No.

The Lao People's Democratic Republic

THE MASTER PLAN STUDY ON SMALL-HYDRO IN NORTHERN LAOS

Final Report : Volume 2

EXECUTIVE SUMMARY

December 2005

Japan International Cooperation Agency

Economic Development Department

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JR
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Japan International Cooperation Agency

Ministry of Industry and Handicrafts of Lao PDR

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ON
SMALL-HYDRO IN NORTHERN LAOS

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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.

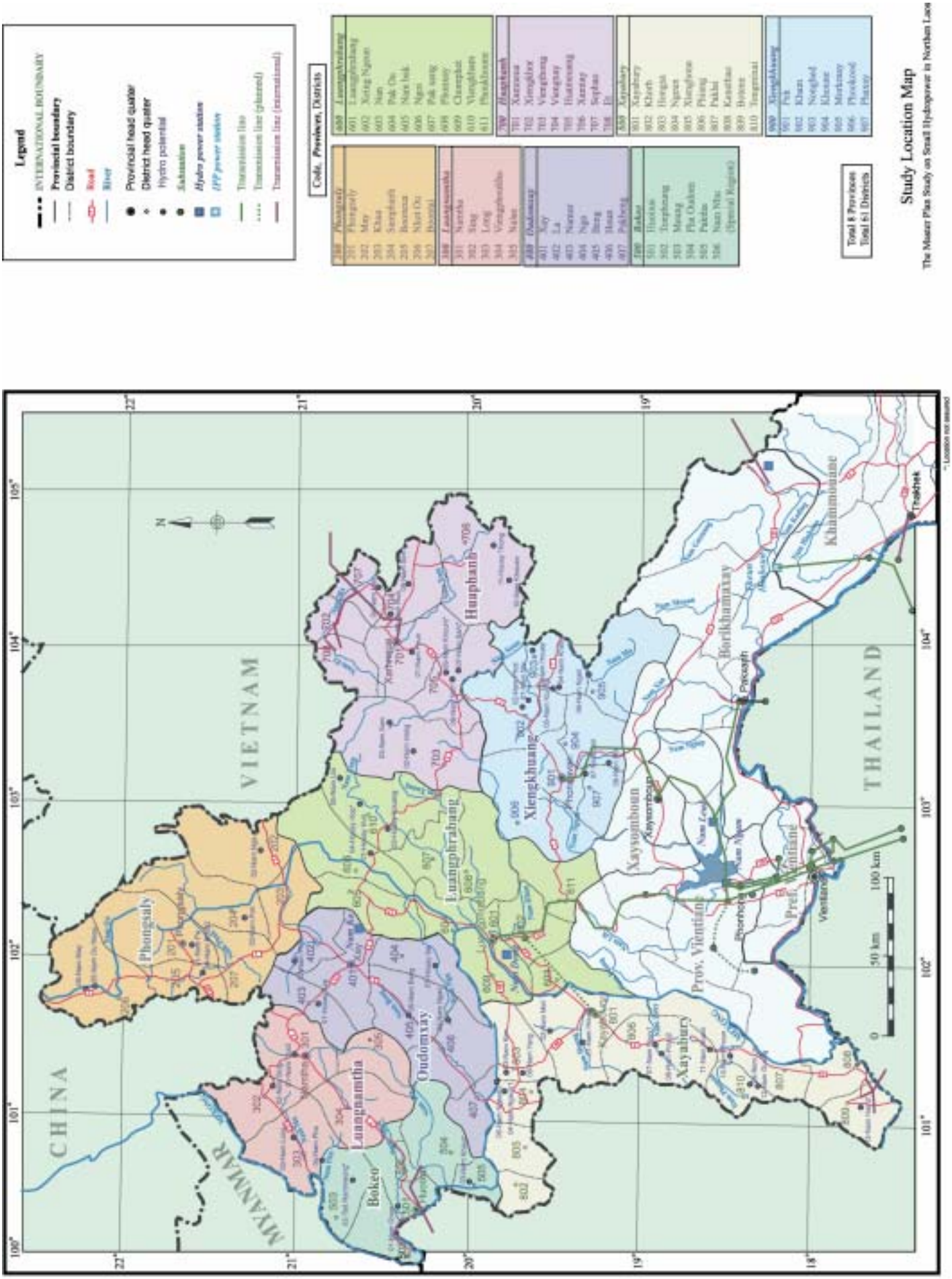
The Final Report consists of four volumes; Main Report, Executive Summary, Small-Hydro Manual and Small-Hydro Visual Guide. The main report covers all the study results including mainly the process of master plan study and Pre-F/S results on some small-hydro potential sites. The manual is expected for 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 quarter
District head quarter
Hydro potential
Substation
Hydro power station
IPP power station
Transmission line
Transmission line (planned)
Transmission line (international)
Code, Provinces, Districts
Total 6 Provinces
Total 61 Districts
Study Location Map
The Master Plan Study on Small Hydropower in Northern Laos
CHINA
VIETNAM
THAILAND
MYANMAR
Phongsaly
Luangnamtha
Oudomxay
Bokeo
Luangprabang
Xiengkhuang
Houaphanh
Xayaboury
Prov. Vientiane
Vientiane
Xaysomboun
Borikhamxay
Khammouane
Pakse
Thakhek
100 km
50 km
0

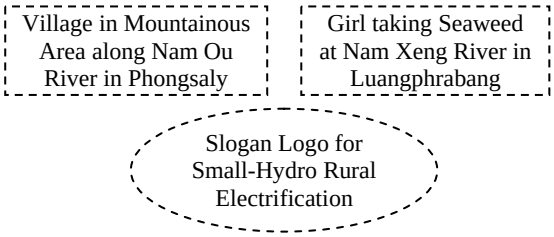
THE MASTER PLAN STUDY
ON
SMALL-HYDRO IN NORTHERN LAOS

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 2 : EXECUTIVE SUMMARY

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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)

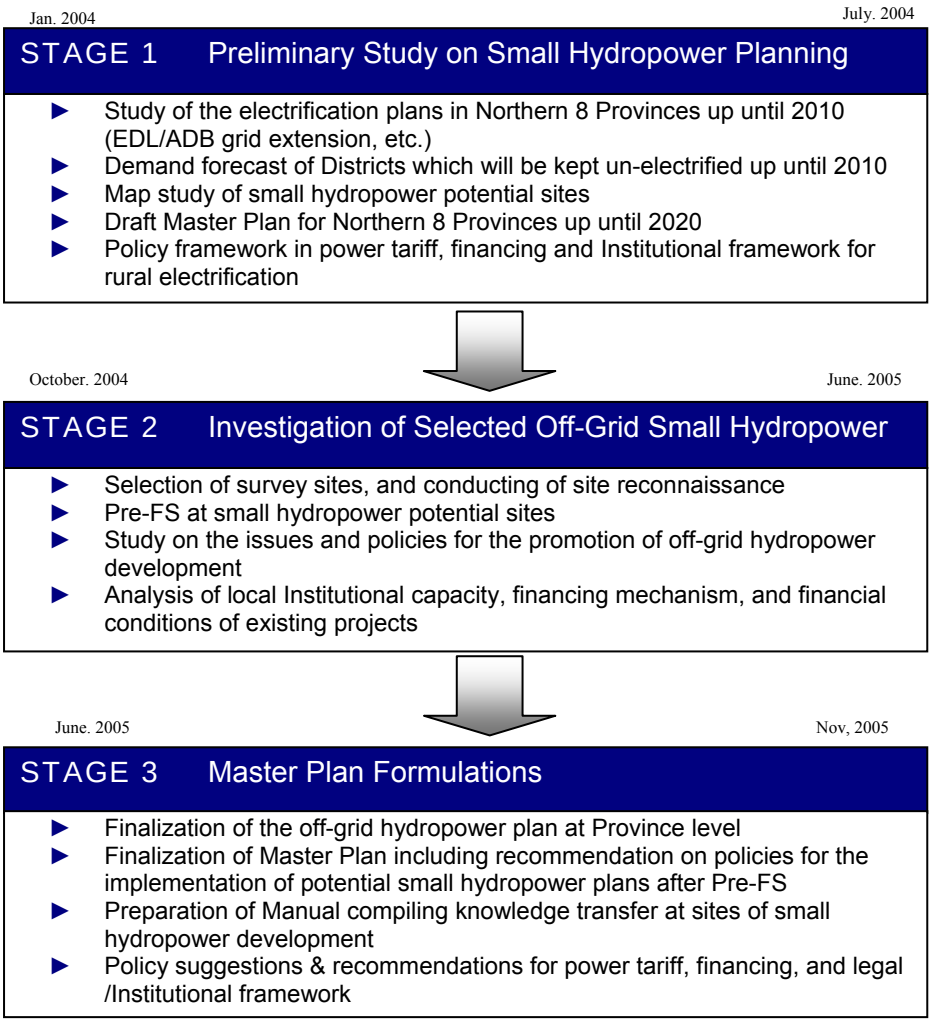
3. PURPOSE AND PROJECT BOUNDARY OF STUDY

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

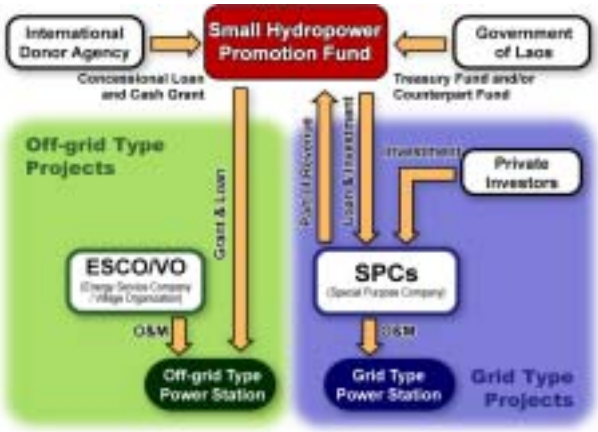
The ways to solve the issue of a high initial cost lies in the ways to reduce initial public investment or during the phase of operation. As shown in the conceptual scheme below, the public fund should be utilized as seed money to increase the coverage of electrification by small-hydro systems. World-wide 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 THROUTH 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.

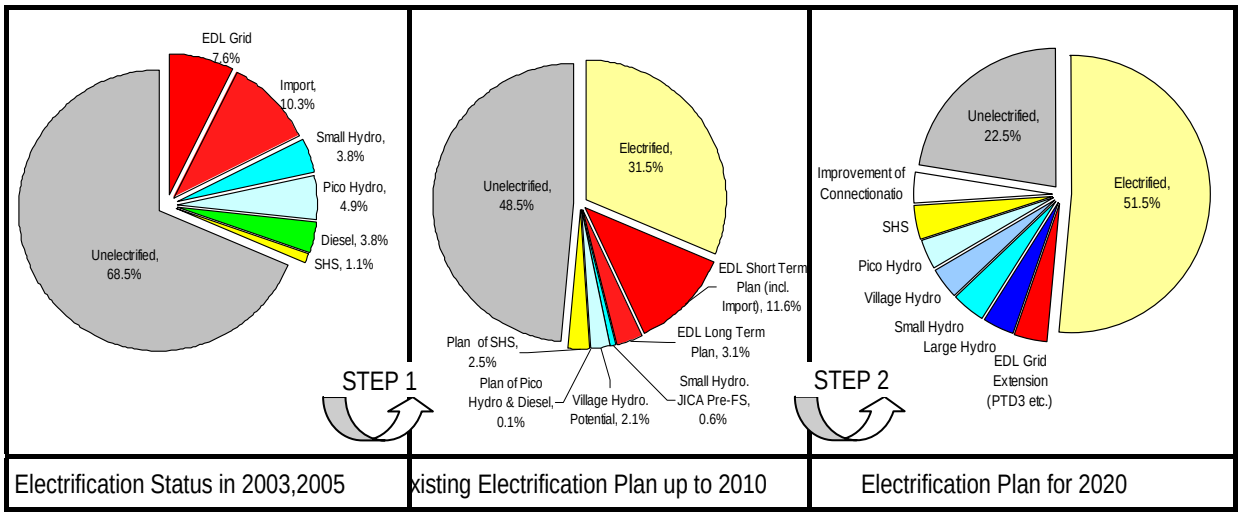
Code	Province	Household Number	Un-electrified Household Number	Rate of Electrif. after Implem. of Existing Electrif. Plan %	Existing Electrification Plan, Off-Grid Pre-FS Project and VH Potential Sites					
					EDL (short term plan)	EDL (Long term plan)	JICA Off-grid Pre-FS	VH Potential sites	Existing 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

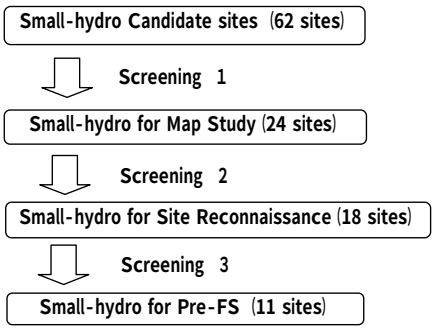
Case	Rough estimate of cost for rural Electrification
SHS of OPS program style by WB is adopted in STEP 2	The total cost for electrification of STEP 1 and STEP 2 is US$140 million. The electrification cost of STEP 2 was estimated about US$32 million.
EDL grid extension is adopted in STEP 2	The electrification 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.

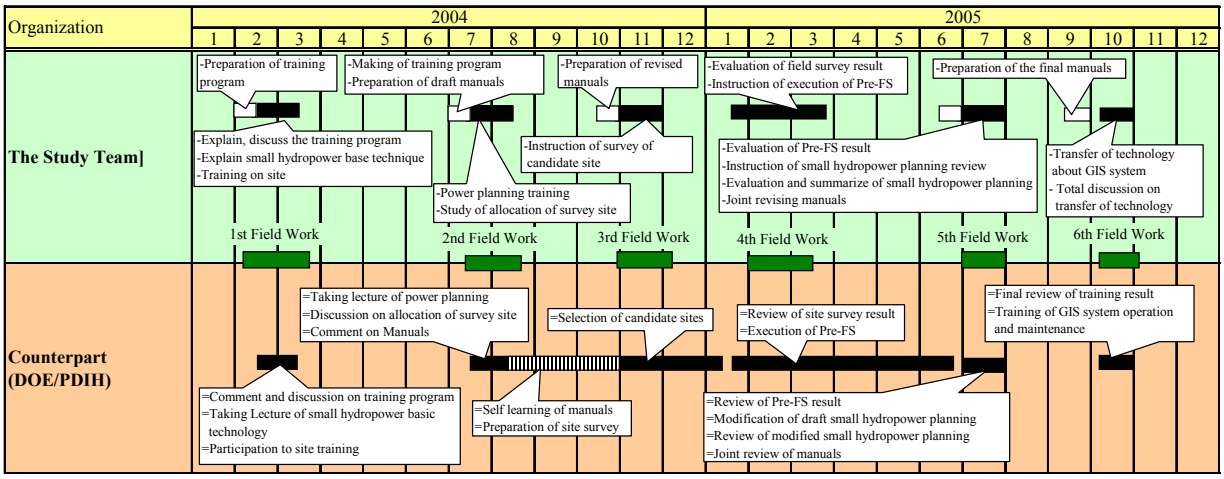
26. OUTLINE OF IEE RESULTS

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. CONCLUSION AND RECOMMENDATION

1.1 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.

1.2 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.

1.3 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:

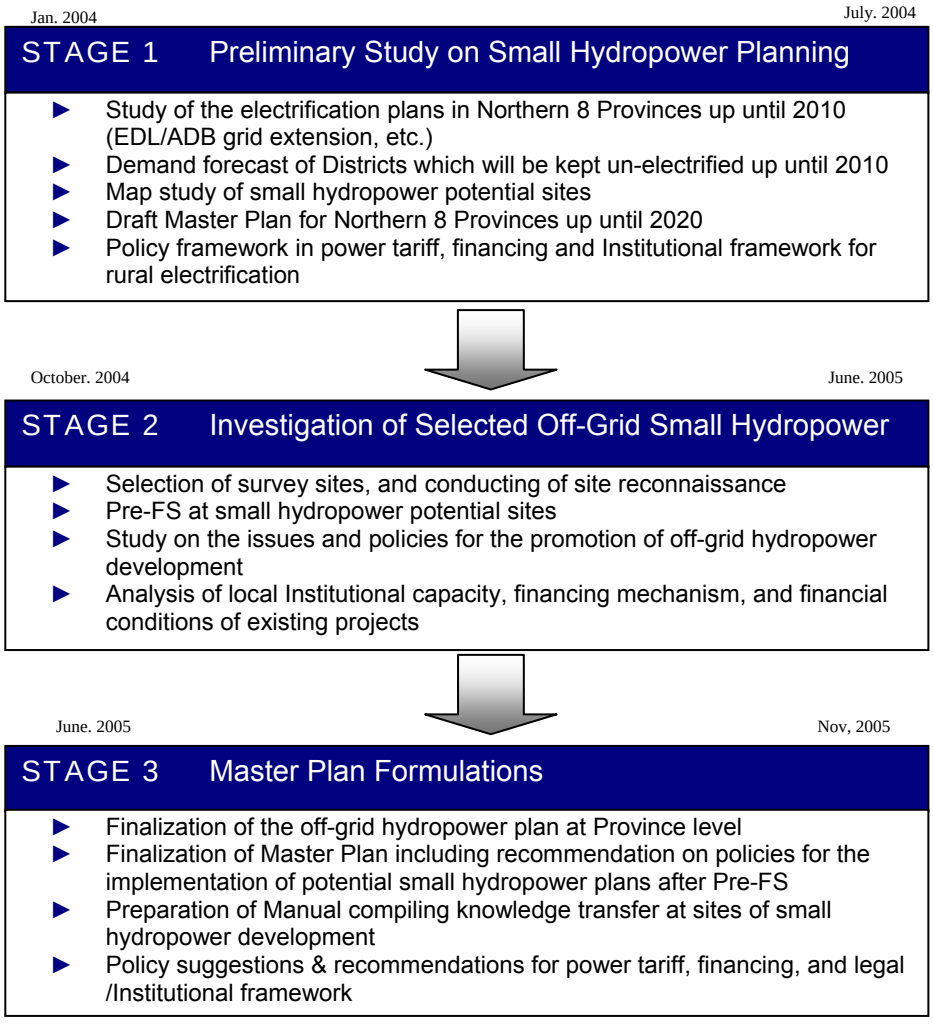
- Preparation of master plan for off-grid small-hydro targeting the year 2020 based on the field reconnaissance results and implementation of Pre-FS,

- 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.

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 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

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.

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.

2.2 PRESENT CONDITIONS AND ISSUES OF RURAL ELECTRIFICATION POWER SECTOR

(1) General

Domestic power is supplied by national transmission line and by 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 generators and small-hydro schemes),

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

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

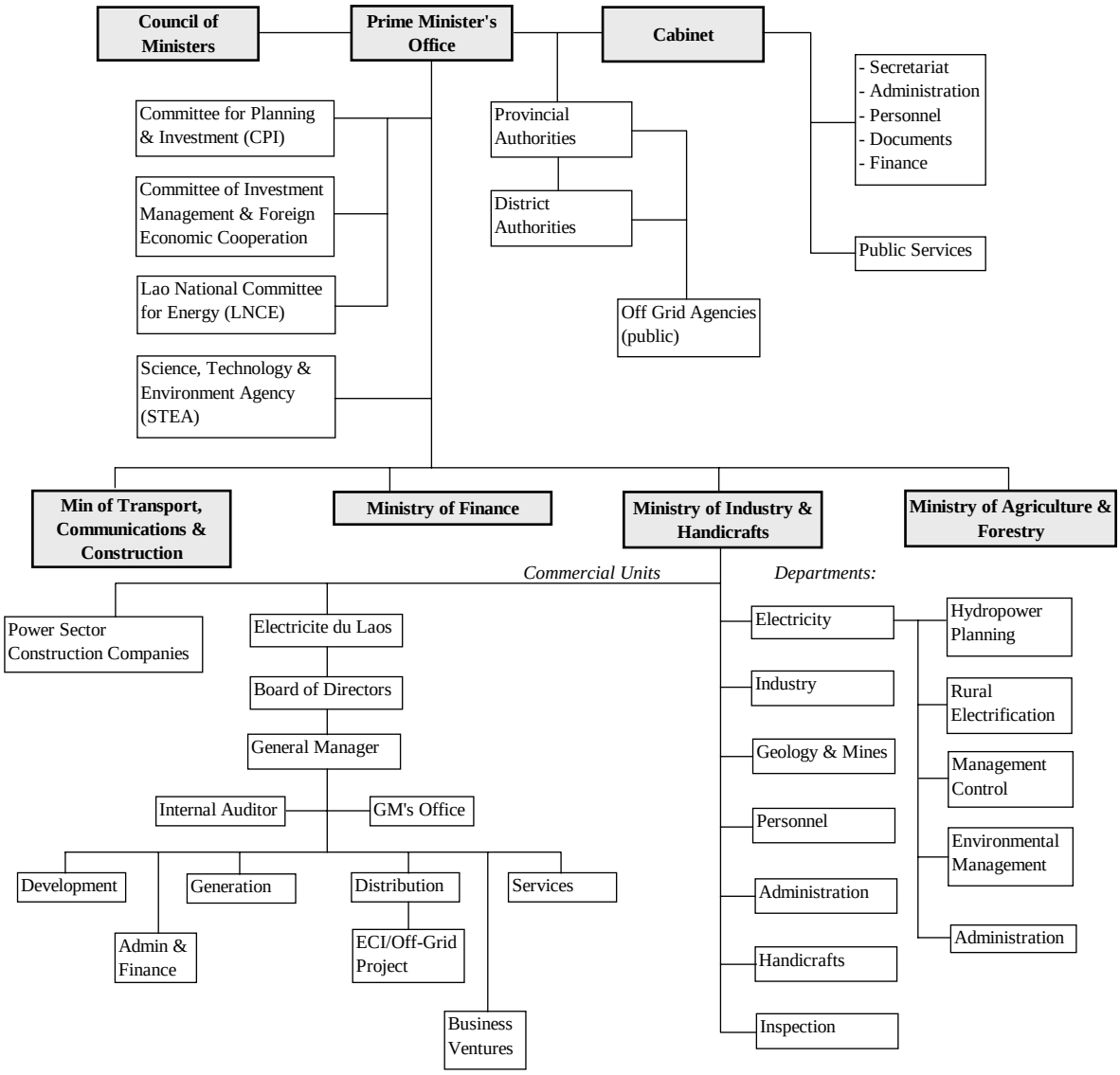
(iii) Small off-grid power supplies imported from Thailand, Vietnam and China

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

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

(2) Organization of Rural Electrification 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 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.

(3) 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: 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.

(4) Rural Electrification Projects and Development Models

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	Const. 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	Content: 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

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.

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(Transmission lines in 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(Transmission lines in 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

2.3 POLICY AND INSTITUTIONAL ISSUE IN SMALL-HYDRO RURAL ELECTRIFICATION

(1) Characteristics of Small-Hydro Systems

In contrast to large hydropower projects, small-hydro projects have advantages as follows:

- No need to have a reservoir thus little negative impact on environment with a good possibility for CDM application,
- Possibility to supply power to remote off-grid areas, thus having high potential for poverty alleviation.

There are three issues that small-hydro projects need to overcome for realization in Laos as follows:

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

(2) Financing for Rural Electrification

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

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.

2.4 RECOMMENDATION 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).

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

In order to improve the financial viability of off-grid rural electrification projects, the public and 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. 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. The fixed sum based approach may avoid the moral hazard in reporting and self-auditing.

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.

2.5 SMALL-HYDRO RURAL ELECTRFICATION SCHEME

(1) Possibility of Application of PPP Scheme to Small-hydro Business

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.

An overall classification of public private partnership for small-hydro projects is as follows:

(i) Management Contract Model,

(ii) Lease Contract Model,

(iii) Concession Model,

(iv) ESCO Model, and

(v) Village Organization/ Cooperative Model.

According to the current Electricity Law in Laos, the extreme case of BOO is not legally possible. BOT is possible but this 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 borne by the government while the risks of management are borne by the private sector participant. 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/or 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 the 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. If the government does not have advantages such as resources in finance or expertise to respond to the needs for regular maintenance or repairs, a community based system needs to be further explored as well as private sector participation.

Out of the five models shown above, (iii) "concession model" would have applicability for the on-grid type small hydro projects, which have proven to have enough profitability (see Chapter 4.4). 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 a private investor to gain a reasonable return on investment from these four projects, and thus these projects are considered to have potential to attract 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 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, (iv) "ESCO Model" and (v) "Village Organization (VO)/ Cooperative Model" would have applicability for the execution of the off-grid type projects.

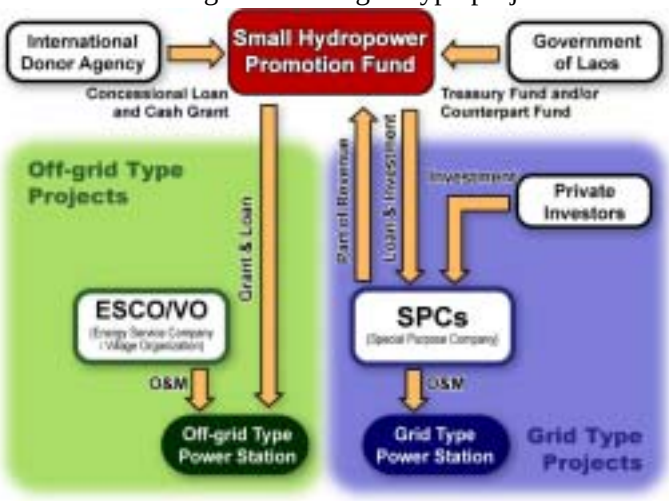
(2) Fund for Small-Hydro Development

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.

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.



Conceptual Diagram of the Fund

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.

2.6 FINANCE PROCUREMENT USING CDM APPLICATION

(1) Background

CDM is an evolving scheme. It is necessary to develop 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) CDM Cash Flow

After commencement of the CDM project, CER will be issued in accordance with GHG emission reduction. There are two (2) methods for financial arrangement using CER: one is up-front payment, and the other is payment on CER delivery.

Up-front payment is valued on the prospective CERs 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.

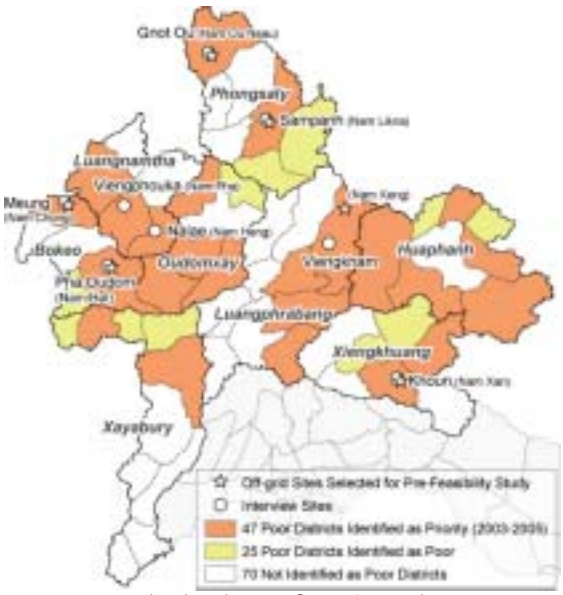
(3) Financial Analysis

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.

2.7 RECOMMENDATION FOR POVERTY REDUCTION THROUGH RURAL ELECTRIFICATION

(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 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 index 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 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%).

The Gini Index of the surveyed areas is 0.351 on average. Compared to national average and other Asian countries[*2], inequity in the surveyed eight (8) sites is 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).

(2) Recommendations for Poverty Reduction and Rural Development 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.

The power generation capacity is designed for the peak power demand of the service area, which appears at dinner time in an independent rural mini grid. The load factor, i.e., the average utilization

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

[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

level of the capacity typically hovers about 20% in rural area. It is necessary to increase daytime demand by inducing productive activities to increase the level of utilization. In other words, improvement of hydropower economy and economic development are two sides of the same coin.

In the future, private operators may enter into off-grid power supply business. If they determine tariff only to pursue their profitability without considering social impact, the poor might be excluded from access to electricity service. 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 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

The above is especially true, in the case of small-hydro projects, in order to fully capture the under-utilized energy generation capacity during off-peak times. It also provides an effective measure for poverty alleviation. Tariffs for industrial/commercial categories in rural area should be attractive enough to induce income generation activities using electricity. Also an integrated development with road access would improve access to the market and induce industrial development as well as reduce the investment cost for rural electrification.

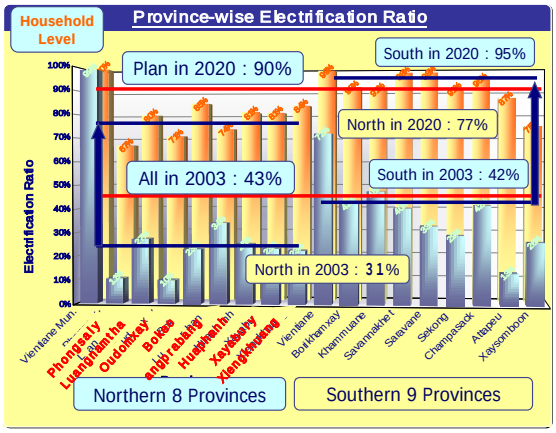
- Tariff for Commercial/Industrial Categories should be kept low.
- Tariff for Irrigation should also be kept low.
- Transport and Energy Infrastructure should be provided in order to achieve a Significant Synergy Effect on Poverty Reduction. And,
- Micro Credit should be offered for Entrepreneurs proposing commercial activities utilizing electricity

3 MASTER PLAN OF SMALL-HYDRO RURAL ELECTRIFICATION

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

(1) Basic Policy of Rural Electrification

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.



Source: JICA Study Team

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 of Pico-hydro and diesel power generation
	12	Existing plan of 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 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 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

Source: JICA Study Team

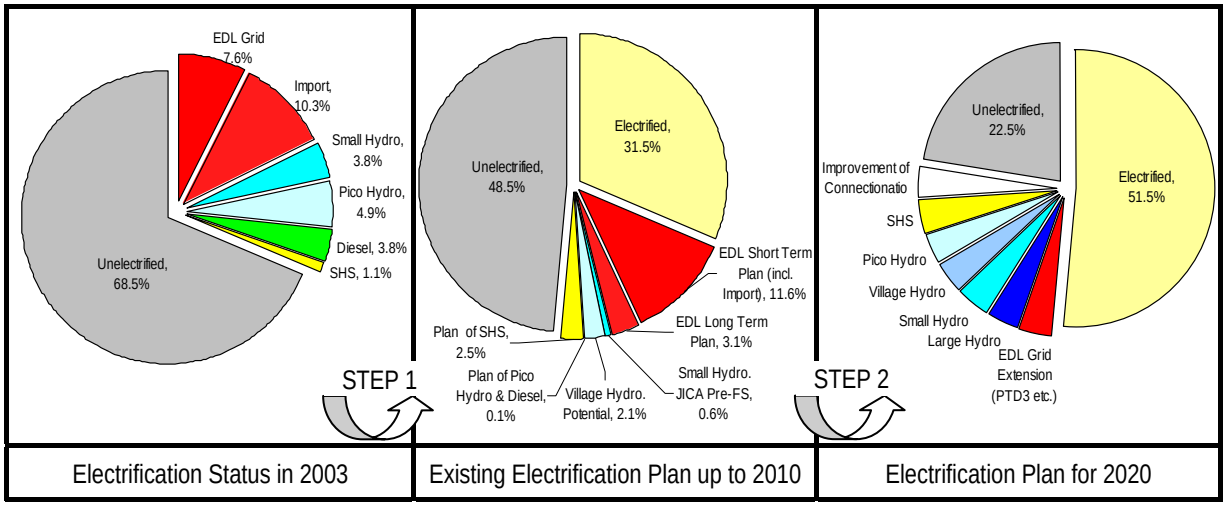
STEP 2

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:

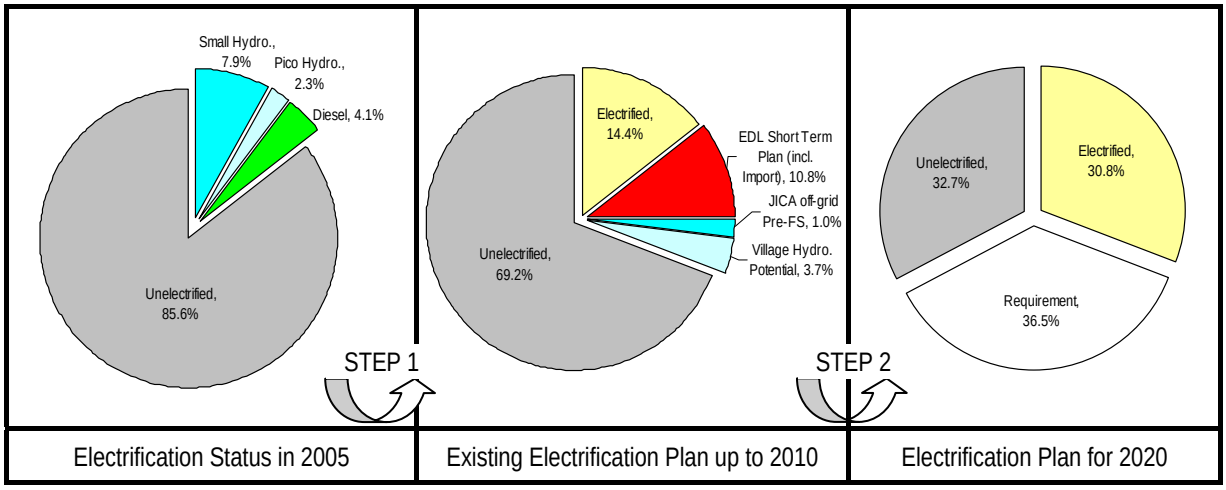
(i) EDL grid extension plan (PTD 3, provincial plan)
(ii) Large hydropower project in northern 8 provinces and electrification of surrounding villages
(iii) Small-hydro project
(iv) Village-hydro project
(v) Pico-hydro project
(vi) SHS

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

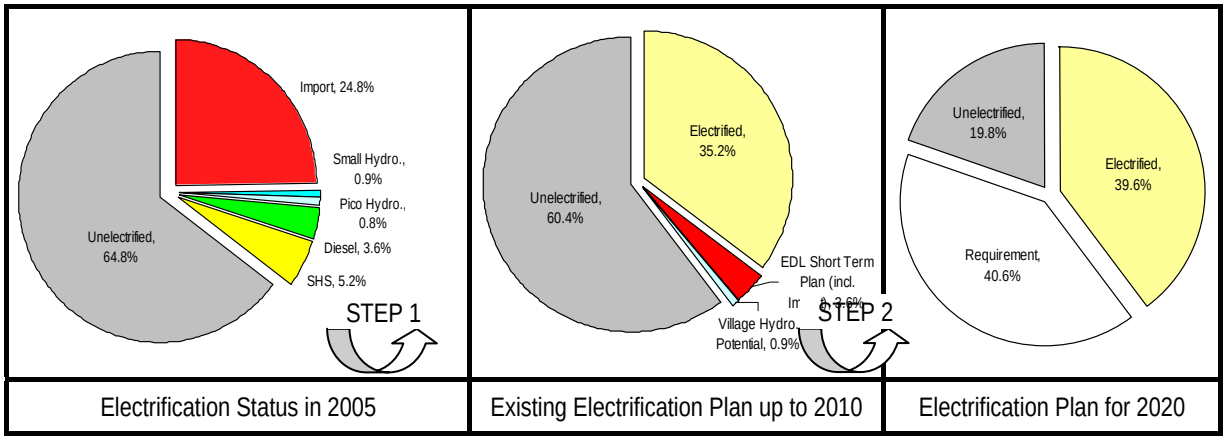
Total of Northern 8 Provinces



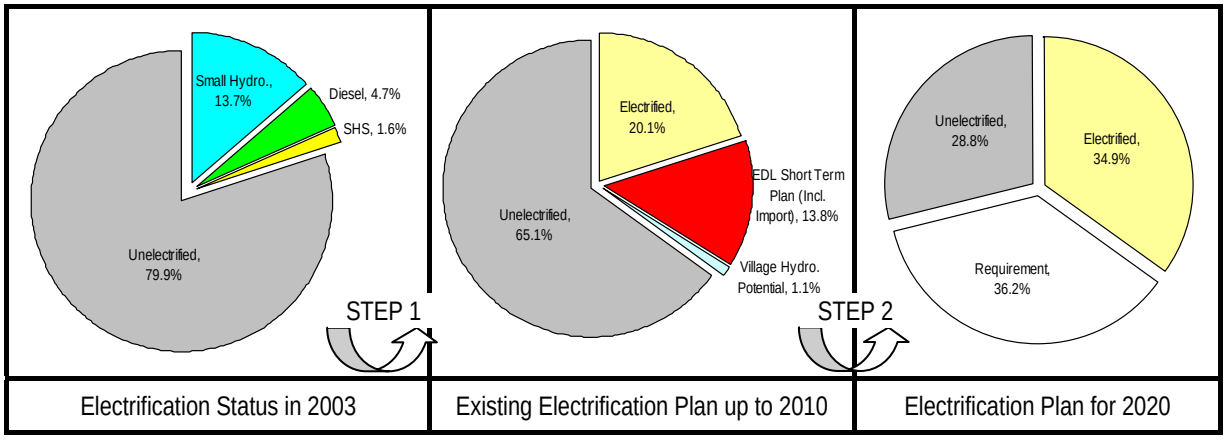
1. Phongsaly Province



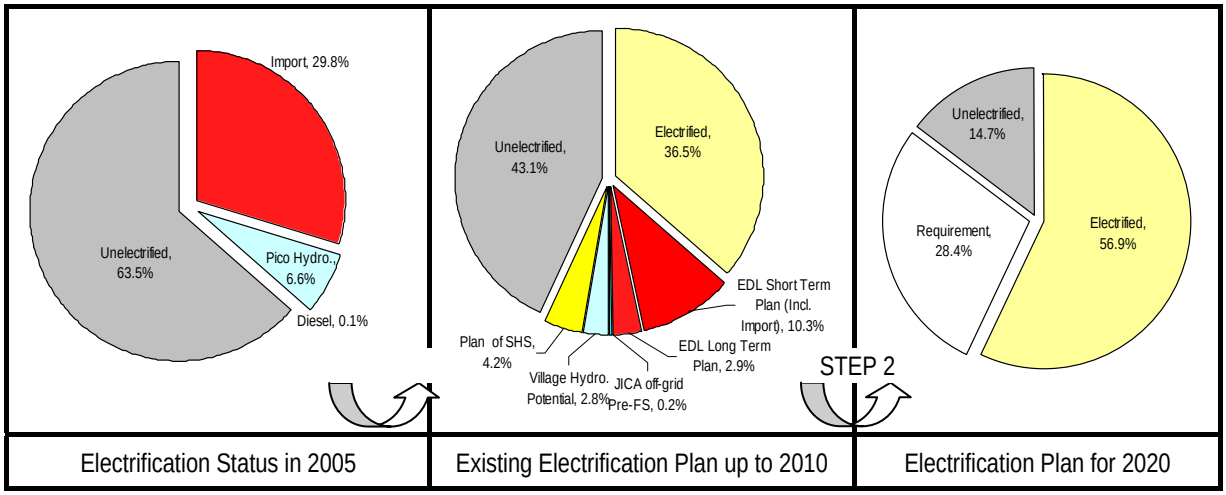
2. Luangnamtha Province



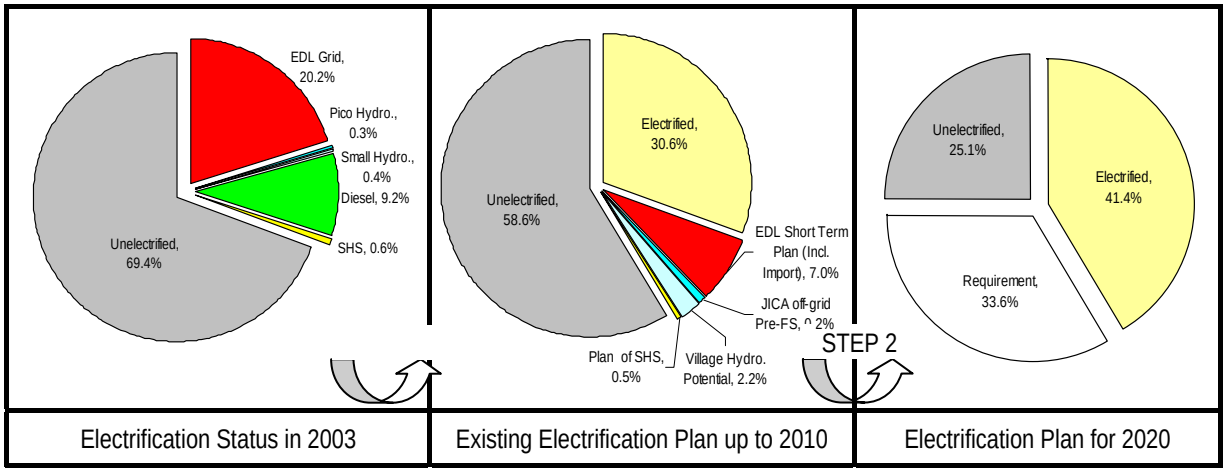
3. Oudomxay Province



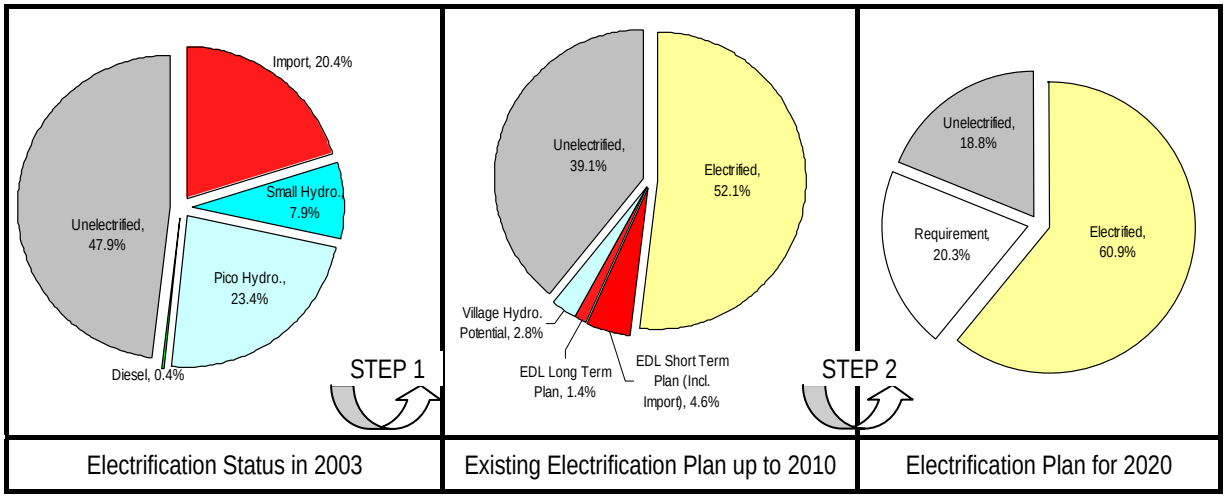
4. Bokeo Province



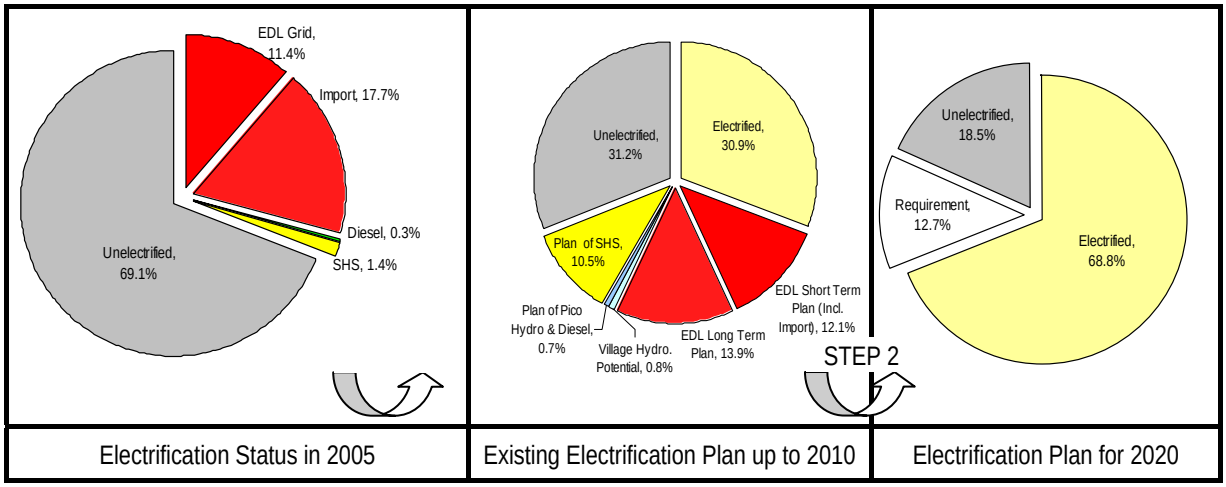
5. Luangphrabang Province



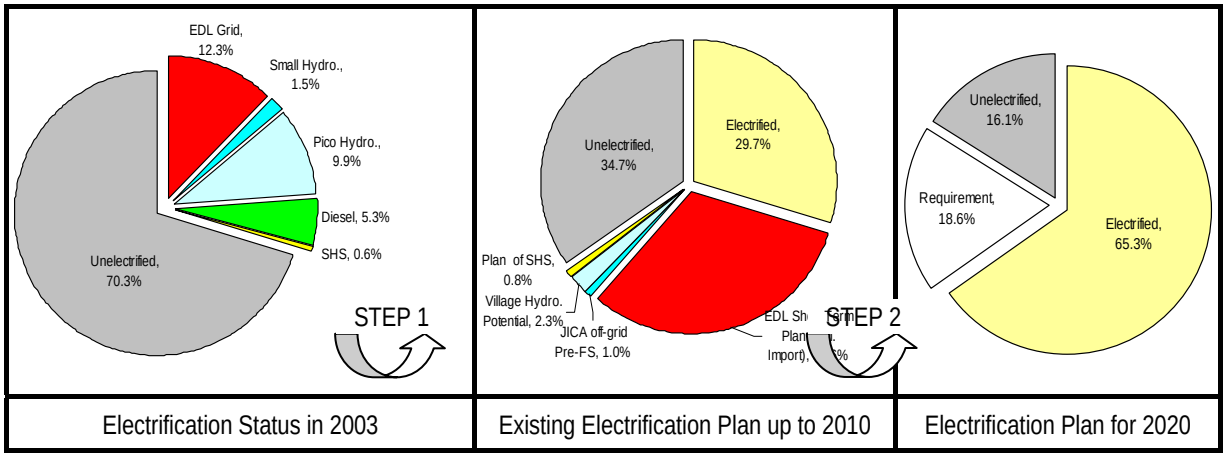
6. Huaphanh Province



7. Xayabury Province



8. Xiengkhuang Province



Source: JICA Study Team

(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 and diesel power	Existing plan of 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

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.

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 increase the average rate of 51% electrification of the northern 8 provinces to 77% in 2020 by EDL grid extension only, was estimated at about US$186 million. This electrification cost is 6 times that of Case 1.

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 SUSTAINABLE RENEWAL OF SMALL-HYDRO RURAL ELECTRIFICATION PLAN

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.

(1) 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:

(i) 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 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.

(ii) 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.

(2) 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:

(i) In this Master Plan Study, capacity building for counterpart staff in DOE and PDIH was carried out through map study, site investigation and 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.

(ii) 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 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 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.

4. PRE-FEASIBILITY STUDIES ON SMALL-HYDRO

4.1 INTRODUCTION

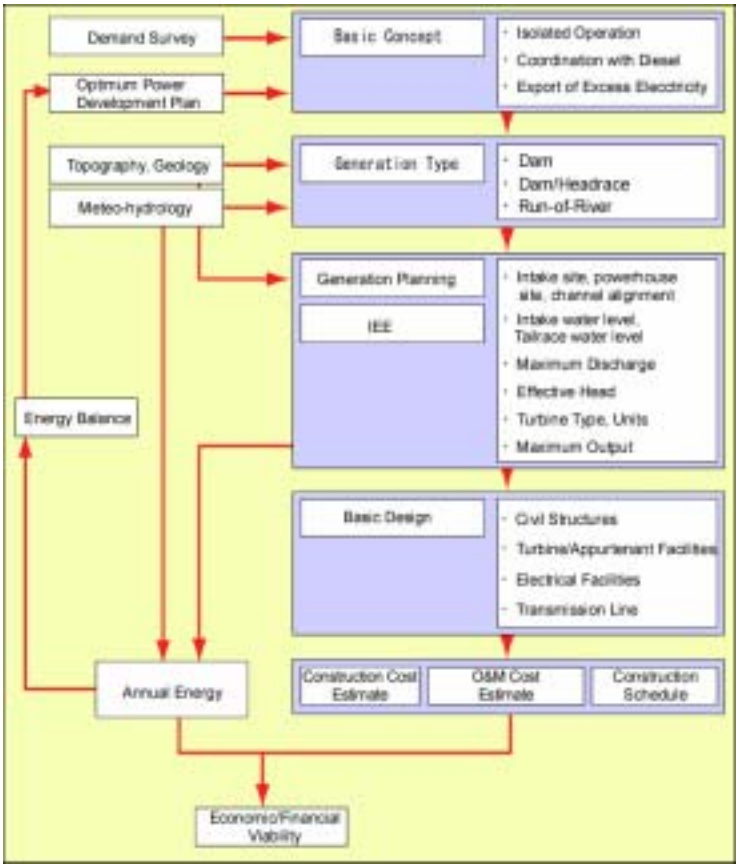
A Pre-F/S has been conducted for the most promising small-hydro potential sites, which were selected through studies of grid extension plans, demand forecasts, and site reconnaissance.

Of the eleven (11) selected sites for the Pre-F/S, topographic surveys, longitudinal profile surveys, and cross-section surveys were conducted for the intake, powerhouse and waterway of the seven (7), mainly MW-class scheme, sites. Furthermore, discharge measurement was conducted for the selected sites during site reconnaissance using equipment purchased by JICA.

The Pre-F/S was conducted keeping in mind the differences between the 100kW-class schemes and the MW-class schemes, such as the difference in scale, cost of development, electricity tariff and financial viability, as well as the differences in the institutional structure for their operation and maintenance.

The Pre-F/S design for the sites where topographic surveys were not conducted was based on 1/50,000 or 1/100,000 topographic maps.

The contents of the ongoing STEP study was considered for the design and cost estimate of the equipment. Further, in the economic/financial analyses, the life-cycle cost, including operation and maintenance, account for the unique characteristics of the northern provinces of Laos.



Flowchart for the Pre-F/S

The study items of the Pre-F/S are as follows:

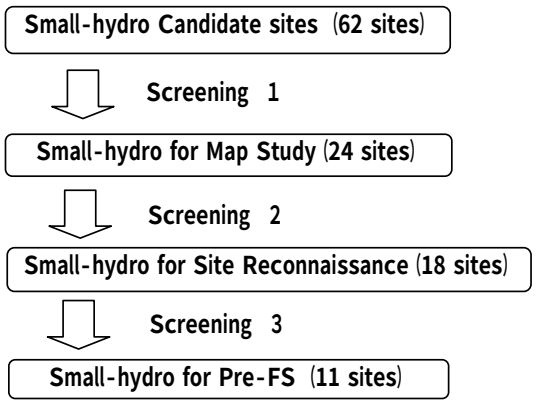
Pre-F/S Study Items

(i) Meteo-hydrological analysis
(ii) Optimum power development plan (Optimization of installed capacity in the case of a grid-connection plan)
(iii) Power development planning and design (civil works, electrical/mechanical equipment, transmission and distribution line, etc.)
(iv) Economic/financial analysis
(v) Initial Environmental Evaluation

4.2 SMALL-HYDRO INVENTORY STUDY

(1) Introduction

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.



(2) 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.

It may also be noted that for load centers in northern Laos with a small load where expanding the mini-grid for the sake of attaining over 100 kW proved to be costly, installed capacities less than 100 kW were considered despite the original scope stating the target installed capacity of the Study to be greater than 100 kW.

Similarly, despite the upper limit of development set at 5 MW in the scope of the Study, MW schemes greater than 5 MW were also considered in order to take full advantage of the economies of scale of the development for replacement of imported power and strengthening of the EDL grid, where sufficient head and discharge are available.

(3) Screening 1 (Selection of Candidate sites for Map Study)

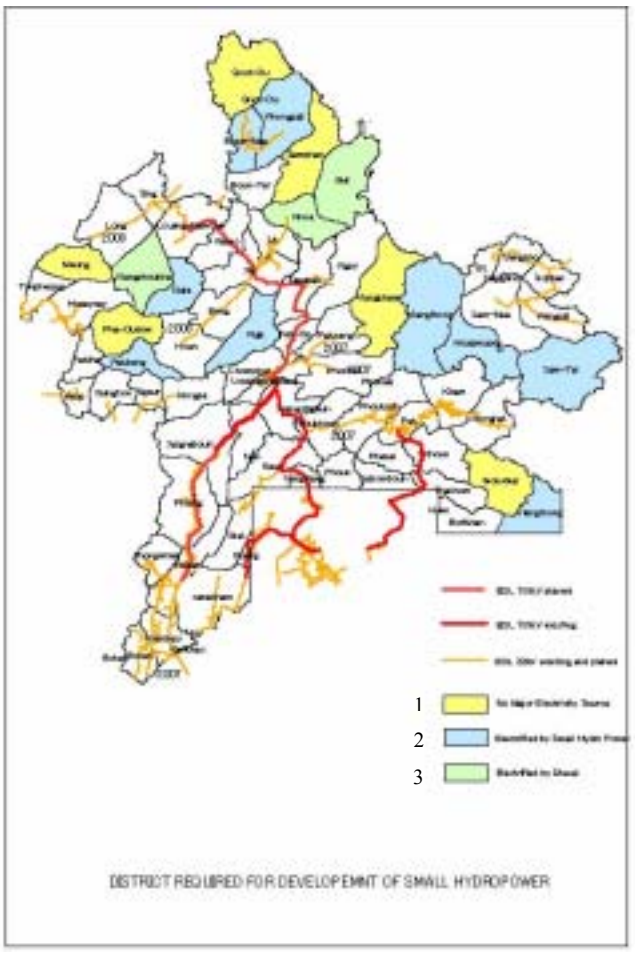
The load centers to be electrified by small-hydro were selected according to studies of the EDL grid extension plan (PTD2, PTD3), power supply/demand balance and other conditions such as substitution of imported power. The existing 115 kV and 22 kV EDL transmission lines and their plan for 2010 are shown in the figure below.

Districts which are not included in the EDL extension plan for 2010 are classified as load centers, which have been further categorized into three categories as shown in the table and figure below.

Categories of the Load Centers

Category	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

Discussions were held with the PDIH staff during the lectures held in Vientiane for the selection of the above load centers, and their comments and requests were reflected accordingly.



In addition to load centers mentioned above, the small-hydro potential sites for replacement of import power and strengthening of the EDL grid were selected on the basis of location of the existing transmission line and its extension plan.

From the small-hydro inventory of 62 potential sites, 24 sites for map study were selected as follows, according to the prioritization of the load centers, as well as the hydropower potential suitable for the reinforcement of the EDL grid power. The projects without hatching in the table below are the small-hydro, which were added during site reconnaissance.

List of Sites for Map Study

Seq No.	Project Name	C/A (km2)	Spec. Dis. (l/s/kw2)	Dis. in Dry Sea. (m3/s)	Effec. Head (m)	Capacity in Dry Season (kW)	Installed Capa. (kW)	District	Province
1	Nam Nga	90	3.1	0.28	16	26	100	202 Mai	No.200 Phongsaly
2	Nam Kai	216	2.7	0.58	24	81	250	203 Khoua	
3	Nam Pok	407	3.2	1.30	80	613	150	204 Samphan	
4	Nam Likna						30	204 Samphan	
5	Nam Ou Neau	610.4	3.7	2.26	40	531	260	206 Gnod Ou	
6	Nam Boune 2						4,000	207 Bountai	
7	Nam Long	143.35	3.6	0.52	215	652	2,500	303 Long	No.300 Louangnamtha
8	Nam Pha	208	3.0	0.62	25	92	250	303 Vienhphoukha	
9	Houay Song						-	304 Viengphoukha	
10	Nam Chouk						-	304 Viengphoukha	
11	Nam Heng	280	1.9	0.53	30	94	225	305 Nalae	
12	Nam Phak	594	2.7	1.60	100	943	5,100	403 Namo	No.400 Oudomxay
13	Nam Ngao	245	2.0	0.49	80	230	840	405 Beng	
14	Nam Tale	88	1	0.09	80	41	80	407 Pakbeng	
15	Nam Gnone	126	2.7	0.34	30	60	600	501 Houasay	No. 500 Bokeo
16	Nam Khanoy	80	3.6	0.29	20	34	80	503 Meung	
17	Nam Chong	-	3.6	0.05	100	25	50	503 Meung	
18	Nam Polao						-	503 Meung	
19	Nam Hat	560	1.0	0.56	15	49	170	504 Pha Oudom	
20	Nam Hat 2	112	1.0	0.11	50	30	120	504 Pha Oudom	
21	Houay Kouang	40	2.4	0.10	34	19	200	610 Vieng Kam	No.600 Luangphrabang
22	Nam Mi						-	610 Vieng Kam	
23	Nam Xeng	420	2.5	1.05	20	123	170	610 Vieng Kam	
24	Nam Peun	216	3.0	0.65	40	152	70	705 Houamouang	No.700 Houaphan
25	Nam Hang	88	2.5	0.22	80	103	70	703 Viengthong	
26	Nam Hao	419	3.0	1.26	129	951	5,000	704 Viengxay	
27	Nam Sim						8,000	704 Viengxay	
28	Nam Ngen 2	1100	1.0	1.10	20	129	610	802 Khorb	No.800 Xayabury
29	Nam Ken	312	1.5	0.47	30	83	380	803 Hongsa	
30	Nam Lay	256.38	1.3	0.33	30	59	220	807 Paklay	
31	Nam Ham 2	100	1.0	0.10	176	103	1,000	809 Boten	
32	Nam Xan 3	136	4.0	0.54	60	192	120	904 Khoune	900 Xiengkhuang
33	Nam Chao	128	4.0	0.51	25	75	100	905 Morkmay	

(4) Screening 2 (Selection of Candidate sites for Site Reconnaissance by Map Study)

The map study of the 24 potential sites was conducted by categorizing them into two (2) groups as explained hereunder.

Grouping for the 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

For the load centers categorized as Group 1, small-hydro potential sites were selected which best satisfied the demand in the respective load centers. Basic data such as discharge and head were roughly calculated in order to make a sketch of a hydropower development plan. The promising sites were selected through analysis of difficulty of construction and economic viability based on these rough data, and by the use of the selection criteria.

As for the sites categorized as Group 2, the hydropower potential was the governing factor for the selection, as they aim to supply power to the EDL grid or to replace expensive imported power.

The selection was conducted by allocating points for the following criteria, while also giving consideration so that the selected sites were not concentrated in a particular province.

(i) Unit construction cost (US$/kW)
(ii) Necessity for electrification (un-electrified area, addition to existing small-hydro, replacement of diesel generator, reinforcement of EDL grid, replacement of imported power)
(iii) Balance between hydropower potential during dry-season and demand
(iv) Accessibility
(v) Possibility to divert water for irrigation

The 18 hatched sites, of which 11 sites are of Group 1 and 7 sites are of Group 2, were selected for site reconnaissance.

(5) Screening 3 (Selection of Pre-F/S 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.

From November to December 2004, two teams, each composed jointly of members of the Study Team and DOE, conducted site reconnaissance separately for a total of 19 sites. Later DOE conducted site reconnaissance for the 4 sites in Houaphan and Xiengkhuang Provinces where the JICA Study Team members were not allowed to enter for security reasons.

No.	Project Name	District	Province	Demand Area	Site Recon by
3	N. Pok	Samphan	Phongsaly	D.C.	3rd Field (A)
4	N. Likna	Samphan		D.C.	3rd Field (A)
5	N. Ou Neau	Gnod Ou		D.C.	3rd Field (A)
6	N. Boune 2	Bountai		Grid	3rd Field (A)
7	N. Long	Long	Louang-namtha	Grid	3rd Field (B)
8	N. Pha	Vienhphoukha		D.C.	3rd Field (B)
9	H. Song	Viengphoukha		D.C.	3rd Field (B)
10	N. Chouk	Viengphoukha		D.C.	3rd Field (B)
11	N. Heng	Nalae		D.C.	3rd Field (B)
13	N. Ngao	Beng	Oudomxay	Grid	3rd Field (B)
15	N. Gnone	Houasay	Bokeo	Grid	3rd Field (B)
16	N. Khanoy	Meung		D.C.	3rd Field (B)
17	N. Chong	Meung		D.C.	3rd Field (B)
18	N. Polao	Meung		D.C.	3rd Field (B)
19	N. Hat	Pha Oudom		D.C.	3rd Field (B)
20	N. Hat 2	Pha Oudom		D.C.	3rd Field (B)
21	H. Kouang	Vieng Kam	Luang-phrabang	D.C.	3rd Field (A)
22	N. Mi	Vieng Kam		D.C.	3rd Field (A)
23	N. Xeng	Vieng Kam		D.C.	3rd Field (A)
26	N. Hao	Viengxay	Houaphan	Grid	DOE
27	N. Sim	Viengxay		Grid	DOE
29	N. Ken	Hongsa	Xayabury	Grid	4th Field
31	N. Ham 2	Boten		Grid	DOE
32	N. Xan 3	Khoune	Xiengkhuang	Sub .C.	DOE

Several formats were prepared for the site reconnaissance in order to secure uniformity in the content the precision and the method of the site reconnaissance of the two teams as well as to serve as a guideline for the DOE engineers to better understand the items that need to be investigated during the reconnaissance. The formats prepared by the Study Team members include those for civil work, transmission line routes, socio-economic surveys, and environmental impact. The Study Team also prepared an explanation sheet introducing small-hydro projects, to be used when visiting district offices and village leaders.

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.

4.3 PLANNING AND DESIGN OF SMALL-HYDRO PRE-F/S

The salient features of the 11 small-hydro sites selected for Pre-F/S are shown in the table below. The Pre-F/S was carried out by separating the JICA Study Team and DOE. Prior to the Pre-F/S, the criteria for planning and design were prepared to ensure uniformity of output.

List of Sites Subject to the Pre-F/S

Cate-gory	Project Name	District	Province	Demand Area	Map Study	Topo Survey	Socio Survey	Gauge Installation	Pre-F/S
U	N. Likna	Samphan	Phongsaly	D.C.	-	-	O	-	S/Team
U	N. Ou Neau	Gnod Ou		D.C.	O	EL only	O	O	S/Team
U	N. Boun 2	Bountai		Grid	-	O	-	-	S/Team
S	N. Long	Long	Louangnamtha	Grid	O	O	-	O	S/Team
I	N. Gnone	Houasay	Bokeo	Grid	O	O	-	O	S/Team
U	N. Chong	Meung		D.C.	-	-	O	-	S/Team
U	N. Hat 2	Pha Oudom		D.C.	-	-	O	-	DOE
U	N. Xeng	Vieng Kam	Luangphrabang	Pak Um	O	O	O	O	DOE
I	N. Sim	Viengxay	Houaphan	Grid	-	O	-	-	DOE
I	N. Ham 2	Boten	Xayabury	Grid	O	O	-	-	DOE
U	N. Xan 3	Khoune	Xiengkhuang	Ngan	O	-	O	-	DOE

Note: I: Import, D: Diesel, U: Unelectrified, AH: Hydro, S: Extension

(1) Small-hydro Planning

The sites selected for the Pre-F/S can be classified into two categories: (i) off-grid type where the power produced is supplied to the district center and the surrounding villages, and (ii) grid type where the power produced is intended for the reinforcement of the EDL grid. 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.

Since hydrological data are not available for any of the Pre-F/S sites, the discharge data at these locations needed to be established. The method of generating discharge data at the targeted location is by catchment area ratio and annual rainfall ratio between the targeted basin and the basins with data, which in this case are Nam Ou and Nam Souang. Prior to the calculation, annual duration curves were prepared for the two basins, and a duration curve that was judged to be standard was selected. In the case of Nam Sim small-hydro only, since the FS was conducted previously, the DOE's set of daily discharge data gathered from another water level gauging station near to the project site was adopted. The discharge data generated in such manner serves as input for the annual power generation simulation.

(2) Design at the 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.

The design flood for the intake weir was decided to be a 100 year probability flood, basically on the basis of the Lao Electric Power Technical Standard prepared by JICA in 2004. However, in the case of the off-grid small-hydro, the installed capacity is as small as 30~260kW and the river width is relatively small at the location of the intake weir. Therefore, if the spillway for a 100 year probable food is designed for the intake weir in such conditions, un-necessary excavation and concrete structures are required and the spillway structure does not match the existing river width. In order to avoid such design, a 50 year probability flood was adopted for off-grid small-hydro in this Pre-F/S.

(3) Cost Estimate at the 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.

(4) Results of Pre-F/S

The results of Pre-F/S from planning and design at the Pre-F/S level of the eleven (11) sites are

summarized in the table below. As part of the results of Pre-F/S, the generated cost per kWh of each project can be one index for the evaluation of the project. In addition to this evaluation, the projects were compared with the other power source, which consisted of a diesel power generation project and the grid extension project considering the distance from the existing EDL grid line.

Salient Features and Results of the 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

4.4 FINANCIAL AND ECONOMIC ANALYSIS INCLUDE CDM

(1) Financial Analysis

In the case of the Grid type projects, 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. Except for Nam Gnone, EIRR of the remaining four (4) projects indicates that they should be financially viable. In particular, the unit generation costs of Nam Boung 2, Nam Sim, and Nam Long are in the US¢ 2.0 range, and these projects are judged to be good projects (EIRR of these projects exceeds 18%).

In the case of the Off-grid type projects, 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. The connection fee and electricity tariff used for the analysis were determined based on the WTP curve, which was estimated based on the village socio-economic survey. Unit generation costs of all the Off-grid type projects exceed US¢20/kWh. In the same way as with other off-grid projects in the developing countries, all the financial indicators show very bad performance, and accordingly all the off-grid projects are judged to be financially not viable.

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%

(2) 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. Except for Nam Gnone, EIRR of the remaining 4 projects are well above the cost of capital in Laos (10.0%) and ADB's standard (12.0%), and thus economically viable. In particular, Nam Boung 2, Nam Sim, and Nam Long are judged to be good projects (EIRR of these projects exceeds 20%).

Economic benefits of the Off-grid type projects are calculated using the consumer's average WTP for connection fees and electricity tariffs. Out of 6 projects, Nam Likna, Nam Ou Neua, and Nam Xan 3 were confirmed as having economic viability. The EIRR of these projects exceeds 10%, but this is below the 12% standard set by the ADB. In addition, Nam Chong shows good economic performance (EIRR: 9.42%). However, Nam Xeng (7.19%) and Nam Hat 2 (5.47%) are obviously not viable.

(3) Least Cost Analysis for Off-Grid Electrification

Out of the six (6) Off-grid type projects, four (4) projects (Nam Likna, Nam Ou Neua, Nam Chong and Nam Xeng) have competitive advantage in supply cost. However, in the case of Nam Xan 3 and Nam Hat 2, since they are located relatively near the EDL grid, electrification through grid extension was selected as the least cost alternative. In reality, since the Pre-F/S, the Bokeo Provincial Government has already decided to extend the transmission line toward the district center of Pha Oudom, which is near the Nam Hat 2 project site.

Comparison of Supply Cost by Alternatives (Unit: US¢/kWh)

Project Name	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**

(4) Selection of the Priority Projects

Out of five (5) Grid type projects, Nam Gnone was excluded from the list because it was financially and economically not feasible. In the case of Nam Sim, and Nam Boung 2, there is not enough demand around the project site before the grid connection. Thus, these projects should be completed in 2015 (Nam Sim) and in 2010 (Nam Boung 2), when the EDL grid is extended to the project sites.

On the other hand, according to EDL's plan, the EDL grid will extend to Long district in 2008, where the Nam Long project site is located. In addition, EIRR and FIRR of the Nam Long project shows good performance, and thus the project can be selected as one of the priority projects. In the case of Nam Ham, there is sufficient energy demand even before the connection, and thus it is also selected as a priority project.

Selected Projects (Grid Type)

Priority Projects	Nam Long (2,500 kW: Luang Namtha Province), Nam Ham 2 (1,000 kW: Bokeo Province)
Candidate Projects	Nam Boung 2 (4,000 kW: Phongsaly Province), Nam Sim (8,000 kW: Huaphanh Province)
Excluded Project	Nam Gnone (600 kW: Bokeo Province)

Out of six (6) Off-grid type projects, Nam Xan 3 and Nam Hat 2 are excluded from the list, because grid extension has been selected as the least cost alternative. Of the remaining four (4) projects, Nam Ou Neua (EIRR: 11.77%) and Nam Likna (10.54%) have been selected as priority projects, because the EIRR of these projects exceeds the cost of capital in the country (10%). While the EIRR of Nam Chong (9.42%) and Nam Xeng (7.19%) are below 10%, these projects are cheaper than diesel generator grid as well as grid extension, and consequently those projects are judged still worth implementation.

The priority projects Nam Ou Neua and Nam Likna are located in Gnot Ou and Sampanh districts respectively. According to the National Poverty Eradication Program, those districts were selected, not only as poor districts, but also as priority development districts. In addition, a village socio-economic survey has revealed that they have potential industry using electricity. It is hoped that the electrification will remove poverty in these districts. When focusing on poverty alleviation, the poorer district of Nam Ou Neua should be selected as the highest priority project. When higher ATP and WTP are regarded as important, Nam Likna can be selected as one of the higher priority projects.

Selected Projects (Off-grid Type)

Priority Projects	Nam Ou Neua (260 kW: Phongsaly Province), Nam Likna (30 kW: Phongsaly Province)
Candidate Projects	Nam Chong (50 kW: Bokeo Province), Nam Xeng (110 kW: Luangprabang Province)
Excluded Projects	Nam Xan 3 (80 kW: Xiengkhuang Province), Nam Hat 2 (120 kW: Bokeo Province)

(5) Financial Benefit on CDM Application

In this study, the effect of CDM application was studied as a financial benefit. This analysis was implemented for Nam Ham 2, Nam Ou Neua and Nam Likna projects and the results are shown in table below.

Analysis of 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.

4.5 VILLAGE SOCIO-ECONOMIC SURVEY

(1) 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).

(2) Ability to Pay (ATP) for Electricity

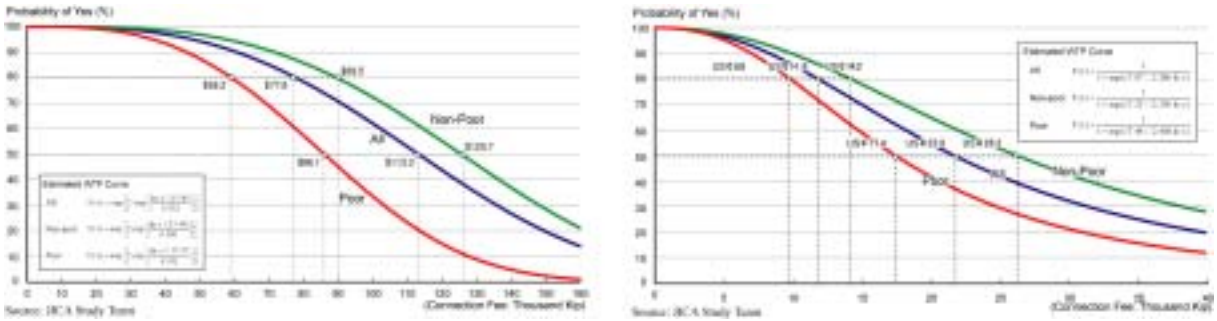
Under the survey, household expenditure for energy and other goods/services was collected. Based on the collected data, ability to pay for electricity is assumed to be 5% - 10% of household expenditure. As a result, ability to pay for electricity in the surveyed district centers is summarized as follows.

Ability to Pay for Electricity by District Center

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

(3) Willingness to Pay (WTP) for Electricity

In order to elicit respondent's WTP for electricity service in the survey area, the elicitation method of "Double Bounded Dichotomous Choice" was applied. Collected samples were classified as poor or non-poor based on consumption data. WTP of each stratum was estimated by a parametric method with the Logistic model and with the Weibull model. Results of the analysis are summarized as follows.



Estimated WTP Curve for Connection Fee (left) and Electricity Tariff (right) by poor strata, non-poor strata and all

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
All 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)

Estimated WTP for Electricity Tariff of Poor strata, Non-poor strata, and All

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)

WTP in each district center was estimated based on the weighted average of the poverty ratio (calculated based on the consumption) of each district center and the WTP of poor / non-poor.

Estimated WTP for Connection Fee and Electricity Tariff by District Center

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

(4) Comparison of WTP and ATP for Electricity

When comparison was made between WTP and ATP, the average WTP for the sample electricity service is slightly higher than the ability to pay in Nalae and Viengphouka. However, except for these cases, the average WTP is within the range of ATP, and thus estimated WTP is deemed reasonable.

Ability to Pay for Electricity by District Center

Items	Pha Oudom	Meung	Vieng Phoukha	Nalae	Vieng Kham	Khoun	Sampanh	Gnot Ou	Average
Average WTP for 25.8 kWh (US$)	6.03	6.01	6.60	5.84	6.92	5.92	7.02	5.95	6.03
Ability to Pay (US$)	4.35	3.58	3.10	2.36	8.59	3.70	5.92	3.49	4.75
	8.71	7.17	6.21	4.73	17.18	7.39	11.85	6.98	9.49

Note): 25.8 kWh is the energy consumption for the model service case, which is presented to interviewee during the socio-economic survey

(5) Potential Electricity Demand for Business and Industry

Currently, there are several types of small-scale business and industry (including grocery store, eatery, repair shop, furniture making shop, handicraft, weaving, silver smith, brick making, and rice-alcohol brewer) in the surveyed villages. Some households are using electricity (such as pico-hydro and diesel mini grid) for business activities. However, due to limited capacity and supply hours (only 2 - 3 hours in the evening), electricity is mainly utilized only for lighting purposes for grocery stores, weaving, and eateries.

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.

4.6 ENVIRONMENTAL IMPACT ASSESSMENT

(1) Screening of Pre-F/S Projects

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.

(2) Outline of IEE Results

No.	Items	Outline of IEE Results
1	Outline of 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 Envir. & Social Conditions of 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 Envir. & 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 & 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	Envir. 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.

5. CAPACITY BUILDING ON SMALL-HYDRO DEVELOPMENT

5.1 BACKGROUND AND SUBJECT FOR CAPACITY BUILDING

The background on the necessity for capacity building on small-hydro is the Lao national target to raise the national electrification ratio to 90% by 2020 and to contribute to poverty alleviation in the rural mountainous areas where more than 80% of the population resides. The electrification ratio at present is 36% at the national level and 20% in the rural areas, whilst that of the northern eight (8) provinces (61 districts, approximately 5,000 villages and 272,000 households) stands at a mere 15%.

The department in charge of off-grid rural electrification is DOE established 8 years ago, responsible for (i) formulation of a small-hydro development plan, (ii) planning of hydropower schemes utilizing irrigation facilities, and (iii) hydrological investigation entrusted by IPP developers. However, as the department's staff capability is inadequate, the development of their capability is a prerequisite, and capacity building of the DOE engineers has been pledged by the Lao Government.

Another player who should be active in the promotion of efficient rural electrification is PDIH, but their understanding of small-hydro at the moment is very limited.

With the above background, the capacity building of the counterparts was viewed as one of the prime objectives of the Study. Thus, the counterparts targeted for capacity building on small-hydro through this Study were the DOE engineers and the PDIH engineers.

5.2 POLICY AND METHODOLOGY OF CAPACITY BUILDING

(1) Policy on Capacity Building

It is believed that the transfer of technology can only become effective when there is an opportunity for the skill to be acquired and only if there is strong will to learn those skills to develop their capacity. In the case of this Study, there is a positive attitude on the part of the Lao counterparts to develop their capacity, and thus the above conditions for capacity building are satisfied. Furthermore, an effective capacity development platform is provided through this Study as it involves lectures and on-the-job training (OJT) where transfer of technology is generally much more effective.

(2) Methodology of Capacity Building

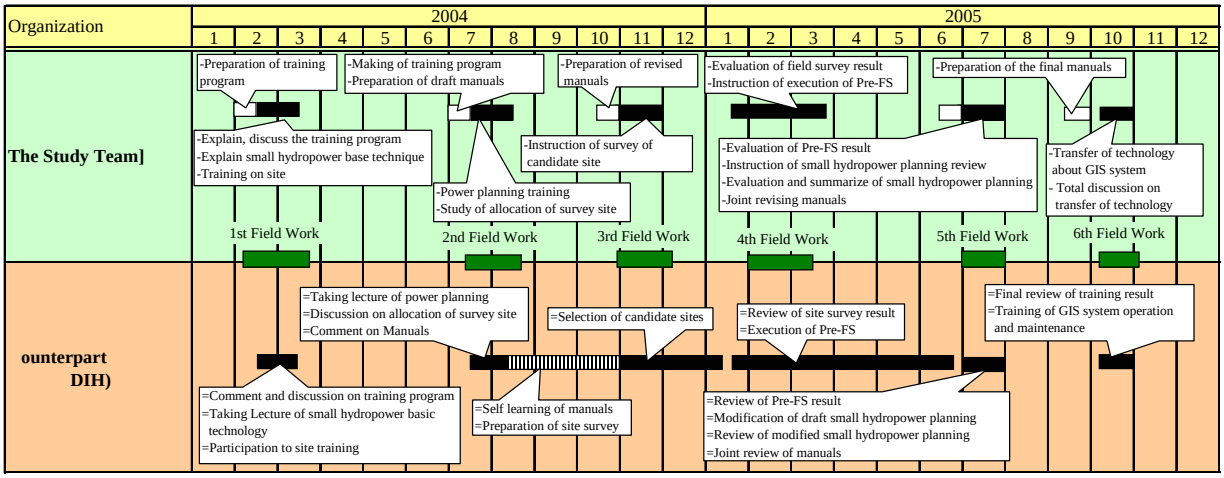
The capacity building conducted through this Study can be categorized into lectures and OJT. The former includes classroom lectures and workshops aiming at the capacity building of the PDIH engineers. The latter, on the other hand, involves site reconnaissance, planning and design at the Pre-F/S level targeting DOE engineers with relatively higher skills. In addition, counterpart training in Japan has been conducted twice aiming to enhance the understanding of small-hydro.

Furthermore, in order for the counterpart engineers to utilize the acquired skills and to continue to improve them after the Study is over, the Study Team has prepared not only a Manual of Small-Hydro Planning, but also several calculation programs that act as useful tools.

5.3 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.

The figure below illustrates the schedule of the capacity development, and the responsibility of the Study Team and DOE.



Work Demarcation and Schedule of Capacity Building

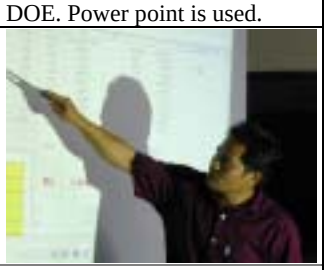
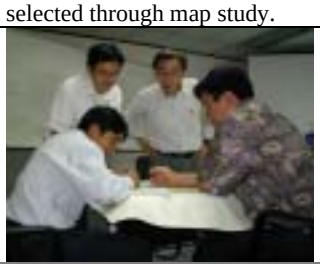
5.4 EXECUTED CONTENTS FOR TRANSFER OF TECHNOLOGY

The items for transfer of technology in this study were as shown in the table overleaf.

LIST OF ITEMS FOR TRANSFER OF TECHNOLOGY (1/5)

FW	Item	Aim and Contents	Methodology	Evaluation
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	Evaluation of questionnaire and reflection to training program
				
		20 Feb, 2004 Visit to Oudomxay PDIH	23 Feb, 2004 Visit to Luang Phrabang PDIH	21 Feb, 2004 Site Visit Nam Dong HPP
	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.	Evaluation of questionnaires, and discussion on results
				
		04 Mar, 2004 1st Workshop	17 Mar, 2004 Questionnaire from PDIH	05 Mar, 2004 Workshop Memorial Photo
		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.	Interview with participants on understanding.
				
		05 Mar, 2004 Nam Mang 3 Hydropower Construction Site Visit	05 Mar, 2004 Nam Mang 3 Hydropower Impounded Area Visit	06 Mar, 2004 Lecture in Nam Mang 3 Hydropower
	Discussion on Training Program	Understanding the present situation and identification of issues on capacity building.	Discussion for the workshop, implementation of questionnaires and conclusion.	Evaluation of questionnaires and minutes of meeting.
	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.	Confirmation of installation and measurement data at 3rd and 4th field investigation.

LIST OF ITEMS FOR TRANSFER OF TECHNOLOGY (2/5)

FW	Item	Aim and Contents	Methodology	Evaluation
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.	Confirmation with DOE on the contents in 2nd Field Work.
	Drafting of the Small-hydro Development Manual	Drafting of the manual. Draft manual will be used for lectures.	-	Discussion with DOE on the contents in 2nd Field Work..
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.	Questionnaires on contents of training manual. Evaluation of understanding range at the beginning of 3rd field investigation.
				
		05 Jul, 2004 1st Lecture Opening Ceremony	06 Jul, 2004 Lao Interpretation and supplementary explanation by DOE member	09 Jul, 2004 1st Discussion with PDIH counterparts
				
		21 Jul, 2004 Nam Ngum HPP Visit	21 Jul, 2004 Nam Ngum HPP Visit	23 Jul, 2004 Awarding of the certificates
	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.	Evaluate Pre-F/S results which DOE implement mainly.
				
		06 Jul, 2004 Teaching how to use current meter for discharge measurement	19 Jul, 2004 Map Study with PDIH counterparts	23 Jul, 2004 Map Study with PDIH counterparts

LIST OF ITEMS FOR TRANSFER OF TECHNOLOGY (3/5)

FW	Item	Aim and Contents	Methodology	Evaluation
3rd Home Work	1st JICA Counterpart 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.	Counterpart satisfaction with the training program in Japan, and experiences and technologies in Japan equipped them for the promotion of rural electrification by small-hydro in Laos.
				
		20 Sep, 2004 Lecture on small-hydro using PC	17 Sep, 2004 Discussion by counterparts in the meeting	17 Sep, 2004 Discussion with Lao side through internet at JICA-NET Meeting
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.	Conclusion of site reconnaissance results. Site reconnaissance results of 6sites carried out by DOE including records, data, photo and drawings are reviewed and evaluated.
				
		26 Nov, 2004 Project data hearing for Nam Pha Project at Village house of B.Tatmouan, Oudomxay	25 Nov, 2004 Site Reconnaissance of Xen River in Luangprabang Province	05 Dec, 2004 Discharge measurement in Nam Long Project
4th Home Work	2nd JICA Counterpart 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	Counterpart satisfaction with the training program in Japan, and experiences and technologies in Japan equipped them for the promotion of rural electrification by small-hydro in Laos.
				
		11 Jun, 2005 Lecture on Small-Hydro Planning	13 Jun, 2005 Site Visit to Small-Hydro in Japan	23 Jun, 2005 Awarding of the certificates at the end of the program

LIST OF ITEMS FOR TRANSFER OF TECHNOLOGY (4/5)

FW	Item	Aim and Contents	Methodology	Evaluation
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.	Evaluation on Pre-F/S results made by DOE.
	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.	Collecting their comments for the training and manual. Confirmation at site reconnaissance in the 3rd field survey.
	2nd Workshop	Presentation of a progress report by DOE and study team.	Reporting Pre-F/S by DOE supported by study team.	Confirmation at 2nd Workshop.
				
		07 Mar, 2005 2nd Workshop Opening Speech	07 Mar, 2005 Presentation by counterpart staff in workshop	07 Mar, 2005 Workshop participants
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.	Confirmation at 4th Lecture.
	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.	Confirmation at Pre-F/S and Workshop.
				
		18 Jul, 2005 4th Lecture memorial photo	18 Jul, 2005 Translation by DOE in the 4th Lecture	18 Jul, 2005 Reporting Reconnaissance of Site by DOE counterpart staff
	Transfer of Technology on GIS	Transfer of GIS technology and its maintenance.	Transfer of GIS technology made through review of data and operation manual.	Actual operation, print out and preparation of materials for Workshop
				
		20 Jul, 2005 Preparation of their own provincial GIS map	19 Jul, 2005 GIS lecture	19 Jul, 2005 GIS lecture

LIST OF ITEMS FOR TRANSFER OF TECHNOLOGY (5/5)

FW	Item	Aim and Contents	Methodology	Evaluation
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	Confirmation at CDM Seminar.
				
		10 Jul, 2005 CDM Site Reconnaissance at Nam Xeng	21 Jul, 2005 CDM Seminar	21 Jul, 2005 CDM Seminar Memorial Photo
	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.	Confirmation at 3rd Workshop.
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 Workshop, there is presentation on study results by DOE including explanation of Pre-F/S results made by DOE.	Confirmation at 3rd Workshop.
				
		2 Nov, 2005 View of Workshop room. Panelists are on the stage.	3 Nov, 2005 Lecture by JICA Specialist on Rural Electrification issues	2 Nov, 2005 Participants at Workshop scrutinizing exhibition panels
	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.	Actual operation of GIS, preparation of map, print out, preparation of materials for Pre-F/S and workshop.