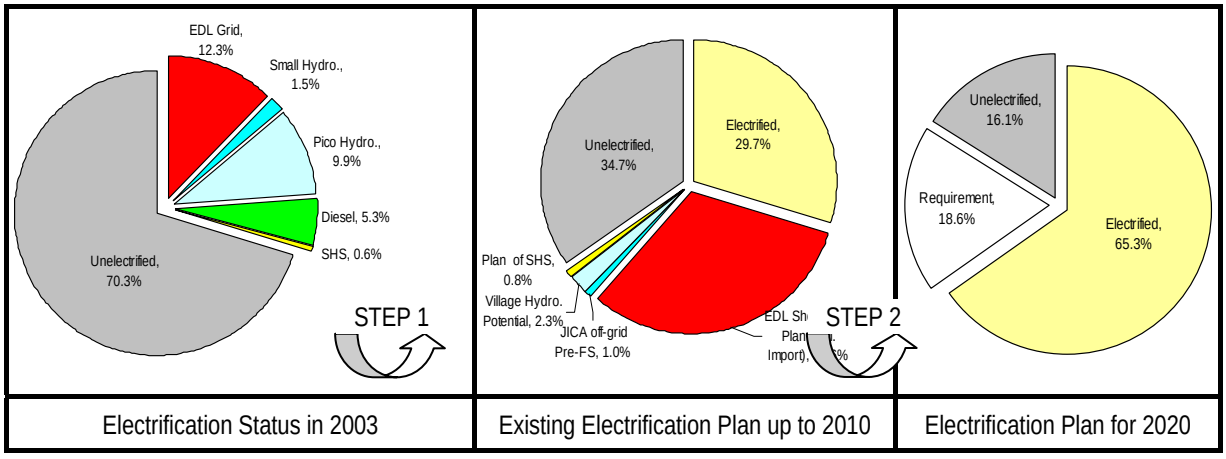
Electrification Status in 2003	Existing Electrification Plan up to 2010	Electrification Plan for 2020

7. Xayabury Province



Electrification Status in 2005	Existing Electrification Plan up to 2010	Electrification Plan for 2020

8. Xiengkhuang Province



Electrification Status in 2003	Existing Electrification Plan up to 2010	Electrification Plan for 2020

3.1.2 ROUGH ESTIMATE OF COST FOR RURAL ELECTRIFICATION

The rough project cost for electrification in the northern 8 provinces was estimated in STEP 1 and STEP 2 respectively. In this estimate, since the electricity source in STEP 2 is not clear, the following conditions are assumed:

Case 1 : SHS of OPS program style by WB is adopted in STEP 2

Case 2 : EDL grid extension is adopted in STEP 2

The conditions of rough project cost estimation are as follows:

Conditions of Rough Project Cost Estimation

(i) The electrification of villages by EDL grid in the existing plan is limited to the PTD 2 project or the other grid extension plans for which budget was secured. The electrification by PTD 3 is not considered as part of the existing plan on this estimation, because of the unconfirmed condition of its size and area. The electrification cost for one household by grid extension was assumed at the unit rate of US$1,610, which was estimated from the total electrification cost and electrified households numbers of SPRE 2, SPRE 3, PTD 2 and PTD 3 mentioned in PDP2004-13 produced by EDL.

(ii) The project costs of the Pre-F/S small-hydro projects in this master plan, except Nam Hat 2 small-hydro in Bokeo, were estimated and included in the project cost.

(iii) The projects selected as the village-hydro plan potential sites at the map study level, except small-hydro projects selected Pre-F/S in this master plan, are counted as village-hydro projects. The construction cost for electrification of one household by village-hydro was assumed at the unit rate of US$227, which was adopted for the cost estimate in the rural electrification framework study by the World Bank.

(iv) When there was a plan for pico-hydro, SHS and/or diesel power generation for a village, it was counted as the future power source. The construction cost for electrification of one household by Pico-hydro, SHS and diesel power generation was assumed at the unit rate of US$279, which was adopted for the construction cost of SHS in the rural electrification framework study by the World Bank.

(v) The number of villages shall not change from 2003 and the number of households of each village shall increase by the ratio used for the household increase rate in PDP 2004-13 prepared by EDL.

The expected household numbers of each province in 2020, the required household numbers for electrification during STEP 2 and the target electrification ratio after STEP 2 are summarized below.

Code	Province	Household (H/H) Numbers (2020)	Required H/H numbers for electrification by STEP 2 (2020)	Target Electrification Ratio after STEP 2 (%)
02	Phongsaly	35,304	23,472	67
03	Luangnamtha	32,416	16,294	80
04	Oudomxay	55,610	33,132	71
05	Bokeo	33,046	16,291	85
06	Luangphrabang	89,761	46,460	75
07	Huaphanh	55,772	19,957	81
08	Xayabury	79,045	42,409	82
09	Xiengkhuang	46,266	24,284	84
Total	Source: JICA Study Team	427,221	222,299	77

Results of rough project cost calculation (Case 1 & Case 2) are summarized below:

Case 1 : Rough Project Cost by SHS in STEP 2 aiming at Electrification Target at 2020

Code	Province	Household Numbers	Rate of Electrif. after Implem. of Electrif. Plan %	Project Cost of Existing Electrification Plan for each Power Source (STEP 1)						Required cost for SHS aiming at 90% Electrification finally(STEP 2)	Total Cost for Electrifiation (US$)
				EDL (short term plan)	EDL (Long term plan)	JICA Off-grid Pre-F/S	VH Potential sites	Existing Pico-hydro & diesel power	Existing plan for SHS		
02	Phongsaly	35,304	67.3	6,119,430	0	1,786,140	300,270	0	0	3,595,461	11,801,300
03	Luangnamtha	32,416	80.2	1,891,196	0	0	62,861	0	0	3,675,057	5,629,114
04	Oudomxay	55,610	71.2	12,346,800	0	0	134,143	0	0	5,619,826	18,100,770
05	Bokeo	33,046	85.3	5,470,368	1,546,965	229,360	207,879	0	387,741	2,617,340	10,459,654
06	Luangphrabang	89,761	74.9	10,154,882	0	859,392	450,491	0	115,523	8,408,336	19,988,623
07	Huaphanh	55,772	81.2	4,168,097	1,234,033	0	360,757	0	0	3,161,398	8,924,285
08	Xayabury	79,045	81.5	15,382,558	17,676,048	0	142,972	121,336	2,309,555	2,805,713	38,438,182
09	Xiengkhuang	46,266	83.9	23,554,493	0	462,633	237,565	0	99,447	2,396,816	26,750,954
Total		427,221	77.0	79,087,824	20,457,046	3,337,525	1,896,938	121,336	2,912,266	32,279,946	140,092,881

Source: JICA Study Team

Total electrification cost US$140 million accumulated in table above was made on the assumption of the no grid extension plan after implementation of PTD2 and existing grid extension plan, and adoption of SHS for electrification required to attain 90% of target rate of household electrification in whole country at 2020 (77% in the northern 8 provinces). The electrification cost of STEP 2 was estimated about US$32 million.

In the case of that the un-electrified villages in whole country will be electrified step wise procedure (SHS in first stage and grid connection in second stage), the total electrification cost of STEP 2 accumulated in table above is a much for the cost for first stage (SHS).

Case 2 : Rough Project Cost by EDL Grid Extension in STEP 2 aiming at Electrification Target at 2020

The electrification cost of STEP 2, which is required to pull up 51% rate of average electrification of northern eight (8) provinces to 77% in 2020 by EDL grid extension only, was estimated about US$186 million. This electrification cost is 6 times of Case 1.

The electrification condition and further electrification plan of each province and district is shown in following Chapter 3.4, which is background for estimation of rough project cost calculation mentioned above. Furthermore, the electrification plans for each district were inputted on the GIS map with the EDL grid extension plan and small-hydro plan of this Master Plan Study. The potential sites for village-hydro were found at the map study level and inputted on the same GIS map. The prepared GIS maps showing the electrification condition after STEP 1 are shown in the attached Figures 1 to 8, and this will provide effective information for further EDL grid extension planning,

site selection for SHS or VH in WB's OPS program and future electrification planning by provinces and districts.

3.2 BASIC DATA FOR FORMATION OF MASTER PLAN

3.2.1 INTRODUCTION

One of the purposes of this investigation is drawing up the master plan which incorporated investigation / analysis result about the policy subject for planning and promotion of the off-grid small-hydro project of the district level of northern eight (8) provinces. The master plan was made on the basis of following basic data.

No.	Description of Basic Data and Relations with Mater Plan
Data-1	**Lao PDR Development Policy/Implementation Situation on small-hydro/rural electrification:** By 2020, the electrification target of the Lao PDR is attaining 90% rate of household unit. Moreover, for that purpose, about 90% of the electrified household in future is electrified by grid connection. In this master pan, the electrification method after 2010 (in Step 2) is assumed to be flexible and the rough electrification cost were estimated for the both cases of electrification by SHS which is most simple and the EDL grid extension.
Data-2	**Project Contents of Transmission & Distribution Line of EDL/ADB(PTD1~3):** PTD 3 is scheduled to be carried out after PTD 2. However, the outline of PTD 3 was not decided yet. In GIS map of this master plan was made considering PTD 2 information and it will be useful for planning of the electrification area in PTD 3.
Data-3	**Project Contents and Relation to Northern Area of WB Southern Provinces Rural Electrification Project(SPRE):** In SPRE, SHS and VH are under promotion for the villages which will not receive EDL grid electrification for the time being. To attain the national target of electrification, these electrification methods are important, and unit rate of these electrification were adopted to estimate the cost of electrification in this master plan.
Data-4	**Effectiveness of Rural Electrification on the National Poverty Eradication Program(NEPE):** There is relationship between the district on which off-grid small-hydro was planed in this master plan, and subjected district on the NEPE.
Data-5	**Effectiveness of Off-grid rural electrification in Northern Laos:** The distribution condition, size, source of fund and problem on O&M of existing small-hydro in the northern 8 provinces were concluded, and some point should be considered for the Pre-F/S.
Data-6	**Small-hydro Potential Site in Northern Laos (Map Study and Pre-F/S Results) :** The local characteristics based on the hydrological data were collected for selection of small-hydro potential sites. Further, the EDL grid extension plan was compiled as basic information for electrification condition of each district in future and it was effective on electrification master plan.
Data-7	**Electrification Condition/Electricity Demand Forecast at District Level:** On the basis of the results of electrification demand forecast, the household electrification demand was adopted for estimation of electricity demand of villages in the Pre-F/S.
Data-8	**GIS Data:** The electrification conditions, electrification plan and the potential of village hydro were shown in GIS map. It is useful to grasp the electrification situation and can be basic information for the master plan.
Data-9	**Off-grid Electrification Plan in Northern Laos:** The data of electrification source and planning of each village was collected through PDIH's cooperation and was plotted on the GIS map as the basic data for master plan.

The master plan was concluded with the off-grid small-hydro generation plan of a district level after examination of the above-mentioned considerations, and was shown in Chapter 3.3 with GIS maps which show the existing electrification condition and future plan of electrification of village units.

3.2.2 BASIC DATA ON 9 SUBJECTS

Data-1: Lao Development Policy/Implementation Situation on small-hydro/rural electrification

The rate of electrification of the household unit which was shown in Census Data 2003 announced by the Lao National Statistical Center in February, 2004 is as being shown below:

No.	Province	District Nos.	Village Nos.	Household Nos.	Rate of Electrification	Population
1	Vientiane municipality	9	496	114,793	94.2	637,041
2	Phongsaly	7	607	27,573	14.7	162,716
3	Luangnamtha	5	401	24,965	28.6	138,297
4	Oudomxay	7	657	40,987	18.0	251,632
5	Bokeo	6	364	24,126	28.2	136,222
6	Luangphrabang	11	887	66,632	30.4	391,088
7	Huaphanh	8	839	41,614	51.5	272,310
8	Xayabury	10	495	59,112	25.3	330,116
9	Xiengkhouang	7	537	34,527	29.4	223,247
10	Vientiane	12	590	63,533	58.9	365,416
11	Bolikhamxay	6	323	36,624	51.5	215,674
12	Khammuane	9	804	60,933	52.6	325,263
13	Savannakhet	15	1,542	125,955	47.3	782,617
14	Saravanh	8	724	53,506	34.6	309,471
15	Xekong	4	262	13,694	29.8	79,457
16	Champasak	10	924	101,186	37.7	578,669
17	Attapeu	5	211	19,053	11.9	103,782
18	Xaisomboun Spetial Zone	3	89	5,639	24.6	35,133
	Total	142	10,752	914,452	45.1	5,338,151

Source: Lao National Statistical Center

By 2020, the electrification target of the Lao PDR is attaining a rate of 90% of household unit, and aims at 70% in 2010. Moreover, for that purpose, electrification of 745,000 HH will be needed by 2020 from now on, about 90% of the household is electrified by grid connection, and except its is considering as the object of an off-grid.

According to the final report of Rural Electrification Frameworks Study by WB, the cost for satisfying a rate of 90% of number-of-HH electrification of the Lao PDR in 2020 is estimated as follows.

Electrification Category	Electrified Household Nos.	Cost(US$)	Average Cost per Household(US$/HH)
Grid Connection	654,000	370 million	575
Off-Grid	150,000	51 million	343
Total	745,000	421 million	565

* The 33% of systems is assumed to be become un-serviceable over a 10 year period.
Source: Final Report of Rural Electrification Frame Work Plan (World Bank)

Assumption of depending about 90% of the number of households to be electrified from now on with on-grid connection should be premised on it being judged that electrification of the remote village by grid extension is appropriate. However, if the dispersion situation of un-electrified villages in the remote district is taken into consideration, the estimate of average cost of grid connection per household is US$ 1,610/HH, which was estimated on the basis of data of PDP2004-13 prepared by EDL. And total cost for electrification aiming at 90% of national target will be higher than cost estimated in table above.

Moreover, the process of the electrification towards 2020 of the present non-electrified village was examined. According to the opinions of PDIH, many un-electrified villages have a desire to shorten

the time by electrification. That is, even when electrification is planned in the EDL grid in 2010 and afterwards, village people want to get minimum lighting from SHS within 1 or 2 years first, and they do not want to wait for five years or more. And if the grid of EDL reaches, they want to shift to grid connection from SHS. The SHS which became unnecessary will be diverted to some other village in the un-electrified area located more remote district at the time. Thus, after electrifying by SHS as the first step, the work in the night, such as handy crafts, is attained under the electrical lighting of the SHS, and the income and living standard of a household would go up. Therefore, the access charge in the time of an EDL grid reaching and the WTP of an electricity bill can be raised. If there is not WTP in village people, and villages is not crowded each other, EDL grid extension will not be materialized economically.

Therefore, it is important to spread as broadly as possible the electrification plan of the village unit by SHS and VHGS of the OPS program which the World Bank is performing now, or a similar program as an initial stage for improvement in the rate of electrification of the Lao PDR. In the OPS program of SPREII-Phase 1 which the World Bank is carrying out now, it aims at village electrification of 10,000HH by December, 2007 in the Lao PDR. The drastic increase in the electrification schedule number of households by SHS by an OPS program or similar program is effective towards 2020 after SPREII-Phase 2 carried out following on it.

Definition of Rate of Household Electrification

As a definition of the power source for examining the rate of household electrification, it consists of an EDL grid also including imported electric power or a provincial grid system, the independent small-hydro plant and diesel power generation, a solar home system (SHS), village-hydro generation (VH), and Pico-hydro generation. In the rural electrification framework study of the World Bank, the Pico-hydro generation itself is not considered as a power source in the case of examining the rate of household electrification, after the argument of whether the existence of a controller in Pico-hydro generation. However, if the track record and reliability of Pico-hydro generation in Huaphanh province and Xiengkhuang province are taken into consideration, it will be hard to think that it is inferior to SHS. Furthermore, in consideration of the fact of a promotion of Pico-hydro generation by districts and provinces, it shall be considered that Pico-hydro generation is one of power sources in the case of examining the rate of household electrification by this master plan.

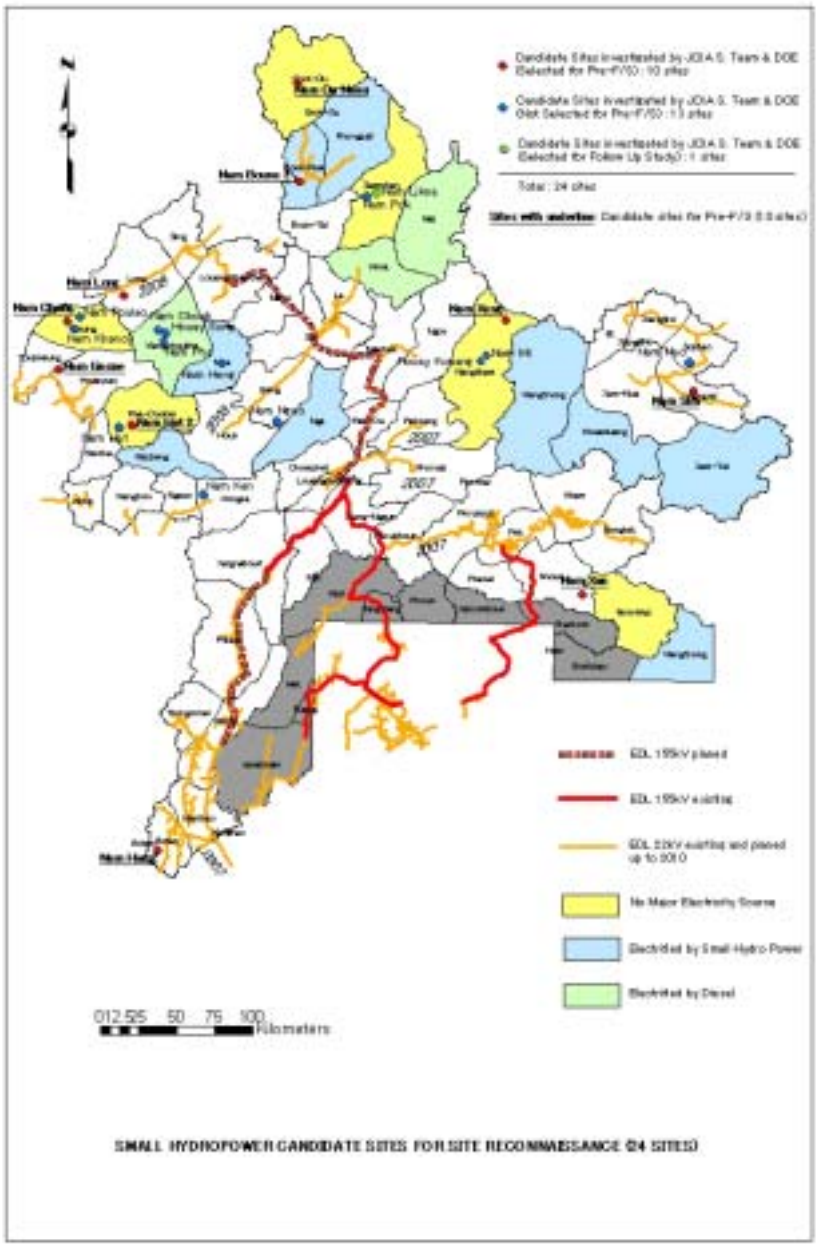
Data-2: Project Contents of Transmission & Distribution Line of EDL/ADB(PTD1~3)

Relation to the existing situation of extension plan of EDL distribution line, the PTD1 by ADB has been completed and the PTD 2 is under construction up to 2008. As shown in the following figure, 115kV TL will reach Luangnamtha from the Luangprabang through Oudomxay in PTD2, by 2006. Moreover, in a Xayabury province, there is a 115kV TL extension plan from the central part of a Xayabury to the Paklai district, and it is under planning by the Chinese government fund.

Furthermore, in PTD2, 22kV TL will extend towards the central part of each un-electrified district at a branch ceremony from 115kV TL extended as the backbone. However, the extension plan of 22kV

TL from Namo district in Oudomxay to Bonnua district in Phohgsaly was postponed after PTD 2 due to shortage of budget.

According to hearing in planning section of EDL in July 2005, the actual route and area of PTD 3 has not been decided yet. However, the basic concepts of PTD 3 are i) further extension of 22kV with same manner as PTD 2, and ii) the new 22 kV TL will be decided to be expanded toward villages having high demand of connection at a branch ceremony from 22kV TL constructed in PTD 2. The information of budget for PTD 3 was not available. According to EDL planning section, though ADB's budget has not fixed yet, the project cost for PTD 3 may be same as that of PTD 2 (US$ 40 million) and it seems to be clear within 2006. In the planning section of EDL, they are up-dating the electrification information of each village by following extension of EDL 115kV and 22kV TL on the GIS map, and these information is quite important for our Master Plan.



Data-3: Project Contents and Relation to Northern Area of WB/SPRE Project

As a part of the Southern Provinces Rural Electrification-I (SPRE-I) of the World Bank, the off-grid renewable energy electrification promotion and the support pilot project (OPS program) was carried out. This program was made by fund of GEF (UNDP) grant of US$744,000 and an IDA credit of US$900,000. An OPS program founds the office inside MIH, and is managed by the DOE staff. OPS program is the system of nominating Electricity Supply Company (ESCO) in each province and carrying out installation plan for SHS and VHGS, installation, and charge recovery in cooperation with a village electrification manager (VEMs). As of April, 2004, the installation number of households was 3,351 HH, and the applied number of households was 1,359 HH. In almost all cases, it is introduction of SHS.

SPRE-II (Phase-1) is under enforcement now, and 10,000 HH are due to be electrified by the OPS program in the period in May, 2005 to December, 2008. However, according to this pamphlet, the target provinces are Luangnamtha, Oudomxai, Xiengkhouang, Bolikhamsay, Vientiane and Champassack, and Escos is specified in each province. SPRE-II (Phase-2) is due to carry out as a future plan by 2010.

In this program, there are the following power source choices and each charge system is set up.

(i) SHS - 20, 30 and 40, and 50Wp(s) (household average cost US$ 279)

(ii) Micro-hydro and distribution equipment (household average cost US$ 227)

(iii) Micro diesel and distribution equipment (household average cost US$ 227)

The village people should pay about 10% of all costs at the time of connection, and the balance should be repaid in ten years every month. In the final report of rural electrification frameworks study, the GEF reviewed the OPS program and made high evaluation that it is a highly complete functional system is carried out.

In this master plan, it is recognized that the public relations and spread in the Laos whole country of OPS program will contribute to the achievement a rate of 90% of household electrification in 2020 and indispensable to the poverty eradication by electrification of a remote non-electrified village, and improvement in a life level which is important role greatly. In the case of the range of installed capacity of hydropower plan that is smaller than the range of this master plan (100kW ~ 5 MW), the electrification in a village unit (about 20~50 HH) is realistic because of the disperse condition of villages. If a grid is not connected to villages, the electrification by SHS or village-hydro with the OPS program or a similar program is considered to become the realistic electrification method.

In the National Poverty Eradication Program (NPEP) September, 2003 the Lao government confirmed the necessity for the poverty eradication in each district, and CPC and each province organization specified 72 districts as the poverty district. Furthermore, 47 districts out of 72 districts were

appointed as the maximum poverty county, and it considered as the priority investment outlet area from 2003 to 2005. The distribution map of the maximum poverty county of 47 counties is as being shown in a separate Supporting Data Files. Moreover, in this master plan, five districts are chosen as an off-grid small-hydro plan sites because those districts does not have main power source in its district center as of 2010. All of these five districts in which off-grid small-hydro is being planed, coincide with the maximum poverty county which NPEP specifies. Therefore, it is thought that the small-hydro plan in this master plan is meeting with NPEP's concept.

Data-5: Effectiveness of Off-grid rural electrification in Northern Laos

In northern Laos eight (8) provinces, a small-hydro plant is an indispensable power source, and has been contributing to electrification of each district centers in each province. A source of funds were the subsidy of a prefecture budget and the Chinese government subsidy or a loan, the subsidy of USA, a government fund, etc. as shown in the following table.

However, these hydraulic power plants are being operated with having various problems, as shown in table. Although these problems are divided into civil work problems including flood damage, and the mechanical and electrical problems on a turbine and generator, in almost all cases, they have become being left by the problems due to the shortage of knowledge and budget for the restoration or part exchange. What have shading in the project name in the following table are obliged to the present operation stop. Also there are hydropower plants, which are being operated with problems at present, may be driven into an operation stop within recent years, if restoration or part exchange is not carried out on them. The reasons for these problems are the adoption of various standards for design and construction due to diverse type of fund, and various specifications for safety evaluation of civil works and electro-mechanical works. Moreover, other reasons are considered to be shortage of educational instruction about O&M, and no reservation of a spare part etc.

In order to gather the rate of electrification of the Lao PDR country towards 2020, it is thought that the rehabilitation of the hydroelectric power station currently driven into the present operation stop and maintaining the hydropower plants operated with some problems now are important, besides planning and building a new hydropower plants.

The existing situation of off-grid hydropower plant in northern area is as being shown below.

Condition of Existing Small-Hydro in Northern Laos 8 Provinces

Province	District	Hydropower Plant	Installed Capacity	Starting Generation	Tariff kip/kWh	Load Center	Fund	Note
Phongsaly	Phongsaly	Nam Ngai	1.2MW	2003	600 kip/kWh	District Center	Province Budget	300k Generaion only due to less demand Damage in Exciter of No.1 Generator Damage in Pump
	Booneua	Nam Boun1	110kW	1996	600 kip/kWh	District Center	Chinese subsidy	Actual Output 80kW Demand is bigger than power supply. Damage in Stater Coil
Luangnamtha	Long	Houay Key Buan			-	Xienkok	Chinese Loan	Planning and Construction by Chinese contractor is not suitable. Open channel was damaged. After restoration, it was damaged again and abandoned.
	Nalae	Houay Nung	30kW	1999	-	District Center	Province Budget	In dry season, 3 hours generation by manual control, Leakage from Open channel

Province	District	Hydropower Plant	Installed Capacity	Starting Generation	Tariff kip/kWh	Load Center	Fund	Note
Oudomxay	Xay	Nam Ko	1.5MW	1996	EDL Tariff	Xay, La	Chinese Loan	In rainy season, output is 1.2MW only. In dry season 300~500kW due to less water flow. Peak demand is 1.7MW. No connection with EDL grid. Debris entered to waterway.
	Pakbeng	Houay Kasen	155kW	2002	1000 kip/kWh in Ave.	District Center	Province Budget	Chinese governor problem and manual control. In dry season, 40kW only due to less water. District requested to repair of governor. Excavated slope beside open channel in going to collapse.
	Nga	Houay Se Hybrid	1150kW	2005	-	District Center	NEDO Test plant	Solar and small-hydro
Luangphrabang	Nam bak	Nam Mong	70kW	2004	EDL Tariff	Nam mong and other 6 villages	NEF Test plant	EDL line reached at off-grid area.
Huaphanh	Vieng thong	Nam Ad	80kW	1998	Light 450 Industry 50 Irrigation 20 Service 70 (kip/kWh)	Bat and other 12 villages	USA Aid	Actual output 63 kW No sand flush way Inlet valve damaged No TL protection
		Nam Sad	250kW	1999		Thathiep and other 14 villages	USA Aid	Actual output 180kW which is not enough. In dry season, less water flow In rainy season, penstock is inundated. Water level gauge was damaged TL protector was damaged Battery for exciter was consumed.
	Huameuang	Nam Peun	40kW	1986		District center and 4 villages	USA Aid	Actual output 40kW which is not enough. In rainy season, tailrace is inundated. Inlet valve control system was damaged.
	Xamtay	Nam San	110kW	1995		Sobsan and other7 villages	Government Budget	Weir was designed for 55kW and not enough as waster intake Inlet valve controller was damaged.
		Nam La	104kW	2002	-	Phiangphoun and 4 villages	Government Budget and Australia	Exciter of No.2 Generator and router is damaged. Only 1 generator operation (52kW) Governor was damaged.
	Viengxay	Nam Souy	12kW	1993	-	Chad village	Village Fund	Dam was washed away due to flood. Open channel was damaged due to land slide. Generator was burned. Control system was damaged.
	Sopbao	Nam Long	20kW	1997		Muanglong and other 3 villages	Government budget and Village Fund	Weir must be repaired after every rainy season. Open channel has no lining. Measurement equipment and breaker were damaged.
Xiengkhuang	Kham	Ban Sob Ma	55kW	1995	2000kip/20W lamp-month (560kip/kWh)	District Center	-	-
		Nam Tieng	75kW	1995		Nam Tian & 5 villages	Ptovince Budjry	Turbine & generator have trouble frequently.
	Morkmay	Nam Chat	100kW	-		District center	-	Open channel damaged due to land slide
	Phaxay	Ban Nong	40kW	1995		-	-	Operation was stopped due to damage in open channel.
		Nam Ka 1	12kW	1987		-	Province Budget	-
		Nam Ka 2	81kW	1995		-	Province Budget	-
		Nam Ka 3	5kW	1995		Nam Ka & 5 villages	Province Budget	Stopped due to trouble in generator
		Nam Pue	24kW	1995		-	-	Stopped due to trouble in generator

Source: JICA Study Team

The design of small-hydro plants will be carried out in this Pre-F/S with raising safety about a civil structure and an electro-mechanical works considering various problems in existing plants above-mentioned. However, it is also a fact that there is a case which the cost of equipment will leap up if high quality turbine and generator is chosen, and a spare part is also prepared further. In such case, the feasibility of a project falls, and does not result in implementation. Therefore, it needs to be cautious of selection of the production country and specification of equipment, especially turbine and generator. Moreover, about the educational instruction about O&M, the PDIH staff themselves recognizes the importance and the preponderant educational training about O&M should be carried out at

construction time simultaneously. In Vientiane, the EDL is managing the training school of the business relevant to plant, and is considered for training of the operator using this institution to be also effective.

Data-6: Small-hydro Potential Site in Northern Laos (Map Study and Pre-F/S Results)

As the basic data for Data-6, the following data were collected and attached in the Supporting Data Files.

1	Study Location Map
2	Small-hydro candidate Sites for map Study (24 Sites)
3	River System
4	Location of Rainfall Station, Availability of Data for Monthly Rainfall, Temperature and Wind, Monthly Rainfall Data in Provinces
5	Hydrology Station of Daily Discharge Measurement, Availability of Daily Discharge Data, Daily Discharge Data
6	Hydrology Stations of Discharge Measurement in Dry Season (1998, 1999 and 2002) by JICA
7	Specific Discharge in Dry Season at Northern Laos

The small-hydro project potential sites were selected as an area need off-grid small-hydro to be developed (Load Center) based on the result of conditions, such as an electrification situation and an electrification plan for every provinces of northern Laos 8 prefectures and an EDL grid network extension plan (PTD2, other transmission line extension plans), and electric power supply and demand, electric power import, and electricity demand forecast. The EDL 115kV TL and the 22kV TL were shown in the insertion figure of a Data -2, which is showing the existing lines and the extension plan up to 2010 in the northern 8 provinces.

The districts where the power-transmission and distribution line of EDL are not connected with by 2010, are set up as the small-hydro priority area (Load Center). And it is classified into the following three categories as it numbered in the figure.

Though Phongsaly and Booneua districts in Phongsaly Province have not been connected by EDL grid yet, there is Nam Ngai hydropower project which is supplying electricity to this area. Moreover, as there is schedule of EDL grid connection to this area, Phongsaly and Booneua districts are not defined as load center of this master plan. In order to determine the load centers for this master plan, the discussion with PHIH were held and the request from provinces and necessity of electrification were examined.

Category	District Electrification Condition in 2010	Province	District
1	No major electricity source	Phongsaly	Nhot Ou, Samphan
		Bokeo	Meung, Pha Oudom
		Luangphrabang	Viengkhoune
		Xiengkhuang	Morkmay
2	Electricity source is Existing small-hydro and generated power is not enough.	Luangnamtha	Nalae
		Oudomxay	Nga, Pakbeng
		Huaphanh	Viengthong, Huameuang, Xamtay
3	Electricity source is diesel power generation and generated power is not enough.	Phongsaly	May, Khua
		Luangnamtha	Viengphoukha

The maps of potential site of small-hydro in northern Laos (24 sites for Map Study) were made on topographic map with scale 1:100000 and GIS map. As the results of the map study, the project sheets showing catchment area and other information, layout of distribution line and basic layout of

structures were made and concluded in Supporting Data Files. The results of the Pre-F/S which have been completed are show in Chapter 4.

Data-7: Electrification Condition/Electricity Demand Forecast at District Level

The power demand was forecasted up to 2020 on the basis of district data collected in the first home work, the 2003 LECS survey results and information obtained through interview at PDIH offices.

In particular, the electricity demand was estimated for every district about both the amount of annual electricity demand (GWh) and peak power (MW) by 2020. The electricity demand of each district was presumed also about demand other than home electric power, in three classification of an urban area, a rural area with and without access, based on LECS investigation results.

Electrification Ratio Target Year	Village Electrification Ratio	Household Electrification Ratio
2003 (Northern 8 Provinces, Present)	19%	27%
2010(Whole country target)	43%	55%
2020(Whole country target)	80%	90%

Source: Electricity sector socio economic development policy of Lao government

According to the electricity sector socio economic development policy of Lao government March 2001, the electrification ratio for whole country will be pulled up to 90% as shown in table above. The demand for home electric power was forecasted on the basis of this government's goal.

Moreover, the population increase rate of PDP 2004-13 prepared by EDL was used for the pace of expansion of population and the number of households as the newest data. On the other hand, the average power consumption in each household was decided on the basis of the numerical value of the JICA Lao PDR transformation line master plan ended in 2002.

The power demand forecast result in a district level is separately shown in Supporting Data Files Part-A, and outline is shown below.

Code No.	Province	Annual Electricity Demand (GWh) Peak Power Demand (MW)	2003	2010	2020
02	Phongsaly	Energy Demand(kWh)	15,256,028	34,102,295	77,245,754
		Peak Power Demand (MW)	4.19	7.94	17.29
03	Luangnamtha	Energy Demand(kWh)	14,633,798	31,717,161	80,204,891
		Peak Power Demand (MW)	4.02	7.39	17.95
04	Oudomxay	Energy Demand(kWh)	21,701,894	49,620,500	112,971,445
		Peak Power Demand (MW)	5.96	11.56	25.29
05	Bokeo	Energy Demand(kWh)	9,949,508	25,825,536	63,335,700
		Peak Power Demand (MW)	2,54	6.02	14.18
06	Luangprabang	Energy Demand(kWh)	51,578,156	91,340,847	234,834,223
		Peak Power Demand (MW)	13.0	21.3	52.6
07	Hoaphanh	Energy Demand(kWh)	19,212,724	45,396,392	111,319,509
		Peak Power Demand (MW)	5.66	10.58	24.92
08	Xayabury	Energy Demand(kWh)	35,787,111	82,255,025	186,260,385
		Peak Power Demand (MW)	9,8	19.2	41.7
09	Xiengkhuang	Energy Demand(kWh)	18,680,304	37,235,735	133,038,602
		Peak Power Demand (MW)	5.1	8.7	29.78

Source: JICA Study Team

The electricity demand forecast in this Master Plan Study was based on the forecast method which was

used in JICA Lao PDR Master Plan Study for Transmission line and Sub-Station, and is aiming at household electrification ratio of 90% by 2020. Though the electrification ratio of 90% is given condition, it is considered to greatly influence demand forecasting whether the power source is an EDL grid or it is an off-grid. The electricity demand forecast in this Master Plan Study was assumed 600kWh/year for rural area with access and 75kWh/year for rural area without access. This assumption means that the area with access was assumed to be electrified with EDL grid power supply.

However, though there is access to some village, the feasibility of EDL grid extension to remote villages may not be economical because of its long distance for transmission lines. Further, the area of EDL grid extension depends on the grid extension plan of PTD 3 of ADB and other project, or provincial grid extension plan. The electrification in the area without hydropower potential will be carried out by EDL grid extension or SHS/VHGS system and Pico-hydro, and such selection shall be depends on the amount of budget for EDL grid extension of Lao PDR up to 2020.

Moreover, as shown in the results of village socio economic survey, the electricity demand in the remote un-electrified villages is born after getting the opportunity to connect electricity source because of desire of purchase of electrical appliances. The amount of electricity demand seems to be decided on the basis of possible electricity supply amount and ability to pay of the village people.

In addition to electricity demand forecast mentioned above, the latest village data for electricity sources and existing plan of electrification were obtained though PDIH staff in 8 provinces and concluded. Further, potential map of village hydro (10kW class) was made by map study of whole area of northern Laos. On the basis of these data, the electricity source of each village in future was assumed from category of EDL grid, off-grid small-hydro and Pico-hydro (village hydro or SHS), and the cost for electrification in STEP 2 (2010~2020) was estimated for the two cases which consist of i) electrification in STEP 2 by SHS and ii) electrification in STEP 2 by EDL grid extension. The results was concluded in Chapter 3.1.2

Data-8: GIS Data

(1) Establishment of Database

Various data was collected and produced for establishing GIS database for the small-hydro project. Data available at NGD (National Geographic Department) that they had collected for the JICA project, “the study for GIS base map data for the Mekong River Basin in Lao people’s democratic republic (hereafter referred to as “Mekong GIS Project”)”, implemented from 1998 to 2003 were suitable as the framework data of the database.

However, among the eight northern provinces to be covered in this small-hydro master plan, GIS data for the Huaphan province is not

available because the Huaphan province does not belong to the river basin area covered in the Mekong GIS Project. (See the right map).

In addition, contour data available at NGD was found inaccurate in two respects: (i) some counter lines on certain maps were incompatible; and (ii) contour intervals varied according to topographic configuration.

Accordingly, generation of missing GIS data over the Huaphan province and correction of contour lines for the 24 sites for field reconnaissance to be covered at the map study were re-consigned to NGD and carried out.

Data required for establishing GIS database for the master plan study on small-hydro was either provided by related institutions as necessary, or newly generated by the study team based on various documents. Due to the variance in the source information, some data turned out to be inconsistent with the framework data for GIS offered by NGD as indicated in the right map. To solve the issue and secure the consistency, NGD data was prioritized in data compilation where such disagreement was observed. Data provided by related institutions or newly produced are summarized in the list below.

No.	Item	Source	Remarks
1	Administrative boundary	NGD: National Geographic Department	
2	Built-up area	ditto	
3	Contour	ditto	
4	Digital Elevation Model	ditto	
5	Elevation point	ditto	
6	Hydrology (Line)	ditto	
7	Hydrology (Polygon)	ditto	
8	Land use	ditto	
9	Road	ditto	
10	Small object	ditto	
11	Village	ditto	
12	Ethnic group	Master Plan Study on Integrated Agricultural Development in Lao PDR, JICA	Edited by study team
13	National Biodiversity Conservation Area	Social and Environmental Division, Department of Electricity	ditto
14	Soil classification	Master Plan Study on Integrated Agricultural Development in Lao PDR, JICA	ditto
15	Hill shade image	Study team	Generated newly by study team
16	22kv transmission line	Electricite du Laos	Added newly and edited by study team
17	35kv transmission line	ditto	ditto
18	115kv transmission line	ditto	ditto
19	Candidate site on this project	Study team	Generated newly by study team
20	Catchment area of candidate site	ditto	ditto
21	Channel of candidate site	ditto	ditto
22	Contour of candidate site	NGD	Subletting work
23	National road	Ministry of Communication Transport Post and Construction	Coordinate system was changed only by study team
24	National and province road	ditto	ditto
25	Solar power station	Electricite du Laos	Edited by study team
26	Power Station	ditto	ditto
27	Structures of candidate site	Study team	Generated newly by study team
28	Power Substation	Electricite du Laos	Edited by study team
29	Transmission line of candidate site	Study team	Generated newly by study team

No.	Item	Source	Remarks
30	Electrified Village	Electricite du Laos	Added newly and edited by study team
31	Average Annual Rainfall	Water Resource Guide Book of Lao PDR Volume-I Second Published 2002. Ministry of Agriculture and Forestry, Department of Metrology and Hydrology. Cooperated by JICA	Generated newly by study team
32	Discharge in Dry Season	Daily Recorded Rainfall of 1991 –1996 in Lao PDR. Ministry of Agriculture and Forestry, Department of Metrology and Hydrology. Cooperated by JICA (1997)	ditto
33	Rainfall station	Water Resource Guide Book of Lao PDR Volume-I Second Published 2002. Ministry of Agriculture and Forestry, Department of Metrology and Hydrology. Cooperated by JICA, and Department of Electricity, Ministry of Industry and Handcrafts	ditto

Source: JICA Study Team

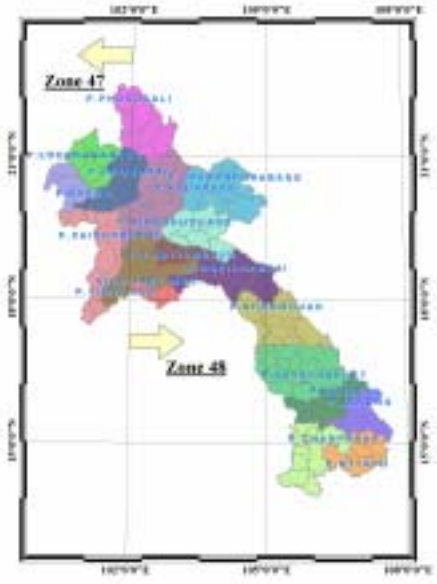
(2) Points to be Considered in terms of Geographic Data in Laos

It is important to keep in mind that in Laos, the reference level applied not only to GIS data but also to the existing contour map of 1:100,000 scale is different from the world standard. Conversion of map projection and/or reference level without knowing this fact could result in producing inaccurate data. In addition, due to differences in specifications between GIS data and existing map as shown below, geographic coordinates derived from GIS data and the ones derived from contour maps are not the same.

Items	GIS database	Existing 1:100,000 scale map
Map projection	UTM (Universal Transverse Mercator)	Gauss Grugar (Transverse Mercator)
Geodetic datum	Lao National Datum 1997	Vientiane Datum 1982
Spheroid	Krasovsky	Krasovsky
Conversion parameter (comparison to WGS84)	DX: 44.585/DY: -131.212/DZ: -39.544	DX: 42.358/DY: -124.688/DZ: -37.366

Source: JICA Study Team

On top of that, in UTM map used in GIS, the country is divided into left and right zones (47 and 48) at longitude 102 ° E (see the map on the right).

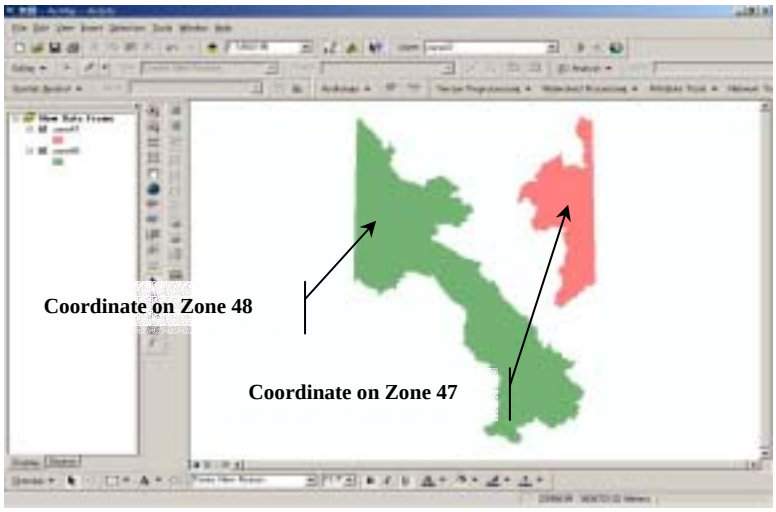


The two (2) zones apply respective coordinates different to each other. Thus, when the two zones are shown in one data, misalignment occurs as shown below: The reason for this is that the two zones are based on different points of origin[1].

In order to prevent such problem from happening and achieve an overall display of the country, zone 47 (western side of longitude 102 ° E) data was converted into zone 48. At the

[1] The UTM projection divides the world by 6 degrees starting at longitude 180 ° towards the east (60 zones altogether). The coordinate origin is the crossing point of the central meridian and the equator in each zone. The origin is defined as a point 500 km west of the central meridian of each longitudinal zone to avoid negative numerical expression in the western side.

same time, a collection of the whole data converting into zone 47 was also prepared just in case it would be needed.



(3) GIS Software & Data Format

ArcGIS ver 8.3 (ArcView function) of Environmental Systems Research Institute, Inc. (ESRI) was selected as the GIS software, in consideration of user-friendliness, versatility, functionality, availability of follow-up system in the country and the prospect for future use.

Furthermore, the Spatial Analyst and 3D Analyst functions were added to enable 3D analysis and display based on spatial analysis data and height information (contour data, etc.).

Thus, the GIS database (shape file and coverage file) established in this project is accessible and available in formats operable by the software.

(4) Application of GIS Data to Master Plan Study on Small-Hydro

Using the created GIS database, the followings tasks were implemented within the scope of the project:

No.	Item	Tasks
1	Production of various output maps	・ Map of the project sites ・ Schematic drawing of EDL grid extension ・ Map of precipitation monitoring sites ・ Map of flow measurement sites ・ Flow map in comparison with the dry season ・ Map study layout ・ Map of river basin subjected to the map study and the measurement of river basin area ・ Pre-F/S basic contour map ・ Basic map for the master plan regarding electrification based on minor hydraulic power plants
2	Information on rural areas	・ Prediction of demand for electricity in rural areas based on the number of rural villages, in planning power transmission lines at the map study. ・ Specifying sites where electricity is needed based on the information on electrification. ・ Specifying potential sites for constructing hydraulic power plants based on a distribution map of villages not connected to the power grids.
3	Environmental impact assessment	・ Land use map ・ Map on soil texture ・ Map of the national protected areas ・ Ethnic distribution map
4	Capacity building of the counterpart	・ To be used in lectures to improve map interpretation skills of the counterpart, in preparation for the map study.

Data-9: Off-grid Electrification Plan in Northern Laos

The existing condition and future plan of off-grid rural electrification in northern Laos was drawn up on the basis of the attainment time of an EDL grid, and was concluded in the Supporting Data Files.

Further, in order to grasp the existing electrification rate of each village, its source of electricity and information about the potential of electricity source, all information was collected through cooperation of PDIH on the basis of the census data about electrification of each village in 2003.

Further, the household number to be electrified and construction cost required for the electrification were estimated at each electrification step, which consists of construction of small-hydro (100kW ~ 5 MW), the World Bank OPS program VHGS system or similar program and village-hydro power electrification (10kW ~ 20kW) in order to satisfy the target electrification rate of the national plan at 2020. The results of improvement of electrification and its cost were concluded in "3.3 future plan of each province and a master plan".

3.3 SUSTAINABLE RENEWAL OF SMALL-HYDRO RURAL ELECTRIFICATION PLAN

3.3.1 SUSTAINABLE PLANNING OF SMALL-HYDRO FROM MASTER PLAN STUDY

In the rural electrification plan, which consists of STEP 1 and STEP 2, the results of small-hydro planning in this Master Plan Study will contribute to an increase of household electrification ratio as follows. In consideration of the condition of dispersed villages in the northern 8 provinces, the average number of households in villages (about 40 HH) and electricity demand per household (190W as of 2010), the electrification by village unit may be the actual electrification method for many cases in the future. Therefore, village-hydro planning with installed capacity of 10~20kW will also be considered in this section.

STEP 1: In STEP 1, a small-hydro plan is required to pull up the average electrification ratio of 31% in the northern 8 provinces in 2003 to 51% in 2010 as follows:

1. In this Master Plan Study, Pre-F/Ss were carried out for 6 off-grid small-hydro plans. The certain implementation of 5 small-hydro plans, excluding Nam Hat 2 in Bokeo, is important. As the result of financial and economic analysis, it was confirmed that the Nam Ou Neau, Nam Likna, Nam Xeng and Nam Chong small-hydro plans are more economical than electrification by diesel power generation or by extension of electricity distribution lines from the existing ELD grid. Therefore, these 4 small-hydro plans should be shifted to the FS stage on the basis of results of the Pre-F/S.

   In the case of Nam Xan 3 small-hydro, it was found that the grid extension toward the electricity demand area was more economical than development of off-grid small-hydro. Therefore, further study on the results of the Pre-F/S is required, aiming at more economical planning and design. Otherwise, the change of planning concept from off-grid to grid strengthening should also be considered, and this can be planned by shifting the location of the

powerhouse downstream to have a bigger head of 1,000m for a MW class small-hydro or cascade type 100kW class small-hydro project.

2. It would be effective to accelerate site investigation, implementation planning and construction of village-hydro plans that were identified at map study level in this Master Plan Study. The village-hydro potential sites are indicated on the GIS maps of each province. Further, the village-hydro is one of the items of the OPS program of the World Bank project. The acceleration of site investigation and village socio-economic survey by ESCO of each province through the rural electrification division of DOE would be effective to realize the electrification of villages in remote areas by village-hydro.

STEP 2: In STEP 2, it is necessary for an increase of electrification ratio to have the investigation, planning and design of small-hydro and village-hydro undertaken by DOE and PDIH staff themselves as follows:

1. In this Master Plan Study, capacity building for counterpart staff in DOE and PDIH was carried out through map study, site investigation and the Pre-F/S of 11 small-hydro plans. On the basis of this basic knowledge, the staff of DOE and PDIH should contribute to an increase of electrification ratio in the northern 8 provinces by continuing the finding, planning, site investigation, design, financial and economic analysis, and acceleration of implementation of small-hydro projects for which Pre-F/Ss have not yet been carried out. In this case, DOE staff should support the PDIH staff on all the procedures.

2. In addition to the village-hydro projects that were selected in this study for implementation in STEP 1, it is necessary to undertake map study and site investigation to find and develop more sustainable village-hydro projects. In this Master Plan Study, two (2) plans of small-hydro schemes were made with installed capacity less than 100kW due to the dispersion of villages, even in a district center. Therefore, the electrification of un-electrified villages in rural areas will be carried out as village units to avoid the high cost of connection between villages with distribution lines. For the development of village-hydro potential sites, it is important that the basic information about the existence of a potential of village-hydro should be confirmed by PDIH and village people themselves through close consultation.

3.3.2 NOTES ON SMALL-HYDRO RURAL ELECTRIFICATION

(1) Planning based on Topographic Information at Site

In this Master Plan Study, the candidate sites for small-hydro schemes were selected from existing reports for small-hydro in plans prepared previously and from the results of map study. Eleven (11) small-hydro plans for the Pre-F/S were selected on the basis of site investigation results. In this screening procedure, there is one disadvantage of map study. Since the map study was carried out on the basis of topographic maps with a scale 1/10,000, or GIS maps with the same scale, the intervals between contour lines were big, being 20m or 40m. Therefore, the effective head for small-hydro

planning, estimated from the topographic maps, was not confirmed at site and this reduces expectation by 50% in some cases, so it was necessary to look for other alternative candidate sites. When we proceed to the small-hydro planning, planning based on not only topographic maps but also the topographic information at site obtained from PDIH staff is required, because in small-hydro planning, the difference of head of 5m has a significant effect on the economic and financial analysis results.

(2) Collaboration with EDL Grid Extension Plan

Though the candidate sites for off-grid small-hydro were selected on the bases of existing EDL grid extension plans, such grid extension planning was adjusted during this study period. Therefore, we confirmed with EDL about the latest grid extension plan at each field investigation. In 2006, the next grid extensions scheme, PTD3, is scheduled for formulation. It is important that the grid extension plan of PTD3 should be obtained and understood as soon as possible through confirmation with EDL planning section by DOE staff, and further off-grid small-hydro electrification plans should be implemented aiming at consistency with PTD3. For reference, the grid extension plans demanded at province level after PTD 2 were indicated in GIS maps as much as possible.

(3) Small-Hydro Planning considering Local Hydrology and Topography

As a result of plotting the electrification condition at each village on a GIS map, it was found that there is a local characteristic of electrification method for remote areas to which the EDL grid has not yet reached in each province. In Huaphanh province, which has much annual rainfall comparatively, there are many existing small-hydro plants and Pico-hydro schemes permeate through many households. On the other hand, in Xayabury and Bokeo provinces, SHS is quickly becoming widespread. This situation reflects whether there is sufficient available river discharge required for small-hydro.

As shown in the specific discharge map in dry season in northern Laos, which was prepared in this Master Plan Study, small-hydro can be developed with high efficiency in the whole area of Huaphanh, Xiengkhuang, Phongsaly and the northern areas of Luangnamtha, Oudomxay and Luangphrabang. On the basis of this local characteristic, and considering topographical conditions, the electrification method for un-electrified villages in remote areas that will not receive EDL grid distribution, should be selected to achieve efficient electrification.

3.3.3 DATABASE OF GIS SYSTEM

The database prepared in this Master Plan Study was divided into following 4 categories as shown in GIS diagram considering with the characteristics and meaning of each data, and the purpose in this Master Plan Study. The each data was made on the basis of data contents from 4 types of data form, which consist of point data, line data, polygon data and grid data.

The database has been classified into four items as indicated in the diagram taking into account the characteristics and implications of the different data, the purposes of use thereof in the study, etc. Furthermore, it has been generated on the basis of selection from among four forms of data, i.e. points, lines, polygons and grids, according to the content of the geographic information indicated by the different data.

(1) Skeletal Data (Skeletal_GIS)

The first item is GIS data on a scale of 1:100,000 obtained from the NGD (National Geographic Department) at the beginning of the study as basic data. As it is shown in the designations of the different data in the diagram, that data concerns the country's basic geographic information such as roads, rivers and national boundary. There is no editing or other changing of the data in this item.

(2) EIA Data

The second item is data obtained from the Laotian organizations concerned as needed for environmental impact assessment in the study. There has been some editing of data in this item for the sake of ensuring topographical consistency with other data.

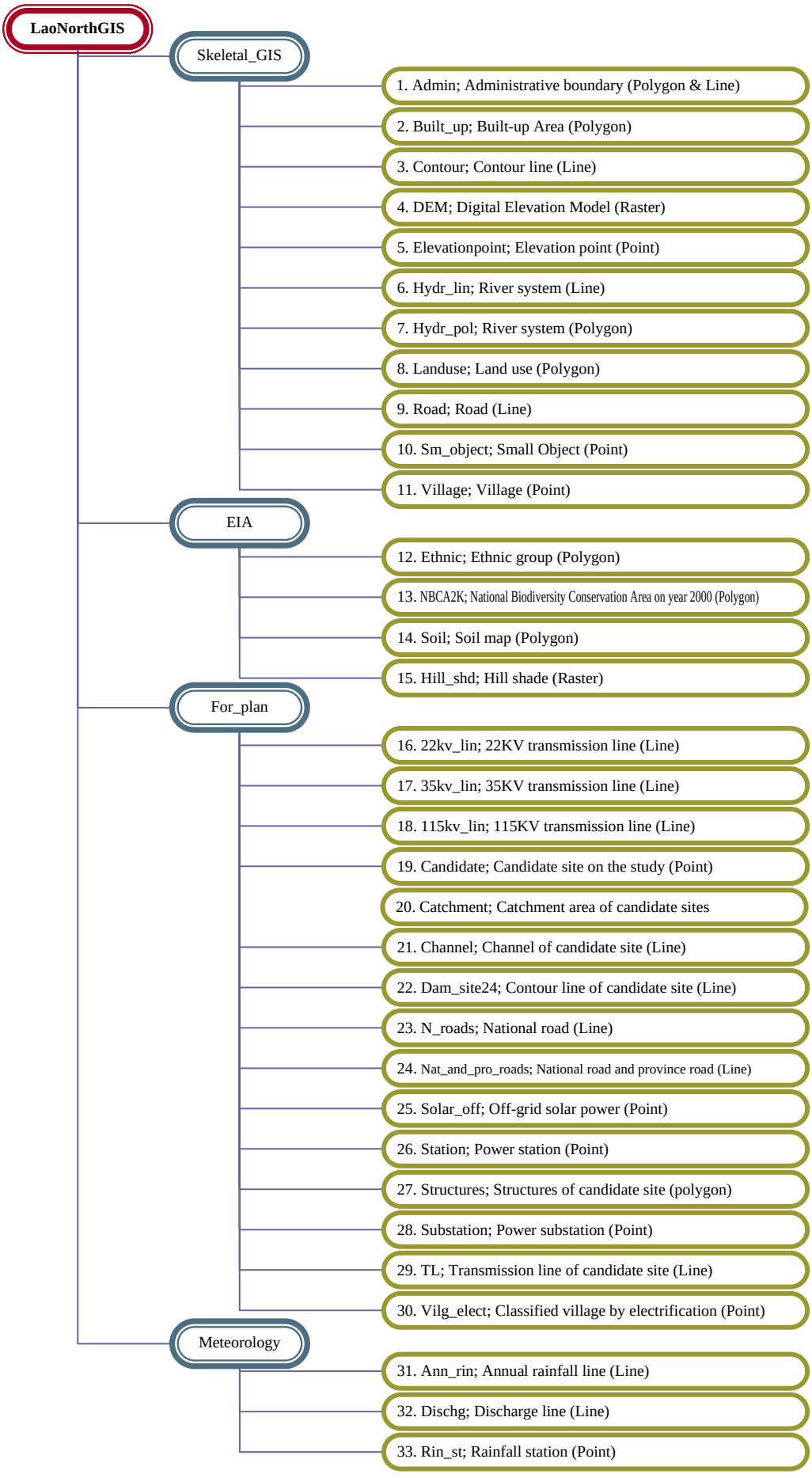
(3) Additional Data for Planning (For_plan)

The third item is data used the most in the study, for purposes such as the master plan for electrification based on small-hydro and specific determination of potential sites for hydropower generation. That data consists of data newly prepared in the study and data obtained from the organizations concerned. Regarding the data in that item, there has been some additional editing of the data obtained from the organizations concerned for the purpose of reflecting in it the new results obtained by the Study Team itself.

(4) Meteorological Data

The fourth item is data of meteorology and hydrology. That data has been newly prepared by the study team on the basis of information on paper collected by it because of inability to collect it in the form of GIS data due to lack thereof.

Judging from the explanations (concerning the techniques of preparation and updating thereof) received at the time of obtaining the data from the organizations concerned and from things like the content of the information that has served as the basis for the newly prepared data, we believe that it is desirable to utilize this GIS database on a scale of about 1:100,000. Furthermore, we very much hope that in future use of such databases the Laotian side will keep in mind such considerations as the techniques and dates of preparation or updating of the individual data and the reliability of the different data.


LaoNorthGIS
Skeletal_GIS
1. Admin; Administrative boundary (Polygon & Line)
2. Built_up; Built-up Area (Polygon)
3. Contour; Contour line (Line)
4. DEM; Digital Elevation Model (Raster)
5. Elevationpoint; Elevation point (Point)
6. Hydr_lin; River system (Line)
7. Hydr_pol; River system (Polygon)
8. Landuse; Land use (Polygon)
9. Road; Road (Line)
10. Sm_object; Small Object (Point)
11. Village; Village (Point)
EIA
12. Ethnic; Ethnic group (Polygon)
13. NBCA2K; National Biodiversity Conservation Area on year 2000 (Polygon)
14. Soil; Soil map (Polygon)
15. Hill_shd; Hill shade (Raster)
For_plan
16. 22kv_lin; 22KV transmission line (Line)
17. 35kv_lin; 35KV transmission line (Line)
18. 115kv_lin; 115KV transmission line (Line)
19. Candidate; Candidate site on the study (Point)
20. Catchment; Catchment area of candidate sites
21. Channel; Channel of candidate site (Line)
22. Dam_site24; Contour line of candidate site (Line)
23. N_roads; National road (Line)
24. Nat_and_pro_roads; National road and province road (Line)
25. Solar_off; Off-grid solar power (Point)
26. Station; Power station (Point)
27. Structures; Structures of candidate site (polygon)
28. Substation; Power substation (Point)
29. TL; Transmission line of candidate site (Line)
30. Vilg_elect; Classified village by electrification (Point)
Meteorology
31. Ann_rin; Annual rainfall line (Line)
32. Dischg; Discharge line (Line)
33. Rin_st; Rainfall station (Point)

3.4 MASTER PLAN OF SMALL-HYDRO RURAL ELECTRIFICATION AT DISTRICT LEVEL

The existing electrification condition was concluded for each province and district on the basis of investigation results of each village unit. The targets of electrification rate of each province and district were assumed by the Study Team considering existing electrification ratio and the national electrification target of electrification by 2020. In order to attain the each target of district, the electrification policy and problem to be solved were studied on the basis of existing electrification condition and plans. In this Master Plan Study, the potential sites of village-hydro were found by the map study. If the potential of village-hydro was found in isolated villages, the village-hydro was considered to be electrification method of their villages and the procedure of OPS program by the World Bank or similar approach was supposed for its implementation. Such village –hydro potential sites were plotted on GIS maps.

In the isolated villages, which have no plan for EDL grid extension, the Pico-hydro and the SHS are considered to be one of electrification method. If the SHS is proposed in this mater plan, the implementation procedure of OPS program of the World Bank or similar approach was supposed for its implementation method. Further, in order to grasp the cost for electrification to attain the target electrification ratio in 2020, the required cost for STEP 2 was estimated by assuming the case of SHS electrification of OPS program, and estimated cost was mentioned in summary table of master plan for each district.

3.4.1 PHONGSALY PROVINCE

Phongsaly province is located at the northernmost tip in northern Laos, and the power line of EDL has not yet reached. The rate of household electrification as of 2005 is 14.4%, and depends on a power supply on off-grid small-hydro (Nam Ngai 1.2MW), diesel power generation, and slight Pico-hydro generation. Although EDL grid is scheduled to be extended to Bonnua in the short term plan of EDL, it is likely to separate from the area of the grid extension plan by PTD2, and is likely to become the realization about 2010. Since the Phongsaly province is behind in electrification, its life level is low, although there was an electric power import plan from China in the past in a Nhot Ou district, village people's solvency is low, and a plan was disappear. The rate target value of household electrification in 2020 of Phongsaly is 67%, and describes the electrification plan of each districts proposed by the Study Team towards this.

(1) Phongsaly District

The rate of household electrification of Phongsaly in the 2005 is 33%, and the Nam Ngai small-hydro (1.2 MW) completed in 2003 serves as the main power source, in addition the Pico-hydro of each

household base also is used. As a future electrification plan, though the grid extension to Phongsaly central part from Bonnua is planned, it is likely to become in 2010 and afterwards. However, the present load of the Nam Ngai small-hydro plant under operation remains in 300kW to the equipment capacity of 1.2 MW. The positive expansion to the near village of the power transmission line from Nam Ngai small-hydro plant can contribute to effective use of the Nam Ngai small-hydro and electrification target achievement by electrification of surrounding villages, and examination of the extension plan by the district is required. Moreover, four village-hydro potential sites, which were confirmed under map study level, are required for site investigation, planning and design.

Furthermore, in order to attain a final target electrification rate of 80% of household, it is thought that the broad electrification by Pico-hydro and SHS of an OPS program type in the isolated villages, which has no grid extension plan, is required. However, as there is no much experience of Pico-hydro and SHS in this district, the public information with trial construction is necessary.

Phongsaly District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	4,483	-	1,471	-	33	-	-
Step 1	EDL Line Extension		473	2,367	8	41	761,041	761,041
	JICA Off-grid small-hydro		0	2,367	0	41	0	761,041
	VH Potential, SHS Plan		241	2,608	4	45	54,674	815,715
Step 2	Required Electrification	5,774	2,011	4,619	35	80	561,092	1,376,807

Source: JICA Study Team

(2) May District

The rate of household electrification of May in the 2005 is 6%, and the diesel power generation for a district center serves as the main power source. As a future electrification plan, although the grid extension plan of EDL is planned a little, it is likely to become in 2010 and afterwards. Moreover, two village-hydro potential sites, which were confirmed under map study level, are required for site investigation, planning and design. In order to attain a target electrification rate of 40% of households, it is thought that the spread of SHS(s) to comparatively rich villages, which locate in center to northern area of district, is appropriate.

As the alternative plan of rural electrification aiming at target, the EDL grid extension to district center along the paved road which continues from Khua district, and shifting to an EDL tariff system from existing electricity tariff of 2,000 kip(s)/kWh. Moreover, as the example of Huaphanh province, if a contract of electricity purchase from Vietnam is realized at a reasonable price, there is possibility of the electric supply stabilized at a cheap price rather than power line extension.

Although the Nam Nga small-hydro project, which map study was carried out by this master plan, was considered as alternative power generation of diesel power generation, it brings a result with the high power generation cost by map study and was judged not to be feasible.

May District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	3	-	214	-	6	-	-
Step 1	EDL Line Extension		121	397	2	8	194,926	194,926
	JICA Off-grid small-hydro		0	397	0	8	0	194,926
	VH Potential, SHS Plan		81	478	2	10	18,420	213,346
Step 2	Required Electrification	4,809	1,446	1,924	30	40	403,409	616,754

Source: JICA Study Team

(3) Khua District

The rate of household electrification of Khua in the 2005 is 12%, and the diesel power generation for a district center serves as the main power source. As a demand of province, although the grid extension plan of EDL may be scheduled as PTD 3, it is likely to become in 2010 and afterwards. Moreover, three village-hydro potential sites, which were confirmed under map study level, are required for site investigation, planning and design. In order to attain a target electrification rate of 70% of households, it is thought that the spread of SHS to villages in south-east area is appropriate.

The Nam Kai small-hydro project which map study was carried out in this master plan, is located in an EDL power line extension plan area, and the Pre-F/S was not carried out.

Khua District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	4,890	-	576	-	12	-	-
Step 1	EDL Line Extension		1,262	2,004	20	32	2,032,206	2,032,206
	JICA Off-grid small-hydro		0	2,004	0	32	0	2,032,206
	VH Potential, SHS Plan		171	2,175	3	35	38,886	2,071,092
Step 2	Required Electrification	6,298	2,233	4,409	35	70	623,116	2,694,209

Source: JICA Study Team

(4) Samphanh District

The rate of household electrification of Samphanh in the 2005 is 6%, and the Pico-hydro is the main power source. As there is no major electrification plan for district center towards 2010, this district center is one of target for electrification in this master plan. The Nam Likna small-hydro is under the Pre-F/S as a candidate site, which has installed capacity of 30kW and located at the small river just behind district center. As the results of the Pre-F/S, the Nam Likna small-hydro is more economical than the other development of electrification method. Moreover, four village-hydro potential sites, which were confirmed under map study level, are required for site investigation, planning and design. Furthermore, the many un-electrified villages locate on the ridge of hill and the access to village is quite difficult. In order to attain a target electrification rate of 60% of households, it is thought that the spread of SHS to villages is appropriate.

Samphanh District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	4,092	-	245	-	6	-	-
Step 1	EDL Line Extension		3	318	0	6	4,147	4,147
	JICA Off-grid small-hydro		68	386	1	7	198,273	202,420
	VH Potential, SHS Plan		273	659	6	13	61,984	264,404
Step 2	Required Electrification	5,270	2,503	3,162	47	60	698,293	962,697

Source: JICA Study Team

(5) Booneua District

The rate of household electrification of Booneua in the 2005 is 28%, and the Nam Boun 1 small-hydro plant (110kW) completed in 1996 supply the electricity for district center and other villages as the main power source. However, the actual generate output is 80kW and it is not enough for the demand of this area, and some problem such as damage of stator coil was confirmed. Some diesel power generation also is carried out. As a future electrification plan, the grid extension plan of EDL is planned. Moreover, one village-hydro potential site, which was confirmed under map study level, is required for site investigation, planning and design. In order to attain a target electrification rate of 80% of households, it is thought that the spread of SHS to villages is appropriate.

Furthermore, the Pre-F/S of Nam Booune 2 hydroelectric project (4MW) was carried out and its effectiveness was confirmed, which will be reinforcement power generation equipment of the EDL power line which is an extension schedule around 2010 to BONNUA. By this enforcement, it may cooperate with Nam Ngai small-hydro project and may become the power source of the grid electric power of Phongsaly province.

Booneua District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	3,279	-	912	-	28	-	-
Step 1	EDL Line Extension		1,195	2,370	28	56	1,924,375	1,924,375
	JICA Off-grid small-hydro		0	2,370	0	56	-	1,924,375
	VH Potential, SHS Plan		70	2,439	2	58	15,788	1,940,163
Step 2	Required Electrification	4,223	939	3,379	22	80	262,039	2,202,203

Source: JICA Study Team

(6) Nhot Ou District

The rate of household electrification of Nhot Ou in the 2005 is 5%, although there was an electric power import plan from China in the past in a Nhot Ou district, village people's solvency is low, and a plan was disappear. However, the demand of electrification of village people is very high. As there is no major electrification plan for district center towards 2010, this district center is one of target for electrification in this master plan. The Nam Ou Neau small-hydro is under the Pre-F/S as a candidate site, which has installed capacity of 264kW and located at Nam Ou River which flowing from sub-district center Ou-neau to district center Ou-tai. Moreover, five village-hydro potential sites, which were confirmed under map study level, are required for site investigation, planning and design. In order to attain a target electrification rate of 50% of households, it is thought that the spread of SHS of

an OPS program type to villages is appropriate.

Not Ou District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	4,130	-	194	-	5	-	-
Step 1	EDL Line Extension		0	250	0	5	1,587,867	1,587,867
	JICA Off-grid small-hydro		611	860	11	16	-	1,587,867
	VH Potential, SHS Plan		422	1,283	6	22	95,899	1,683,766
Step 2	Required Electrification	5,319	1,377	2,660	28	50	384,147	2,067,914

Source: JICA Study Team

(7) Boontai District

The rate of household electrification of Boontai in the 2005 is 12%, and the diesel power and Pico-hydro are the main power source. As a future electrification plan, the grid extension plan of EDL is planned up to around 2010, it makes the rate of electrification to be 32%. Moreover, one village-hydro potential sites, which was confirmed under map study level, is required for site investigation, planning and design. In order to attain a target electrification rate of 100% of households at 2020, it is thought that the spread of SHS of to villages in west and north area is appropriate.

Boontai District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	2,802	-	326	-	12	-	-
Step 1	EDL Line Extension		747	1,167	20	32	1,786,140	1,786,140
	JICA Off-grid small-hydro		0	1,167	0	32	0	1,786,140
	VH Potential, SHS Plan		64	1,231	2	34	14,619	1,800,759
Step 2	Required Electrification	3,609	2,378	3,609	66	100	663,364	2,464,123

Source: JICA Study Team

3.4.2 LUANGNAMTHA PROVINCE

Since Luangnamtha was behind in attainment of the EDL grid line, it started the electric power import from China in provincial management in April, 2003. Imported electricity through the Sing is consumed by the Sing district and district center of Luangnamtha district, and the peak load is about 1 MW. The import tariff from China is 585 kips/kWh, and sales tariff to a consumer is 1000 kip(s)/kWh. The rate of household electrification as of 2005 is 35%, and power source are imported electric power, diesel power generation, slight small-hydro, and Pico-hydro. In the short term plan of EDL, 115kV EDL transmission line is scheduled to be extended to Luangnamtha at 2006 by PTD2. The rate target value of household electrification in 2020 of Luangnamtha is 80%, and describes the electrification plan of each district proposed by the Study Team below.

Moreover, PTD3 is planned as extension and expansion of the further EDL 22kV transmission line after PTD2, the future EDL grid extension plan should be investigated in detail, and the electrification plan of each county needs to be adjusted continuously. The province desires the grid extension of 22kV line from district center toward Nalae and Viengphoukha.

(1) Namtha District

The rate of household electrification of Namtha in the 2005 is as high as 54%, and the electric power imported from China through Sing started in 2003 supply electricity to district center as the main power source, in addition diesel power generation also is used. As a future electrification plan, the Nam Tha 3 small-hydro (1.2MW) will be completed within 2005, and be operated. On the other hand, the EDL transmission line will be extended to Namtha from Luangpharabang by 2006, and it will be connected with grid of imported power. Moreover, one village-hydro potential site only was checked by map study level. In order to attain a target electrification rate of 100% of households at 2020, it is thought that the spread of SHS of OPS program type to villages is appropriate. In this district, as there are some villages which has been electrified along the main road by SHS already, it is thought that public relations can be spread smoothly.

Namtha District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	7,198	-	4,680	-	65	-	-
Step 1	EDL Line Extension		155	6,182	2	67	248,842	248,842
	JICA Off-grid small-hydro		0	6,182	0	67	-	248,842
	VH Potential, SHS Plan		55	6,238	1	68	12,572	261,414
Step 2	Required Electrification	9,271	3,033	9,271	32	100	846,274	1,107,688

Source: JICA Study Team

(2) Sing District

The rate of household electrification of Sing in the 2005 is as high as 42%, and the electric power imported from China through Sing started in 2003 supply electricity to district center as the main power source, in addition diesel power generation also is used. As a future electrification plan, The 22 kV transmission line will be extended from Sing district to Long district by 2008. No village-hydro potential site was checked by map study level. In order to attain a target electrification rate of 80% of households at 2020, it is thought that the spread of SHS of OPS program type to villages is appropriate for northern area of Sing district which is still far from EDL grid in future. In this district, as there are some villages in the central area towards northern area, which has been electrified by SHS already, it is thought that public relations can be spread smoothly.

Sing District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	5,661	-	2,338	-	42	-	-
Step 1	EDL Line Extension		0	3,011	0	42	-	-
	JICA Off-grid small-hydro		0	3,011	0	42	-	-
	VH Potential, SHS Plan		0	3,011	0	42	-	-
Step 2	Required Electrification	7,291	2,822	5,833	38	80	787,268	787,268

Source: JICA Study Team

(3) Long District

The rate of household electrification of Long in the 2005 is the minimum in this province and 10%. The main power source is diesel power generation (30kW), and the district is managing them. As a

future electrification plan, 22kV transmission line is scheduled to be extended from Sing district to Xiengkok of Long district by 2008 in PTD2. Moreover, four village-hydro potential sites were checked by map study level including the Xiengkok area. Moreover, four village-hydro potential sites, which were confirmed under map study level, are required for site investigation, planning and design. Furthermore, in order to attain a target electrification rate of 60% of households, it is thought that SHS is required for the electrification of the northwestern part area. In the northern part of long district, though there are villages electrified by SHS already, it is thought that further public relations and spread are required.

In Xiengkok which is most west village of Long district, the Houay Key Buan small-hydro was constructed (100kW) on the basis of contract between province and Chinese contractor at 2002. However, its water channel was broken due to land slide during first rainy season after completion of project. After that it was restored and it was damaged due to land slide again, finally it was abandoned without power generation. It is guessed that the design by Chinese contractor is not suitable. After this problem, the intake weir has been filled with sedimentation and total restoration seems to be difficult. However, by use of same intake weir, the other alternative small-hydro generation plan is available by diverting river water towards another tributary to fulfill the power demand of Xiengkok. This alternative plan was investigated during site reconnaissance by JICA study team.

Furthermore, the Pre-F/S of Nam Long hydropower project was carried out as a grid reinforcement plan after 22kV power line extends to this area, and the generated cost of about 3 cents/kWh was estimated by usage of head of same falls. The FS is required for the implementation.

Long District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	4,984	-	479	-	10	-	-
Step 1	EDL Line Extension		1,020	1,637	16	26	1,642,355	1,642,355
	JICA Off-grid small-hydro		0	1,637	0	26	-	1,642,355
	VH Potential, SHS Plan		222	1,859	3	29	50,289	1,692,643
Step 2	Required Electrification	6,419	1,993	3,852	31	60	556,061	2,248,705

Source: JICA Study Team

(4) Viengphoukha District

The rate of household electrification of Viengphoukha in the 2005 is 23 %. The main power source is diesel power generation (30kW), and the district is managing them. As a future electrification plan, there is no major electrification plan, and new small-hydro project is required. However, it was found that there is no suitable site for small-hydro project near district center through the site reconnaissance at three candidate project site. Moreover, no village-hydro potential sites were checked by map study level. In order to attain a target electrification rate of 80% of households, it is thought that SHS of an OPS program type is required for the electrification of the northwestern part area. In the northern part of district center, as there are villages electrified by SHS already, it is thought that spread can be developed smoothly. The access towards south area seems to be difficult.

Viengphoukha District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	3,482	-	785	-	23	-	-
Step 1	EDL Line Extension		0	1,011	0	23	0	0
	JICA Off-grid small-hydro		0	1,011	0	23	0	0
	VH Potential, SHS Plan		0	1,011	0	23	0	0
Step 2	Required Electrification	4,485	2,577	3,588	57	80	718,920	718,920

Source: JICA Study Team

(5) Nalae District

The rate of household electrification of Nalae in the 2005 is 15%. The main power source is Hoay Nun small-hydro plant (30kW) at district center, and SHS of at villages around district center and along the main road. The Hoay Nun small-hydro plant is operated for three hours at dry season by manual operation, and diesel generator was installed after 2003 for backup, and electrification situation was improved. As a future electrification plan, there is no major electrification plan, and new small-hydro project is required. However, it was found that there is no suitable site for small-hydro project near district center through the site reconnaissance at candidate project sites. Moreover, no village-hydro potential sites were checked by map study level. In order to attain a target electrification rate of 70% of households, it is thought that SHS of an OPS program type is required for the electrification of the south part area. Near the district center, as there are villages electrified by SHS already, the SHS will spread smoothly. The access towards south area seems to be difficult.

Nalae District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	3,843	-	557	-	15	-	-
Step 1	EDL Line Extension		0	717	0	15	0	0
	JICA Off-grid small-hydro		0	717	0	15	0	0
	VH Potential, SHS Plan		0	717	0	15	0	0
Step 2	Required Electrification	4,950	2,747	3,465	55	70	766,534	766,534

Source: JICA Study Team

3.4.3 OUDOMXAY PROVINCE

The center of Oudomxay, which consists of Xai district and La district, has been electrified by Nam Ko small-hydro Project (1.5MW) at 1996. Nam Ko small-hydro was constructed by Chinese government Loan, and operated by EDL. Though it has installed capacity of 1.5MW, actual out put is 1.2MW at rainy season and 300~500kW at dry season. On the other hand, the peak load of demand center is 1.7MW. Therefore, there is shortage of power supply at rainy season also. To cover this shortage, the diesel generators (300kw x 2, 160kW x 1) were set up for stand by. The rate of household electrification is 20% and power sources are Nam Ko HPP, Houay Kasen HPP in Pakbeng district, diesel generator and SHS of OPS program. In EDL short term plan, the 115 kV transmission line will be extended from Luangphrabang to Luangnamtha through Xay district. Furthermore, the 22 kV transmission line will be extended from Xay district towards Beng and Houn districts by 2008. The target of household electrification rate at 2020 is 71 %, and electrification policy proposed by the

Study Team towards this target is as below.

Moreover, the extension of EDL 22 KV as a PTD 3 is scheduled to be done after PTD 2. It is required to grasp this PTD 3 activity and electrification plan should be adjusted continuously.

(1) Xay District

The rate of household electrification of Xay in the 2003 is as high as 44%, and electricity from Nam Ko HPP is the main power source, in addition diesel power generation also is available for stand by. At present, the villages are located along the road between Xay district and center of La district has been electrified already. As the future electrification plan, the 115 kV transmission line will be extended from Luangphrabang to Luangnamtha through Xay district, the villages locates near this transmission line will be electrified. However, electrification of the village currently distributed to the western part of district is behind, and electrification by SHS of an OPS program is carried out in 7 villages for now. In order to attain a target electrification rate of 95% of households, it is thought that the further electrification by the extension of distribution line toward west area of district, which villages densely locate, and SHS is required.

Xay District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	11,050	-	4,868	-	44	-	-
Step 1	EDL Line Extension		1,570	8,094	0	55	2,528,473	2,528,473
	JICA Off-grid small-hydro		0	8,094	0	55	0	2,528,473
	VH Potential, SHS Plan		0	8,094	0	55	-	2,528,473
Step 2	Required Electrification	14,807	5,973	14,067	40	95	1,666,481	4,194,954

Source: JICA Study Team

(2) La District

The rate of household electrification of La in the 2003 is 24%, and the main power source is same as Xay. At present, the district center of La has been electrified already. As the future electrification plan, the 22 kV transmission line will be extended from Xay to Khua of Phongsaly district, the villages locates near this transmission line will be electrified. However, electrification of the village currently distributed to the eastern and western part of district is behind, and electrification by SHS of an OPS program is required in order to attain a target electrification rate of 95% of households. The potential site for village-hydro was not found in this district.

There was the candidate site of Nam Phak hydroelectric project (EDL grid reinforcement) of MW class in a northwestern of district, and map study was carried out. However, since access was difficult, site reconnaissance was not carried out at his time. The further investigation is required under cooperation of PDIH.

La District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	2,740	-	643	-	24	-	-
Step 1	EDL Line Extension		667	1,529	18	42	1,074,385	1,074,385
	JICA Off-grid small-hydro		0	1,529	0	42	0	1,074,385
	VH Potential, SHS Plan		0	1,529	0	42	-	1,074,385
Step 2	Required Electrification	3,672	1,959	3,488	53	95	546,583	1,620,969

Source: JICA Study Team

(3) Namo District

The rate of household electrification of Namo in the 2003 is 5%, and the main power source is diesel generator and SHS. As the future electrification plan, the 115 kV transmission line will be extended from Luangphrabang to Luangnamtha through Xay and Namo district, the villages locates near this transmission line will be electrified. Furthermore, the 115 kV is scheduled to be extended from center of district to Boontai district of Phongsaly, and electrification at north area also will be expected. However, electrification of the village currently distributed to the south part of district is behind, and electrification by SHS of an OPS program is required in order to attain a target electrification rate of 80% of households. The potential site for village-hydro was not found in this district.

Namo District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	4,960	-	268	-	5	-	-
Step 1	EDL Line Extension		1,253	1,612	19	24	2,017,169	2,017,169
	JICA Off-grid small-hydro		0	1,612	0	24	0	2,017,169
	VH Potential, SHS Plan		0	1,612	0	24	-	2,017,169
Step 2	Required Electrification	6,646	3,705	5,317	56	80	1,033,723	3,050,892

Source: JICA Study Team

(4) Nga District

The rate of household electrification of Nga in the 2003 is 23%, and the main power source is NEDO Houay Se Hybrid small-hydro project (150kW) and diesel generator. Due to this HPP, 10 numbers of villages has been electrified. Though there is no major electrification plan in this district, 11 village-hydro potential sites, which were confirmed under map study level, are required for site investigation, planning and design. However, for the villages, which have no river in south part of district, the SHS is required to attain 70% of final rates of target household electrification.

Nga District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	4,121	-	970	-	24	-	-
Step 1	EDL Line Extension		0	1,300	0	24	-	-
	JICA Off-grid small-hydro		0	1,300	0	24	-	-
	VH Potential, SHS Plan		391	1,691	7	31	88,821	88,821
Step 2	Required Electrification	5,522	2,174	3,865	39	70	606,663	695,483

Source: JICA Study Team

(5) Beng District

The rate of household electrification of Beng in the 2003 is 7%, and the main power source is diesel generator. As the future electrification plan, the 22 kV transmission line will be extended from Xay district to Houn District by 2008 in PTD 2, the villages locates near TL will be electrified. Three villages were electrified by SHS already. However, for the villages far from this 22kV line, the SHS is required to attain 55% of final rates of target household electrification. The potential site for village-hydro was not found in this district though Map Study.

Beng District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	5,324	-	380	-	7	-	-
Step 1	EDL Line Extension		2,601	3,110	37	44	4,187,513	4,187,513
	JICA Off-grid small-hydro		0	3,110	0	44	-	4,187,513
	VH Potential, SHS Plan		0	3,110	0	44	-	4,187,513
Step 2	Required Electrification	7,134	814	3,924	11	55	227,008	4,414,521

Source: JICA Study Team

(6) Houn District

The rate of household electrification of Houn in the 2003 is 10%, and the main power source is diesel generator and SHS of OPS program. As the future electrification plan, the 22 kV transmission line will be extended from Xay district to Houn District by 2008 in PTD 2, the villages locates near TL will be electrified. However, for the villages far from center of Houn district, the SHS of OPS program type is required to attain 50% of final rates of target household electrification. The SHS has been installed at 9 villages in south part of district. The potential site for village-hydro was confirmed at 1 location.

The map study was carried out for Nam Nga small-hydro project which was located at east part of Houn district. However, it was not selected for the Pre-F/S because of the long distance from project site to 22 kV line which will be constructed in PTD 2, difficulty on access and small head for power generation. According to head of Beng district, there is diversion scheme from Nam Nga towards Nam Beng through headrace tunnel which will have head of 200m or more for power generation, further investigation with PDIH is necessary.

Houn District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	9,403	-	937	-	10	-	-
Step 1	EDL Line Extension		1,518	2,774	12	22	2,444,334	2,444,334
	JICA Off-grid small-hydro		0	2,774	0	22		2,444,334
	VH Potential, SHS Plan		92	2,866	1	23	20,988	2,465,323
Step 2	Required Electrification	12,600	3,434	6,300	27	50	958,016	3,423,339

Source: JICA Study Team

(7) Pakbeng District

The rate of household electrification of Pakbeng in the 2003 is 7%, and the main power source is

Houay Kasen small-hydro project (155kW). This small-hydro plant was designed and constructed by Chinese contractor with district budget. However, the actual power generation is 75kW in rainy season to meet low load and 35~ 40kW with 2 hours generation in dry season due to small river flow, which is not satisfied for demand. Moreover, the excavated surface beside waterway is going to collapse due to steep excavation slope, and the maintenance civil work is required urgently. Further, the governor is not working properly and the power generation with low efficiency is being continued. As there is no major electrification plan, the additional power source is necessary. However, for the villages locate at southwest area, there is no VH potential site. Therefore, the SHS of OPS program type is required to attain 50% of final rates of target household electrification. The potential sites for VH of OPS program were confirmed at 3 locations in west part of district.

In order to have power source for Pakbeng which is the main port in the Mekon River for tourism, the map study was carried out for Nam Tale small-hydro project. However, it was not selected for the Pre-F/S due to long distance from project site to load center. The other alternative plan should be made and investigated with PDIH.

Pakbeng District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	3,902	-	272	-	7	-	-
Step 1	EDL Line Extension		59	423	1	8	94,926	94,926
	JICA Off-grid small-hydro		0	423	0	8	0	94,926
	VH Potential, SHS Plan		107	531	2	10	24,334	119,260
Step 2	Required Electrification	5,229	2,084	2,614	40	50	581,352	700,612

Source: JICA Study Team

3.4.4 BOKEO PROVINCE

Since Bokeo locates at most west side of northern Laos and was behind in attainment of the EDL grid line, it started the electric power import from Thailand in provincial management in 1996 with operation by EDL. The electricity imported through Huoixai is consumed in Huoixai, Tonpheung and Paktha, the peak load is about 2 MW. The tariff of imported power is 8cent/kWh at peak time and 3.5 cent/kWh at off-peak time, and sales tariff for consumer is EDL tariff. The rate of household electrification as of 2005 is 37% and main power sources are imported power and Pico-hydro. According to EDL plan, there is no extension plan of 115kV and 22kV transmission line to Bokeo. The rate target value of household electrification in 2020 of Luangnamtha is 85%, and describes the electrification plan of each district proposed by the Study Team below.

(1) Huoixai District

The rate of household electrification of Huoixai in the 2005 is as high as 51%, and the main power source is power imported from Thailand. At present, the electrified area is center of Huoixai and area along the Mekon River towards upstream and downstream sides, 22kV line is being extended toward south part of Paktha. Moreover, the electrified area is expanding along the road from center of Huoixai towards Luangnamtha gradually. As the future electrification plan, existing 22kV line is

extending from center to north area in which village is crowd, and neighboring villages will be electrified. Though electrification of the village currently distributed to the eastern part of district is behind, 6 village-hydro potential sites, which were confirmed under map study level, are required for site investigation, planning and design. In order to attain a target electrification rate of 100% of households, the further electrification by SHS also is required as same procedure as 4 villages electrified already.

There is Nam Gnone small-hydro project site at Gnone River which locates in western part of district, and map study, site reconnaissance and the Pre-F/S have been finished. The purpose of Nam Gnone Project is reducing of power imported from Thailand due to connection with import grid. However, as the results of the Pre-F/S, the Nam Gnone small-hydro is not good enough economically to reduce power imported from Thailand. The main reason seems to be low head.

Huoixai District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	10,241	-	5,202	-	51	-	-
Step 1	EDL Line Extension		1,526	8,226	11	62	2,457,311	2,457,311
	JICA Off-grid small-hydro		0	8,226	0	62	-	2,457,311
	VH Potential, SHS Plan		644	8,870	5	67	161,258	2,618,568
Step 2	Required Electrification	13,190	4,320	13,190	33	100	1,205,267	3,823,835

Source: JICA Study Team

(2) Tonpheung District

The rate of household electrification of Tonpheung in the 2005 is as high as 78%, and the main power source is power imported from Thailand. The villages locates along 22 kV line which is extended from Huoixai along the Mekon River towards north direction have been almost electrified, and such area will go up towards further north direction to electrify some villages. There is possibility of extension of 22kV line towards inside of district. In order to attain a target electrification rate of 90% of households, the further electrification by SHS also is required in the isolated villages.

Tonpheung District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	4,877	-	3,808	-	78	-	-
Step 1	EDL Line Extension		33	4,938	1	79	53,916	53,916
	JICA Off-grid small-hydro		0	4,938	0	79	-	53,916
	VH Potential, SHS Plan		0	4,938	0	79	-	53,916
Step 2	Required Electrification	6,282	715	5,653	11	90	199,548	253,464

Source: JICA Study Team

(3) Meung District

The rate of household electrification of Meung in the 2005 is 23%, and the main power source is Pico-hydro and the electricity is available for the room lump and black and white TV during night time even at district center. Furthermore, there is no major electrification plan in this area, and this area is the target of electrification by small-hydro in our master plan. The Nam Chong small-hydro project was found during site reconnaissance and the Pre-F/S is being carried out. The possibility of

electrification of district center by use of intake weir for irrigation at Chong River is confirmed to be high. Further at the PouLao River which is flowing into the Mekon River, there is existing hydropower plan for future development. In order to attain a target electrification rate of 70% of households, the further electrification by SHS also is required.

Moreover, the Nam Khanoy small-hydro project which locates in southern area of district was judged not to be feasible due to long distance to demand center.

Further, the 22kV transmission line will be extended to Xiengkok in Luangnamtha, which locates in upstream side of the Meung district along the Mekon River, up to 2008. Since the district center locates in short distance from Xiengkok, the possibility of electrification of Meung district center by extension of 22 kV line from Xiengkok along the Mekon River should be studied.

Meung District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	1,327	-	301	-	23	-	-
Step 1	EDL Line Extension		0	388	0	23	-	-
	JICA Off-grid small-hydro		32	420	1	24	229,360	229,360
	VH Potential, SHS Plan		157	577	10	34	35,670	265,030
Step 2	Required Electrification	1,709	619	1,196	36	70	172,812	437,842

Source: JICA Study Team

(4) Pha Oudom District

The rate of household electrification of Pha Oudom in the 2005 is 0.6%, and the main power source is minor diesel generator. Furthermore, there is no major electrification plan in this area, this area is the target of electrification by small-hydro in our master plan. The map study and site reconnaissance has been carried out at Nam Hat 2 small-hydro project, and on the basis of results of them, the Pre-F/S is being carried out. On the other hand, this district center has applied to receive the SHS system and the possibility of electrification by SHS shortly is high. However, the small-hydro at this district center is being studied, which can supply high quality power supply to the demand area. Moreover, the 4 potential sites for village-hydro in the mountainous area were confirmed. In order to attain a target electrification rate of 75% of households, the further electrification by SHS also is required.

Though the Pre-F/S of Nam Hat 2 was carried out to electrify its district center, it was found in the fifth field investigation that the application of grid extension to district center by provincial demand was adopted. Therefore, the requirement of small-hydro for this district center became to be unnecessary.

Pha oudom District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	5,676	-	34	-	0.6	-	-
Step 1	EDL Line Extension		2,123	2,166	0	30	3,417,425	3,417,425
	JICA Off-grid small-hydro		35	2,201	1	31	-	3,417,425
	VH Potential, SHS Plan		1,069	3,270	14	45	280,848	3,698,273
Step 2	Required Electrification	7,311	2,213	5,483	30	75	617,367	4,315,640

Source: JICA Study Team

(5) Paktha District

The rate of household electrification of Paktha in the 2005 is 0.3%, and the main power source is Pico-hydro. As the future electrification plan, the 22 kV line of import power grid from Thailand will be extended along the Mekon River down to Paktha. For electrification in south area, further extension of transmission line is required. In order to attain a target electrification rate of 60% of households, the further electrification by SHS also is required. The 2 villages have applied SHS system already.

Paktha District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	2,913	-	10	-	0.3	-	-
Step 1	EDL Line Extension		676	689	18	18	1,088,682	1,088,682
	JICA Off-grid small-hydro		0	689	0	18	-	1,088,682
	VH Potential, SHS Plan		435	1,124	12	30	117,844	1,206,526
Step 2	Required Electrification	3,752	1,127	2,251	30	60	314,361	1,520,887

Source: JICA Study Team

(6) Nam Nhu Special Region

The rate of household electrification of Nam Nhu Special Region in the 2005 is 2%, and the main power source is Pico-hydro. In order to attain a target electrification rate of 50% of households, the further electrification by SHS also is required.

Nam Nhu Special Region District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	623	-	11	-	2	-	-
Step 1	EDL Line Extension		0	14	0	2	0	0
	JICA Off-grid small-hydro		0	14	0	2	0	0
	VH Potential, SHS Plan		0	14	0	2	0	0
Step 2	Required Electrification	802	387	401	48	50	107,985	107,985

Source: JICA Study Team

3.4.5 LUANGPHRABANG PROVINCE

The Luangphrabang province locates at center of northern Laos 8 provinces, and the center area was electrified by Nam Dong small-hydro project (1MW) in 1971. Furthermore, the EDL grid was connected to center of Luangphrabang in 1994, and the power supply from the Nam Ngum hydropower plant was started. The rate of household electrification as of 2003 is 31% and main power sources are EDL grid and diesel power generation. According to EDL plan, the 22kV line will be extended to Pakxeng and Phonxay districts by 2007 in PTD 2. The rate target value of household electrification in 2020 of Luangphrabang is 75%, and describes the electrification plan of each district proposed by the Study Team below.

(1) Luangphrabang District

The rate of household electrification of Luangphrabang in the 2003 is as high as 77%, and the main

power source is EDL grid and Nam Dong small-hydro plant, and demand center is concentrated at center of Luangphrabang. At present, the electrified area is expanding from district center to eastern area, and also downstream side of the Mekon River. The 3 potential sites for village hydropower were confirmed at tributaries into the Mekon River, the VH of OPS program type is seems to be suitable. In order to attain a target electrification rate of 100% of households, the further electrification by SHS also is required. However, as the distances from existing grid to un-electrified villages are not so far, the electrification of these villages by extension of grid line also seems to be possible.

Luangphabang District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	12,666	-	9,693	-	77	-	-
Step 1	EDL Line Extension		1,478	14,467	8	85	2,379,612	2,379,612
	JICA Off-grid small-hydro		0	14,467	0	85	-	2,379,612
	VH Potential, SHS Plan		315	14,782	2	87	75,245	2,454,857
Step 2	Required Electrification	16,972	2,191	16,972	13	100	611,261	3,066,118

Source: JICA Study Team

(2) Xieng Ngeun District

The rate of household electrification of Xieng Ngeun in the 2003 is 30%, and the main power source is EDL grid connected in 1995 and diesel generation. The villages locate near EDL 115 kV line have been electrified. The potential sites for village-hydro were confirmed at 3 locations in northern area and 1 location in southern area. In order to attain a target electrification rate of 100% of households, the further electrification by extension of distribution line and SHS in north east area also is required.

Xieng Ngeun District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	4,809	-	1,480	-	30	-	-
Step 1	EDL Line Extension		909	2,892	3	33	306,351	306,351
	JICA Off-grid small-hydro		0	2,892	0	33	-	306,351
	VH Potential, SHS Plan		202	3,094	3	36	64,182	370,533
Step 2	Required Electrification	6,444	1,417	4,511	64	100	1,437,866	1,808,398

Source: JICA Study Team

(3) Nan District

The rate of household electrification of Nan in the 2003 is 6%, and the main power source is EDL grid connected in May 2003 and diesel generation started in 1998. The only villages, which locate near EDL 115 kV line and are not so poor, have been electrified. Moreover, four village-hydro potential sites, which were confirmed at the tributaries flowing into the Mekon River under map study level, are required for site investigation, planning and design. In order to attain a target electrification rate of 80% of households, the electrification by further extension of distribution line and SHS also is required.

Nan District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	4,903	-	303	-	6	-	-
Step 1	EDL Line Extension		0	406	0	6	-	-
	JICA Off-grid small-hydro		0	406	0	6	-	-
	VH Potential, SHS Plan		202	608	3	9	45,931	45,931
Step 2	Required Electrification	6,570	4,648	5,256	71	80	1,296,696	1,342,627

Source: JICA Study Team

(4) Pak Ou District

The rate of household electrification of Pak Ou in the 2003 is 26%, and the main power source is EDL grid connected in 2000 and diesel generation. The only villages, which locate near EDL 115 kV line and are not so poor, have been electrified. Moreover, when the 22kV line will be extended to Pak Xeng district, the surrounding villages will be electrified. The potential site for village-hydro was confirmed at only 1 location. In order to attain a target electrification rate of 80% of households, the electrification by further extension of distribution line and SHS for the area to which EDL grid will not reach also is required.

Pak Ou District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	4,413	-	1,134	-	26	-	-
Step 1	EDL Line Extension		398	1,918	6	32	640,748	640,748
	JICA Off-grid small-hydro		0	1,918	0	32	-	640,748
	VH Potential, SHS Plan		71	1,989	2	34	16,122	656,869
Step 2	Required Electrification	5,913	2,742	4,731	46	80	765,067	1,421,936

Source: JICA Study Team

(5) Nam bak District

The rate of household electrification of Nam bak in the 2003 is 23%, and the main power source is EDL grid connected in 2002, Nam Mong small-hydro plant (70kW) by NEF and diesel generation. Nam Mong small-hydro plant has dummy load governor function, and the surplus power generated in daytime is released through it by conversion to heat. However, in dry season, the discharge control by valve within its capability is required to save river water. Moreover, the EDL grid line pass through this area from and surrounding villages has been electrified. This means that the villages in this district center were electrified by both of EDL grid and Nam Mong HPP. Furthermore, the area surrounding 22kV line towards Ngoy district has been electrified already, and 22kV line will be extended toward northern area. The potential site for village-hydro was not founded in map study level. In order to attain a target electrification rate of 70% of households, the electrification by further extension of distribution line and SHS for the area to which EDL grid will not reach also is required.

Nam bak District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	9,343	-	2,180	-	23	-	-
Step 1	EDL Line Extension		1,264	4,185	10	33	2,034,428	2,034,428
	JICA Off-grid small-hydro		0	4,185	0	33	-	2,034,428
	VH Potential, SHS Plan		0	4,185	0	33	-	2,034,428
Step 2	Required Electrification	12,520	4,579	8,764	37	70	1,277,517	3,311,945

Source: JICA Study Team

(6) Ngoi District

The rate of household electrification of Ngoi in the 2003 is 15%, and the main power source is EDL grid 22kV line connected in 2003 and diesel generation started from 1998. The diesel power generation systems are scattered about district. The villages locate near EDL 22 kV line only have been electrified. The potential sites for village-hydro were confirmed at 4 locations in northern area and 1 location in southern area. In order to attain a target electrification rate of 50% of households, the further electrification by SHS also is required widely for the outer area of district.

Ngoi District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	6,653	-	1,024	-	15	-	-
Step 1	EDL Line Extension		0	1,372	0	15	-	-
	JICA Off-grid small-hydro		0	1,372	0	15	-	-
	VH Potential, SHS Plan		492	1,864	6	21	111,634	111,634
Step 2	Required Electrification	8,915	2,594	4,458	29	50	723,606	835,240

Source: JICA Study Team

(7) Pakxeng District

The rate of household electrification of Pak Xeng in the 2003 is 12%, and the main power source is diesel generation and minor solar battery system (1,456kW). As the future electrification plan, the 22kV line will be extended to center of district by 2007 in PTD 2. Furthermore, the district is planning the grid extension towards Viengkham district along the road. The potential sites for village-hydro were confirmed at 3 locations in eastern area. In order to attain a target electrification rate of 51% of households, the further electrification by SHS also is required for the outer area of district.

Pakxeng District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	4,269	-	492	-	12	-	-
Step 1	EDL Line Extension		1,033	1,692	18	30	1,663,355	1,663,355
	JICA Off-grid small-hydro		0	1,692	0	30	-	1,663,355
	VH Potential, SHS Plan		220	1,912	3	33	49,886	1,713,241
Step 2	Required Electrification	5,720	948	2,860	17	50	264,506	1,977,747

Source: JICA Study Team

(8) Phonxay District

The rate of household electrification of Phonxay in the 2003 is 16%, and the main power source is diesel generation and minor SHS and Pico-hydro. As the future electrification plan, the 22kV line will

be extended to northwest area of district by 2007 in PTD 2. The potential sites for village-hydro were confirmed at 2 locations in central area. In order to attain a target electrification rate of 60% of households, the further electrification by SHS also is required for the isolated east and south area.

Phonxay District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	4,001	-	622	-	16	-	-
Step 1	EDL Line Extension		1,036	1,869	19	35	1,667,670	1,667,670
	JICA Off-grid small-hydro		0	1,869	0	35	-	1,667,670
	VH Potential, SHS Plan		342	2,211	6	41	95,334	1,763,005
Step 2	Required Electrification	5,361	1,006	3,217	19	60	280,619	2,043,624

Source: JICA Study Team

(9) Chomphet District

The rate of household electrification of Chomphet in the 2003 is 31%, and the main power source is EDL 22kV grid line and diesel generation. As the future electrification plan, the 22kV line will be extended to central and east area of district. The potential site for village-hydro was found at 1 location near The Meakon River in southern area. In order to attain a target electrification rate of 70% of households, the further electrification by the extension of distribution line and SHS also is required for the outer area of district.

Chomphet District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	4,809	-	1,480	-	31	-	-
Step 1	EDL Line Extension		909	2,892	14	45	1,462,717	1,462,717
	JICA Off-grid small-hydro		0	2,892	0	45	-	1,462,717
	VH Potential, SHS Plan		202	3,094	3	48	45,931	1,508,648
Step 2	Required Electrification	6,444	1,417	4,511	22	70	395,282	1,903,931

Source: JICA Study Team

(10) Viengkham District

The rate of household electrification of Viengkham in the 2003 is 11%, and the main power source is diesel power generation (120kW). Furthermore, there is no major electrification plan in this area, this area is the target of electrification by village-hydro in our master plan. As the potential sites of village-hydro, the Houay Kouang village-hydro locates near district center and the Nam Xeng village-hydro locates near sub-district center were studied in map study and investigated by JICA study team. Moreover, the Nam Mi village-hydro project site also was investigated at same time additionally. As the results of site investigation, the Nam Xeng village-hydro was selected for the Pre-F/S, because the potential of hydropower near district center is too small for power demand of district center. As the district center locates in short distance from area of existing grid extension plan and its electricity demand is big enough to invite the grid line, it should be electrified by grid extension within few years. The potential sites for village-hydro were found at 1 location in northern area and 2 locations at central area. In order to attain a target electrification rate of 50% of households, the further electrification by SHS also is required for isolated un-electrified villages.

Viengkham District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	6,587	-	714	-	11	-	-
Step 1	EDL Line Extension		0	957	0	11	0	0
	JICA Off-grid small-hydro		906	1,863	10	21	859,392	859,392
	VH Potential, SHS Plan		126	1,989	2	23	28,593	887,985
Step 2	Required Electrification	8,827	2,425	4,413	27	50	676,500	1,564,485

Source: JICA Study Team

(11) Phoukhoune District

The rate of household electrification of Phoukhoune in the 2003 is 32%, and the main power source is EDL 22kV grid line connected in 1998. There is no major electrification Plan. The potential sites for village-hydro were confirmed at 2 locations in northern area. In order to attain a target electrification rate of 90% of households, the electrification by further extension of distribution line and SHS also is required for the un-electrified villages in northern area.

Phoukhoune District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	3,327	-	1,068	-	32	-	-
Step 1	EDL Line Extension		0	1,431	0	32	0	0
	JICA Off-grid small-hydro		0	1,431	0	32	0	0
	VH Potential, SHS Plan		146	1,577	3	35	33,156	33,156
Step 2	Required Electrification	4,458	2,435	4,012	55	90	679,416	712,572

Source: JICA Study Team

3.4.6 HUAPHANH PROVINCE

Since Huaphanh locates at most northeast side of northern Laos and was behind in attainment of the EDL grid line, it started the electric power imported from Vietnam in 1996 with operation by EDL. Due to electric power imported, the northern 5 districts out of 8 districts of Huaphanh has been electrified. The tariff of imported electric power is 6cent/kWh and sales tariff for consumer is 250kip/kWh. The rate of household electrification as of 2003 is 53% and main power sources are imported power and Pico-hydro, which is spread to many villages. According to EDL plan, the 35 kV line will be extended to reduce un-electrified area. The rate target value of household electrification in 2020 of Huaphanh is 81%, and describes the electrification plan of each district proposed by the Study Team below.

(1) Xamneua District

The rate of household electrification of Xamneua in the 2003 is 58%, and the main power source is imported power and Pico-hydro, and numbers of those power sources are balanced. As the future electrification plan, the EDL grid will be expanded towards northwest area. The potential sites for village-hydro were found at 4 locations in northeast and southwest areas, and site investigation, planning and design are required. In order to attain a target electrification rate of 90% of households,

the further electrification by further extension of distribution line, spread of Pico-hydro knowledge and SHS also is required for the remote area, which has no potential of Pico-hydro also.

Xamneua District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	7,971	-	4,614	-	58	-	-
Step 1	EDL Line Extension		489	6,672	5	63	787,451	787,451
	JICA Off-grid small-hydro		0	6,672	0	63	-	787,451
	VH Potential, SHS Plan		243	6,914	2	65	55,057	842,508
Step 2	Required Electrification	10,681	2,699	9,613	25	90	752,917	1,595,424

Source: JICA Study Team

(2) Xiengkhor District

The rate of household electrification of Xiengkhor in the 2003 is 52%, and the main power source is power imported from Vietnam and minor Pico-hydro. As the future electrification plan, the EDL grid will be expanded towards north and south direction from the EDL grid which lei in east –west direction. The potential sites for village-hydro were found at 2 locations in north area and 1 location in south area, and site investigation, planning and design are required. In order to attain a target electrification rate of 90% of households, the further electrification by further extension of distribution line, spread of Pico-hydro knowledge and SHS also is required.

Xiengkhor District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	3,990	-	2,184	-	55	-	-
Step 1	EDL Line Extension		131	3,058	2	57	211,425	211,425
	JICA Off-grid small-hydro		0	3,058	0	57	-	211,425
	VH Potential, SHS Plan		218	3,276	4	61	49,581	261,007
Step 2	Required Electrification	5,347	1,536	4,812	29	90	428,444	689,450

Source: JICA Study Team

(3) Viengthong District

The rate of household electrification of Viengthong in the 2003 is 51%, and the main power source is village-hydro plants which are Nam At HPP (80kW) and Nam Sat (250kW) and Pico-hydro. There are some problems in Nam At HPP, which are less actual output of 63kW, there is no sand flush facility in the intake weir and is damage of inlet valve. In the case of Nam Sat HPP, the actual output is 180kW only and river flow in dry season is very small. As there is no major electrification plan in this district, the Nam Hang village-hydro project which locates at northern side of Nam Sat HPP, was studied in map study level. The site reconnaissance and the Pre-F/S were not carried out and further study is required. The potential sites for village-hydro were found at 6 locations in north area and 3 locations in south area, and site investigation, planning and design are required. In order to attain a target electrification rate of 90% of households, the potential study of small-hydro and further electrification by Pico-hydro and SHS also is required for whole district.

Viengthong District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	3,754	-	1,914	-	51	-	-
Step 1	EDL Line Extension		0	2,565	0	51	0	0
	JICA Off-grid small-hydro		0	2,565	0	51	0	0
	VH Potential, SHS Plan		291	2,856	6	57	66,007	66,007
Step 2	Required Electrification	5,030	1,672	4,527	33	90	466,428	532,435

Source: JICA Study Team

(4) Viengxay District

The rate of household electrification of Viengxay in the 2003 is 60%, and the main power source is power imported from Vietnum and pico-hydro. Though the Nam Souy mini-hydro (12kW) was constructed by village budget in 1993, it was flushed away due to flood and open channel was damaged due to land slide. It was considered that the knowledge about civil engineering was not enough. As the future electrification plan, the EDL import grid line will be extended towards east direction. Moreover, 6 village-hydro potential sites in northwest area, which were confirmed under map study level, are required for site investigation, planning and design. In order to attain a target electrification rate of 90% of households, the further electrification by Pico-hydro and SHS also are required.

In this master plan, the Nam Sim small-hydro is studied through map study and site reconnaissance, and the Pre-F/S. As the results of that, it was confirmed that the Nam Sim small-hydro with installed capacity of 8MW was economical hydropower development and effective to reduce imported power and to strengthen the EDL grid in future.

Viengxay District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	5,606	-	3,380	-	60	-	-
Step 1	EDL Line Extension		1,668	6,198	23	83	2,685,963	2,685,963
	JICA Off-grid small-hydro		0	6,198	0	83	-	2,685,963
	VH Potential, SHS Plan		52	6,250	0	83	11,863	2,697,826
Step 2	Required Electrification	7,512	511	6,761	7	90	142,590	2,840,416

Source: JICA Study Team

(5) Huameuang District

The rate of household electrification of Huameuang in the 2003 is 23%, and the main power source is small-hydro (Nam Peun 40kW) and Pico-hydro. As the future electrification plan, the EDL 115kV grid line will be extended from Xiengkhuang province to Xamneua district. Though the Nam Peun II small-hydro project was planned at south part of existing Nam Peun small-hydro Project in this master plan, it dose not get the stage of site reconnaissance and the Pre-F/S. Further study is necessary. The potential sites for village-hydro were found at 6 locations in central to west area and 1 location in east area, and site investigation, planning and design are required. In order to attain a target electrification rate of 80% of households, the potential study of small-hydro and further electrification by Pico-hydro and SHS are required.

Huameuang District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	3,794	-	869	-	23	-	-
Step 1	EDL Line Extension		75	1,240	1	24	120,814	120,814
	JICA Off-grid small-hydro		0	1,240	0	24	-	120,814
	VH Potential, SHS Plan		326	1,565	7	31	73,916	194,730
Step 2	Required Electrification	5,084	2,502	4,067	49	80	698,071	892,802

Source: JICA Study Team

(6) Xamtay District

The rate of household electrification of Xamtay in the 2003 is 43%, and the main power source is small-hydro (Nam San 110kW, Nam La 104 kW) and Pico-hydro. The Nam San HPP is facing to problem of shortage of river water because of less weir design for 55kW capacity only. The Nam La HPP is under operation of one generator only due to the damage of exciter and router in No.2 generator. To remain existing electrification ratio, the strengthening of knowledge for repair, operation and maintenance is required urgently. The potential sites for village-hydro were found at 12 locations in this district, and site investigation, planning and design are required. In order to attain a target electrification rate of 60% of households, the potential study of small-hydro and further electrification by Pico-hydro and SHS are required.

Xamtay District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	8,094	-	3,570	-	43	-	-
Step 1	EDL Line Extension		0	4,784	0	43	0	0
	JICA Off-grid small-hydro		0	4,784	0	43	0	0
	VH Potential, SHS Plan		327	5,111	4	47	74,220	74,220
Step 2	Required Electrification	10,846	1,397	6,508	13	60	389,712	463,932

Source: JICA Study Team

(7) Sopbao District

The rate of household electrification of Sopbao in the 2003 is 66%, and the main power source is power imported from Vietnum, small-hydro (Nam Long 20kW) and Pico-hydro. The Nam Long HPP has excavated open channel without lining, and is facing leakage problem. The restoration works in intake weir are required for this HPP at every rainy season. As the future electrification plan, the EDL grid expanded from existing line. The potential sites for village-hydro were confirmed at 4 locations in the center of this district, and should be studied in detail, and it is necessary to study the suitability of extension of distribution line. In order to attain a target electrification rate of 80% of households, the further electrification by extension of distribution line and further development of Pico-hydro is required.

The Nam Hao small-hydro project was selected for map study and site reconnaissance. However, it was not selected for the Pre-F/S due to high construction cost as compared with Nam Sim HPP.

Sopbao District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	4,338	-	2,857	-	66	-	-
Step 1	EDL Line Extension		263	4,091	4	70	422,850	422,850
	JICA Off-grid small-hydro		0	4,091	0	70	-	422,850
	VH Potential, SHS Plan		63	4,154	2	72	14,296	437,147
Step 2	Required Electrification	5,813	496	4,650	8	80	138,478	575,625

Source: JICA Study Team

(8) Et District

The rate of household electrification of Et in the 2003 is 56%, and the main power source is power imported from Vietnam and Pico-hydro. As the future electrification plan, the EDL grid expanded from existing line. The potential site for village-hydro was confirmed at 1 location in the south area, and VH of OPS program type is suitable. In order to attain a target electrification rate of 80% of households, it is thought that the further electrification by extension of distribution line and further development of Pico-hydro is required.

Et District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	4,074	-	2,276	-	56	-	-
Step 1	EDL Line Extension		729	3,779	13	69	1,173,626	1,173,626
	JICA Off-grid small-hydro		0	3,779	0	69	-	1,173,626
	VH Potential, SHS Plan		70	3,848	2	71	15,817	1,189,443
Step 2	Required Electrification	5,459	519	4,367	9	80	144,759	1,334,202

Source: JICA Study Team

3.4.7 XAYABURY PROVINCE

The Xayabury province is located at the southwest part of northern Laos 8 provinces and adjacent to Thailand with long distance in south west direction. Main power source are the EDL 115kV extended from the Luangprabang province, the electric power (Kenethao in 1997, Ngeun in 2001, Khorb in 2004 and Xiengkhor in 2004) imported from Thailand, and diesel power generation. The EDL grid line was connected to the Xayabury in 2003. The tariff of electricity imported from Thailand is 6 cents/kWh at peak time and 3.5 cents/kWh at a off-peak time. The rate of household electrification as of 2005 is 31%. According to EDL plan, the 115 kV line will be extended to from Xayabury district to Paklai district. The rate target value of household electrification in 2020 of Xayabury is 82%, and describes the electrification plan of each district proposed by the Study Team considering the characteristic of hydrology, which is small rainfall comparatively below.

(1) Xayabury District

The rate of household electrification of Xayabury in the 2005 is 37%, and the main power source is EDL grid line. As the future electrification plan, the EDL grid will be expanded from center of district to northwest and south areas, and there are installation plan for SHS and Pico-hydro. The potential

site for village-hydro was confirmed at 1 location at tributaries of the Mekon River in eastern area, and site investigation, planning and design are required. In order to attain a target electrification rate of 90% of households, the further electrification by SHS is required for the area which has no hydropower. There are installation plan for SHS in 27 villages. In this district, the EDL grid extension plan permeate through the whole district including remote villages, which have no EDL grid extension plan, many household demand the adoption of simple electrification source SHS strongly.

Xayabury District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	12,740	-	4,654	-	37	-	-
Step 1	EDL Line Extension		1,728	7,723	10	47	2,782,879	2,782,879
	JICA Off-grid small-hydro		0	7,723	0	47	-	2,782,879
	VH Potential, SHS Plan		3,998	11,721	24	71	1,083,883	3,866,761
Step 2	Required Electrification	16,409	3,047	14,768	19	90	850,227	4,716,988

Source: JICA Study Team

(2) Khorb District

The rate of household electrification of Khorb in the 2005 is 25%, and the main power source is power imported from Thailand with EDL control, and diesel power generation. As the future electrification plan, the import grid line will be extended from center of district towards north are along the Mekon River. The potential site for village-hydro was not found. In order to attain a target electrification rate of 75% of households, the further electrification by SHS is required.

Khorb District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	3,426	-	856	-	25	-	-
Step 1	EDL Line Extension		1,475	2,577	33	58	2,374,364	2,374,364
	JICA Off-grid small-hydro		0	2,577	0	58	-	2,374,364
	VH Potential, SHS Plan		182	2,759	5	63	50,669	2,425,032
Step 2	Required Electrification	4,413	551	3,310	12	75	153,623	2,578,655

Source: JICA Study Team

(3) Hongsa District

The rate of household electrification of Hongsa in the 2005 is 31%, and the main power source is power imported from Thailand with EDL control, and diesel power generation. As the future electrification plan, though the Hongsa Lignite Project is one of candidate of power generation project for export the power to Thailand, it has not reached at the implementation stage. The potential sites for village-hydro were confirmed at 2 locations in the east area and 2 locations in the south area, and site investigation, planning and design are required. In order to attain a target electrification rate of 85% of households, the further electrification by the extension of EDL import grid and SHS in the villages, which have no grid extension plan, are required. There are installation plan for SHS in 12 villages.

The Nam Ken small-hydro project, which locates at same river with water pool of the Hongsa Lignite Project, was selected for map study and site reconnaissance. As the results of site reconnaissance, it

was judged that this project was not feasible due to less water head and long distance of open channel.

Hongsa District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	4,453	-	1,371	-	31	-	-
Step 1	EDL Line Extension		676	2,442	12	43	1,088,682	1,088,682
	JICA Off-grid small-hydro		0	2,442	0	43	-	1,088,682
	VH Potential, SHS Plan		1,897	4,339	33	76	500,325	1,589,007
Step 2	Required Electrification	5,735	536	4,875	9	85	149,508	1,738,515

Source: JICA Study Team

(4) Ngeun District

The rate of household electrification of Ngeun in the 2005 is 41%, and the main power source is power imported from Thailand started in 2001 with EDL control. As the future electrification plan, the EDL import grid extension and the SHS in remote area are started to be introduced. The potential site for village-hydro is not founded by map study level. In order to attain a target electrification rate of 75% of households, the further electrification by SHS of an OPS program type is required for the area which the import grid line will not be extended to and has no hydro potential. There are installation plan for SHS in 4 villages.

Ngeun District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	2,755	-	1,118	-	41	-	-
Step 1	EDL Line Extension		710	2,150	20	61	1,142,598	1,142,598
	JICA Off-grid small-hydro		0	2,150	0	61	-	1,142,598
	VH Potential, SHS Plan		260	2,410	7	68	72,589	1,215,187
Step 2	Required Electrification	3,548	251	2,661	7	75	70,163	1,285,350

Source: JICA Study Team

(5) Xienghone District

Though the rate of household electrification of Xienghone in the 2005 is 0%, this district will be electrified by power imported from Thailand started in 2005 with EDL control. As the future electrification plan, the EDL import grid will be extended towards northern, western and eastern areas, and SHS also will spread into 7 villages. The potential site for village-hydro was not found. In order to attain a target electrification rate of 80% of households, the further electrification by SHS is required for the north area.

Xienghone District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	5,292	-	0	-	0	-	-
Step 1	EDL Line Extension		3,633	3,633	53	53	5,849,851	5,849,851
	JICA Off-grid small-hydro		0	3,633	0	53	-	5,849,851
	VH Potential, SHS Plan		1,278	4,911	19	72	356,477	6,206,328
Step 2	Required Electrification	6,816	542	5,453	8	80	151,143	6,357,472

Source: JICA Study Team

(6) Phiang District

The rate of household electrification of Phiang in the 2005 is 28%, and the main power source is EDL 22kV grid line connected in December 2003 and diesel power generation. As the future electrification plan, the EDL 22kV line will be extended to Paklai district and the 115 kV line also will follow it. The potential site\ for village-hydro was not found. In order to attain a target electrification rate of 70% of households, the further electrification by SHS is required for the remote area. There are installation plan for SHS in 4 villages.

Phiang District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	8,770	-	2,434	-	28	-	-
Step 1	EDL Line Extension		3,187	6,322	28	56	5,130,284	5,130,284
	JICA Off-grid small-hydro		0	6,322	0	56	-	5,130,284
	VH Potential, SHS Plan		282	6,604	3	59	78,698	5,208,982
Step 2	Required Electrification	11,296	1,303	7,907	11	70	363,664	5,572,647

Source: JICA Study Team

(7) Paklai District

The rate of household electrification of Paklai in the 2005 is 34%, and the main power source is import 22kV grid line from Thailand connected in June 1998 and diesel power generation. As the future electrification plan, the EDL 22kV line will be extended from Phiang district and also 22kV line from Kenethao in west side course. The SHS was installed in 8 villages and the further plans of installation are in 3 villages. The potential site for village-hydro is not found by map study level. In order to attain a target electrification rate of 80% of households, the further electrification by SHS is required for the remote area.

In this master plan study, the Nam Lay small-hydro project which locates at west area of Paklai district was studied in map study. However, it was not selected for site for site reconnaissance due to high construction cost. The further detail study should be carried out. This project was aiming at reduce of imported electrical power by connecting with national grid.

Paklai District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	11,232	-	3,772	-	34	-	-
Step 1	EDL Line Extension		4,574	9,432	31	65	7,363,638	7,363,638
	JICA Off-grid small-hydro		0	9,432	0	65	-	7,363,638
	VH Potential, SHS Plan		757	10,189	5	70	211,299	7,574,937
Step 2	Required Electrification	14,467	1,384	11,573	10	80	386,160	7,961,096

Source: JICA Study Team

(8) Kenethao District

The rate of household electrification of Kenethao in the 2005 is 39%, and the main power source is import 22kV grid line from Thailand connected in June 1997 and minor diesel power generation. As the future electrification plan, the EDL 22kV line will be extended from to northern area along

existing road, and electrification of surrounding villages. The potential site for village-hydro was not found by map study level. In order to attain a target electrification rate of 85% of households, the further electrification by SHS is required for the remote area. There are installation plan for SHS in 6 villages.

Kenethao District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	7,505	-	2,937	-	39	-	-
Step 1	EDL Line Extension		2,432	6,215	25	64	3,915,108	3,915,108
	JICA Off-grid small-hydro		0	6,215	0	64	-	3,915,108
	VH Potential, SHS Plan		693	6,908	8	72	193,331	4,108,439
Step 2	Required Electrification	9,666	1,309	8,216	13	85	365,191	4,473,631

Source: JICA Study Team

(9) Botene District

The rate of household electrification of Botene in the 2005 is 36%, and the main power source is import 22kV grid line from Thailand connected in December 1998 and minor diesel power generation. As the future electrification plan, the EDL 22kV line will be extended to northern and southern areas, and electrification of surrounding villages. The potential site for village-hydro was not found by map study level. In order to attain a target electrification rate of 85% of households, the further electrification by SHS is required for the remote area.

In this master plan study, the Nam Ham small-hydro project was studies in map study, and site reconnaissance was carried out by DOE. The Pre-F/S was carried out and it was confirmed that the Nam Ham 2 small-hydro with installed capacity of 1 MW is economical to implement. The purpose of this project is reduction of power imported from Thailand by connecting national grid for domestic use.

Botene District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	3,545	-	1,267	-	36	-	-
Step 1	EDL Line Extension		1,449	3,081	32	68	2,332,890	2,332,890
	JICA Off-grid small-hydro		0	3,081	0	68	-	2,332,890
	VH Potential, SHS Plan		95	3,176	2	70	26,592	2,359,482
Step 2	Required Electrification	4,566	705	3,881	15	85	196,655	2,556,137

Source: JICA Study Team

(10) Tongmixai District

The rate of household electrification of Tongmixai in the 2005 is 33%, and the main power source is import 22kV grid line from Thailand connected in July 2003. As the future electrification plan, the EDL 22kV line will be expanded to surrounding villages for electrification. The potential site for village-hydro is not founded by map study. In order to attain a target electrification rate of 85% of households, the further electrification by extension of distribution line is suitable.

Tongmixai District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2005	Existing Situation	1,652	-	552	-	33	-	-
Step 1	EDL Line Extension		670	1,381	32	65	1,078,314	1,078,314
	JICA Off-grid small-hydro		0	1,381	0	65	-	1,078,314
	VH Potential, SHS Plan		0	1,381	0	65	-	1,078,314
Step 2	Required Electrification	2,128	428	1,809	20	85	119,377	1,197,690

Source: JICA Study Team

3.4.8 XIENGKHUANG PROVINCE

The main electricity source of Xiengkhuang is the EDL 115 kV grid line extended from Xaisomboun district, Pico-hydro and diesel power generation. The EDL grid was connected to Pek district and Khoune district in 2003. The rate of household electrification as of 2003 is 30%. According to EDL plan, the 22 kV line will be extended from Pek district towards Kham and Nonghet in east direction and Phookood in west direction. The rate target value of household electrification in 2020 of Xiengkhuang is 84%, and describes the electrification plan of each district proposed by the Study Team below.

(1) Pek District

The rate of household electrification of Pek in the 2003 is 43%, and the main power source is EDL grid line and Pico-hydro, which became widespread to the northern area. As the future electrification plan, the EDL 22kV line will be expanded from electrified area of district center towards Kham district in northeast direction, and towards southern area also. The potential site for village-hydro was not found by map study level. In order to attain a target electrification rate of 100% of households, the further electrification by SHS or Pico-hydro is required for the remote area. The SHS have been installed in 4 villages already.

Pek District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	11,247	-	4,797	-	43	-	-
Step 1	EDL Line Extension		7,103	13,531	47	90	11,436,377	11,436,377
	JICA Off-grid small-hydro		0	13,531	0	90	-	11,436,377
	VH Potential, SHS Plan		32	13,563	0	90	8,973	11,445,350
Step 2	Required Electrification	15,071	1,508	15,071	10	100	420,593	11,865,943

Source: JICA Study Team

(2) Kham District

The rate of household electrification of Kham in the 2003 is 34%, and the main power source is small-hydro plant (Ban Sob Ma 55 kW, Nam Tieng 75kW) and Pico-hydro. As the future electrification plan, the EDL 22kV line will be expanded from Pek district to center of Kham district for electrification. The potential site for village-hydro was confirmed at 1 location in northwest area and 2 locations in central and east area by map study level. In order to attain a target electrification rate of

80% of households, the further electrification by SHS or Pico-hydro is required for the remote area.

Kham District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	6,654	-	2,226	-	34	-	-
Step 1	EDL Line Extension		3,043	6,026	34	68	4,899,455	4,899,455
	JICA Off-grid small-hydro		0	6,026	0	68	-	4,899,455
	VH Potential, SHS Plan		259	6,285	3	71	63,097	4,962,552
Step 2	Required Electrification	8,916	848	7,133	9	80	236,728	5,199,280

Source: JICA Study Team

(3) Nonghet District

The rate of household electrification of Nonghet in the 2003 is 6%, and the main power source is diesel power generation. As the future electrification plan, the EDL 22kV line will be expanded from Pek district through Kham, and to center of this district in east west direction. The potential sites for village-hydro were confirmed at 2 locations in northwest area and 1 location in south area by map study level. Further investigation, planning and design are necessary. In order to attain a target electrification rate of 70% of households, the further electrification by SHS for the villages which have no hydro potential or Pico-hydro is required for the remote area.

Nonghet District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	5,064	-	319	-	6	-	-
Step 1	EDL Line Extension		1,656	2,084	25	31	2,666,546	2,666,546
	JICA Off-grid small-hydro		0	2,084	0	31	-	2,666,546
	VH Potential, SHS Plan		172	2,255	2	33	38,935	2,705,481
Step 2	Required Electrification	6,786	2,495	4,750	37	70	696,053	3,401,534

Source: JICA Study Team

(4) Khoune District

The rate of household electrification of Khoune in the 2003 is 18%, and the main power source is EDL grid. As the electrification plan, the surrounding area of EDL grid will be electrified. In this master plan study, the Nam Xan 3 hydropower project, which is aiming at electrification of sub-district center in eastern area, was studied through site reconnaissance and the Pre-F/S. At beginning of this study, the grid connection was not considered. However, as the results of the Pre-F/S, it was found that the grid extension plan is more suitable for the electrification of this area. Therefore, further detail study is necessary. Further, since this project can have bigger head of 1,000 m by shifting the powerhouse site toward downstream side, the re-planning as MW class hydro-power for grid strengthening also is required. The potential site for village hydropower was confirmed at 1 location in eastern area. In order to attain a target electrification rate of 80% of households, the further electrification by SHS or Pico-hydro is required for the remote area.

Khoune District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	4,611	-	810	-	18	-	-
Step 1	EDL Line Extension		1,048	2,133	17	35	1,687,087	1,687,087
	JICA Off-grid small-hydro		448	2,581	7	42	462,633	2,149,720
	VH Potential, SHS Plan		105	2,685	2	44	23,726	2,173,446
Step 2	Required Electrification	6,179	2,258	4,943	36	80	629,879	2,803,325

Source: JICA Study Team

(5) Morkmay District

The rate of household electrification of Morkmay in the 2003 is 18%, and the main power source is diesel power generation. Though the Nam Chat small-hydro station 100 kW was constructed and operated for electricity supply to district center, the power generation was stopped because of damage of open channel due to land slide. As the future electrification plan, there is hydropower development plan of Nam Mo, which is MW class, and the detail development schedule is not clear. In this master plan study, though the Nam Chao hydropower project was found and studied in map study aiming at electrification of district center, it was not feasible due to high construction cost for its power output. The potential site for village-hydro was confirmed at 5 locations in whole district. In order to attain a target electrification rate of 55% of households, the further electrification by SHS or Pico-hydro is required for the remote area.

Morkmay District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	1,482	-	269	-	18	-	-
Step 1	EDL Line Extension		0	360	0	18	0	0
	JICA Off-grid small-hydro		0	360	0	18	0	0
	VH Potential, SHS Plan		343	704	17	35	77,870	77,870
Step 2	Required Electrification	1,986	389	1,092	20	55	108,457	186,327

Source: JICA Study Team

(6) Phookood District

The rate of household electrification of Phookood in the 2003 is 36%, and the main power source is diesel power generation. As the future electrification plan, the EDL 22 kV line will be extended from district center to center of district and Phoukhoune district in Luangphrabang and the surrounding villages will be electrified. The potential site for village-hydro was confirmed at 1 location in northern area. In order to attain a target electrification rate of 70% of households, the further electrification by SHS or Pico-hydro is required for the remote area. There are installation plan for SHS in 2 villages.

Phookood District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	3,783	-	1,375	-	36	-	-
Step 1	EDL Line Extension		1,136	2,979	23	59	1,829,475	1,829,475
	JICA Off-grid small-hydro		0	2,979	0	59	-	1,829,475
	VH Potential, SHS Plan		267	3,245	5	64	73,005	1,902,480
Step 2	Required Electrification	5,069	303	3,548	6	70	84,530	1,987,009

Source: JICA Study Team

(7) Phaxay District

The rate of household electrification of Phaxay in the 2003 is 27%, and the main power source is small-hydro (Nam Ka-1: 12 kW, Nam Ka-2: 81kW) and Pico-hydro. The Nam Ka-3 small-hydro plant (5kW) started in 1995 and the Nam Pue small-hydro plant have been stopped their power generation due to trouble in generator. As the electrification plan, the EDL 22kV grid line will be extended to southern area and surrounding villages will be electrified. The potential site for small-hydro in southern area was found, which can supply power to 3 villages. In order to attain a target electrification rate of 100% of households, the further electrification by SHS or Pico-hydro is required for the remote area.

Phaxay District Electrification Plan

Item		HH Nos.	Electrified Household Nos.		Rate of Electrification (%)		Required cost for Target at 2020(US$)	
			Indivi.	Sum.	Indivi.	Sum.	Indivi.	Sum.
2003	Existing Situation	1,686	-	447	-	27	-	-
Step 1	EDL Line Extension		643	1,242	28	55	1,035,552	1,035,552
	JICA Off-grid small-hydro		0	1,242	0	55	-	1,035,552
	VH Potential, SHS Plan		226	1,469	10	65	51,406	1,086,958
Step 2	Required Electrification	2,259	791	2,259	35	100	220,577	1,307,536

Source: JICA Study Team