Japan International Cooperation Agency (JICA)

No. 6

The Ministry of Industry and Handicraft
Lao People's Democratic Republic

The Study on Rural Electrification Project by Renewable Energy in the Lao People's Democratic Republic

Final Report

Main Report

February 2001

PROACT International, Inc.
Shikoku Research Institute, Inc.

Japan International Cooperation Agency (JICA)

MINISTRY OF INDUSTRY AND HANDICRAFT
LAO PEOPLE'S DEMOCRATIC REPUBLIC

THE STUDY ON
RURAL ELECTRIFICATION PROJECT
BY RENEWABLE ENERGY
IN
THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

FINAL REPORT

MAIN REPORT

February 2001

PROACT International Inc.
Shikoku Research Institute Inc.

Preface

In response to a request from the Government of the Lao People's Democratic Republic, the Government of Japan decided to conduct a study entitled "Study on Rural Electrification Project by Renewable Energy in the Lao P.D.R" and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent a study team led by Mr. Katsuhiko Otaki of Proact International Inc. to the Lao P.D.R. eight times from October 1998 to December 2000.

The team had intensive discussions with the officials of the Government of the Lao P.D.R., conducted studies based on pilot projects and complied the final results in this report.

I hope this report will contribute to the promotion of rural electrification in remote areas of the Lao P.D.R. and to the strengthening of bilateral relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Lao P.D.R. for their close cooperation throughout the study.

February 2001

Kunihiko Saito
President

Japan International Cooperation Agency

February 2001

Mr. Kunihiko Saito
President
Japan International Cooperation Agency

Dear Mr. Saito,

Letter of Transmittal

I am pleased to submit to you the report of the Study on Rural Electrification Project by Renewable Energy in the Lao People's Democratic Republic. This report contains the results and evaluations of off-grid pilot projects, and a master plan and a strategy for rural electrification by solar energy. It also contains some recommendations for the Lao government to achieve their goal of rural electrification. I highly appreciate the suggestions given to me by the authorities concerned of the Government of Japan and your Agency. Also, comments from the Ministry of Industry and Handicraft of the Lao P.D.R, the counterpart of this study, are reflected in this report.

The pilot projects implemented in the six villages went successfully, and showed a high possibility of implementing sustainable solar-based rural electrification projects from the viewpoints of technology, economy and institutional management. A master plan and its implementation plan for solar-based rural electrification for the next ten years are presented, which will serve as a roadmap for upcoming projects.

In view of the importance of rural electrification in the Lao P.D.R., it is recommend that the Government of the Lao P.D.R. push forward the implementation of rural electrification using renewable energy sources. This report provides various basic data so that the counterpart organization can design and undertake rural electrification projects in the future.

I would like to take this opportunity to express my sincere gratitude to your Agency, the Ministry of Foreign Affairs and the Ministry of International Trade and Industry. I also wish to express my deepest appreciation to the Ministry of Industry and Handicraft and other government agencies of the Lao P.D.R. for their close cooperation and assistance during the study.

Very truly yours,

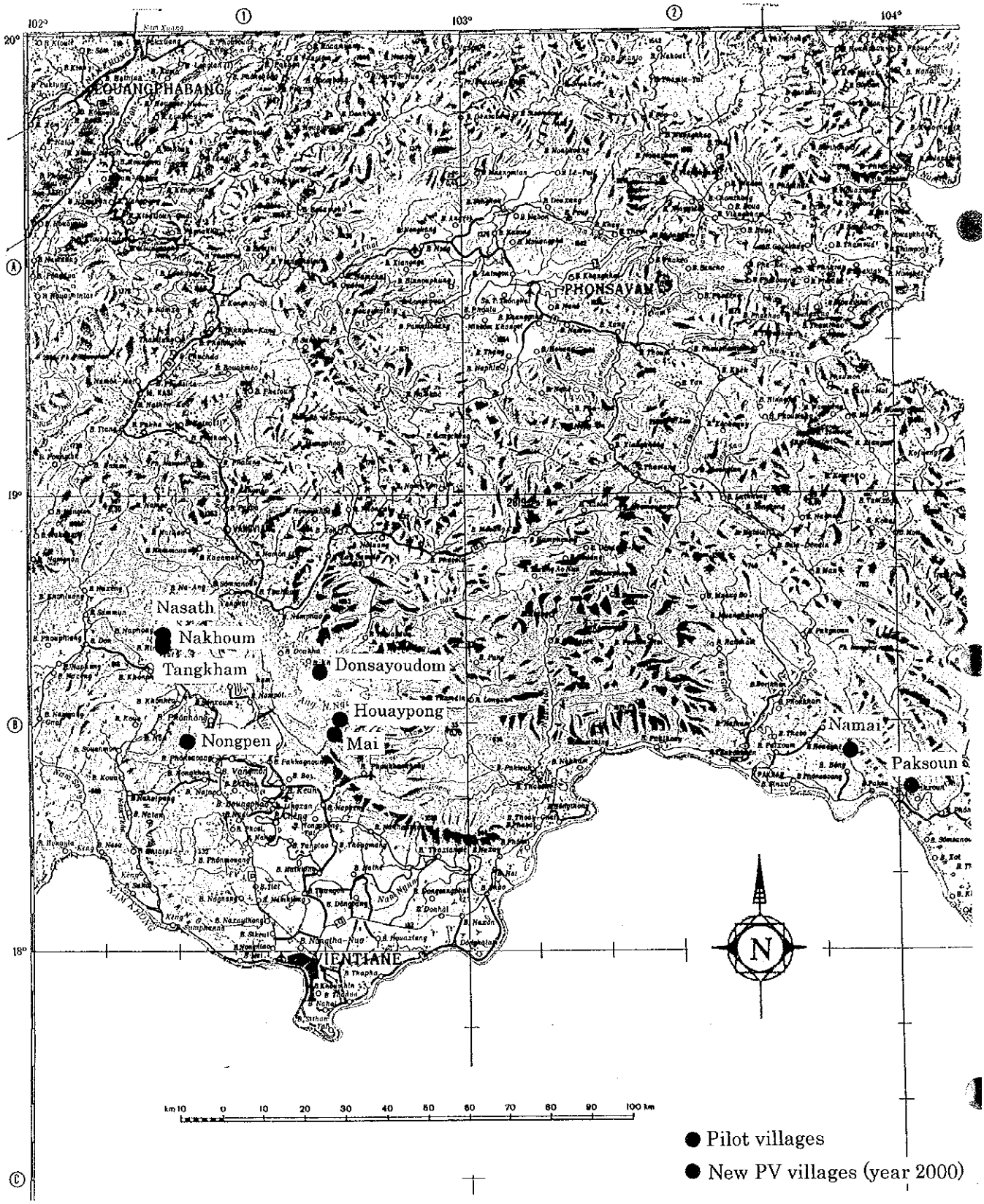
Katsuhiko Otaki
Team Leader
The Study on Rural Electrification Projects by Renewable Energy
in the Lao People's Democratic Republic

Table of Contents

LIST OF TABLES

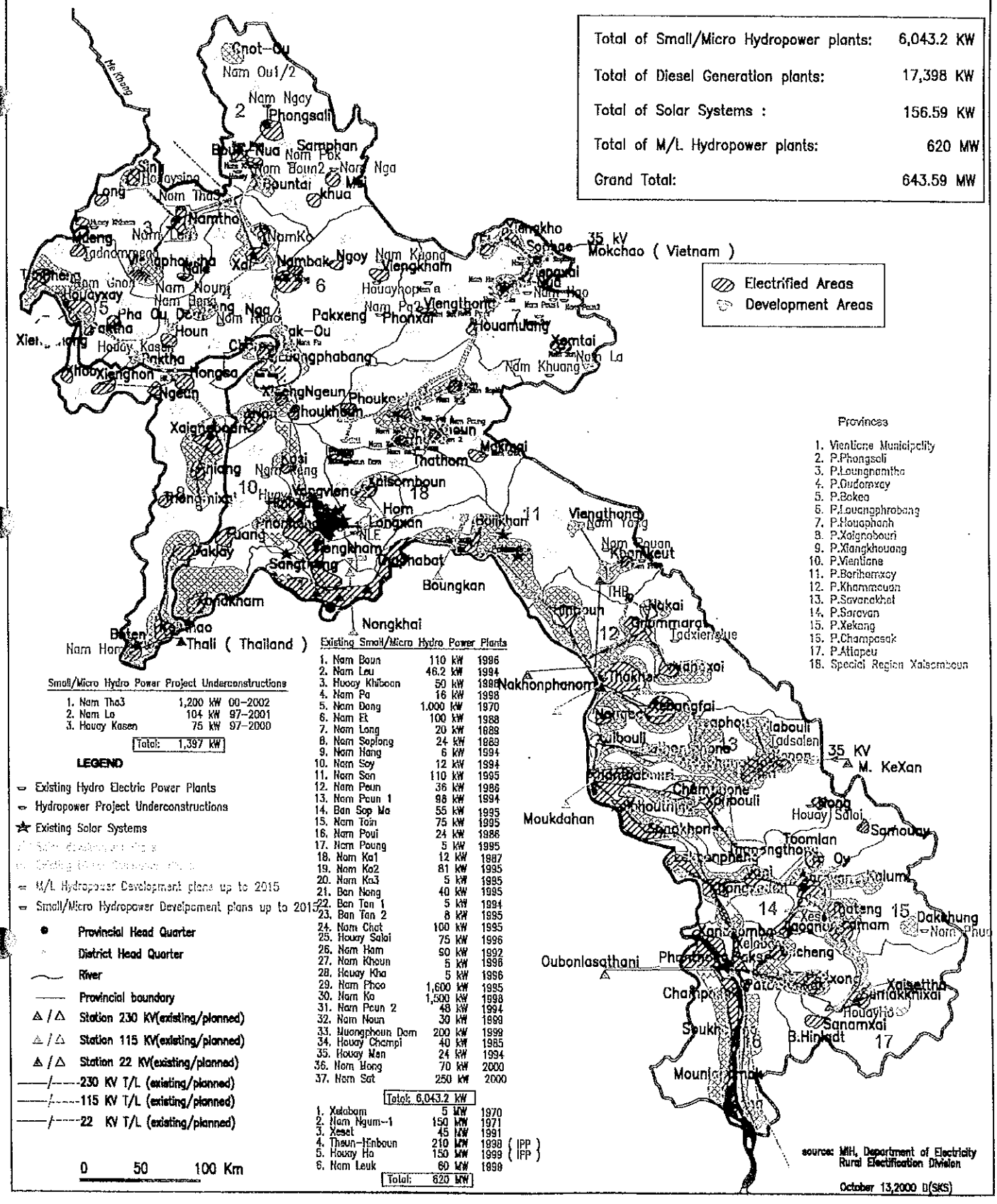
LIST OF FIGURES


Study Area
CHINA
Me Khong
YANMAR
Phongsali Pr.
Luangnamtha Pr.
Bokeo Pr.
Oudomxai Pr.
Luangphabang Pr.
Huoaphan Pr.
Xiengkhouang Pr.
VIETNAM
Xayaboury Pr.
Xaisomboun
Special Zone
Vientiane Pr.
Vientiane Mun.
Bolikhamxai Pr.
Khammouan Pr.
THAILAND
Savannakhet Pr.
Saravan Pr.
Xekong Pr.
Champasak Pr.
Attapeu Pr.
CAMBODIA
LEGEND
Provincial Head Quarter
Provincial boundary
0 50 100 Km



Photovoltaic System Pilot Project Sites

Electric Power Generations and Systems Development Plans by 2010



Background and Objectives

In the rural areas of Laos, where several thousand villages still remain without electricity supply, people strongly desire electric lighting and television. In many villages, people turn on fluorescent lamps and small television sets by using automobile batteries. They carry their batteries to battery charging shops for recharging. Compared with grid power supply, battery power is quite limited in terms of duration and types of usable appliances. However, such battery use is spreading in the unelectrified regions, bringing about a lot of benefits compared to the previous era of reliance on kerosene lanterns. By using lamps, they can do some work even in the nighttime and earn more income.

Though Laos has abundant hydropower resources, and large hydro-electric plants with a total capacity of 620MW are currently operating, most of the generated power is exported to Thailand. Domestic electricity supply is quite limited. The current electrification rate in Laos is low at slightly over 30%, as the domestic electric power network, the distribution network in particular, is underdeveloped. The existing distribution network only covers the areas along the main national roads extending from the capital of Vientiane. Now, the grid extension program is implemented by Electricite du Laos (EdL) with funds from the World Bank and the Asian Development Bank to expand electrified areas, but its progress is slow. It would require utmost efforts to electrify 50% of the population by the year 2010.

The Lao Government has put "rural electrification" on the priority policy agenda. Their goal is to achieve 90% electrification by the year 2020, but it is viewed as insufficient to push grid extension alone. Grid extension into remote areas is often not financially viable, because electricity demand is small and population density is low. Thus, grid extension projects in remote areas do not proceed smoothly. Most unelectrified villages cannot expect grid connection for more than 20 years. Rather, it would be more realistic to develop small off-grid power systems in such villages to supply a minimum level of electricity to meet the basic needs of rural people. This off-grid rural electrification program should be pursued to fulfill the objective of rural electrification.

Recently, photovoltaic (PV) power generation technology has made remarkable progress, and has been spreading in the world owing to improved reliability and reduced price. The expectations for this technology are growing because it is considered as a viable alternative to grid extension in remote areas. Solar systems, which use PV, can be installed in most places, and have an advantage of easy installation and maintenance, which is the most desirable factor in remote areas.

Of course, there is a concern over its limitations of electricity quality (DC power) and usage hours, but it can meet the minimum electricity need of a low-income rural population. Similarly, there is a growing interest in rural electrification by traditional small hydropower technology. Thanks to simplification of design and construction techniques, and cost reductions in small hydro technologies, many projects have been implemented. Small hydropower can supply AC power, which will benefit villagers more than solar systems, but it is largely dependent on natural conditions. To find an appropriate site for small hydro development requires a significant amount of time and effort. The degree of difficult tasks before project implementation cannot be compared with the case of solar systems.

Renewable energy resources such as solar power or small hydropower have been drawing a lot of attention recently due to the growing concern over global environmental issues. Given such a situation, ideas for applying these renewable energies to rural electrification, which is a priority issue in developing countries, are strongly called for. This is not an issue only for countries where development projects are implemented. International society as a whole will benefit from this.

This JICA development study was started based on such background and objectives. Its main objective was to evaluate the acceptability and sustainability of solar-based rural electrification, which had not been considered in Laos, by undertaking some demonstration projects. If solar systems turned out to be quite feasible in rural areas of Laos, a detailed project framework for solar-based rural electrification was to be formulated taking into account the social and economic conditions of rural villages. In order to achieve this goal, we planned and implemented several pilot projects, and tested various ideas related to management systems and tariffs to develop an appropriate mechanism to operate solar systems for many years in remote areas. We assumed a large-scale introduction of solar systems in the near future, and therefore, paid special attention to organizational development and financial planning. Providing on-the-job-training to the counterpart was one of the key issues for the development of capabilities to undertake future projects under the initiative of the Lao people.

As a summary of this study, a 10-year plan is proposed to promote the introduction of solar systems for rural electrification. The plan stresses the viability of solar systems in Laos and addresses a strategy to achieve the ultimate goal of rural electrification: 90% electrification by the year 2020.

Outline of Study

1. Objectives

The overall objective of this study is to formulate a master plan to promote rural electrification in Laos by using renewable energy resources such as photovoltaic (PV) power and small hydropower. An emphasis is placed on the establishment of an appropriate management model for solar-based rural electrification. In particular, technical, financial and organizational aspects regarding the operation and maintenance (O&M) of solar systems were intensively studied considering the socio-economic conditions in rural Laos. With this clear objective in mind, we teamed up with the Ministry of Industry and Handicraft (MIH), which is responsible for power supply in Laos, and undertook several pilot projects at model villages in Vientiane and Borikhamxay provinces. We discussed the tariff system and village organization with the villagers before implementing pilot projects, and tested our proposed ideas during the project period. Based on the results of the pilot projects, we evaluated the feasibility of introducing solar systems into remote areas as a means of rural electrification from technical, financial, and organizational viewpoints. In order to promote solar-based rural electrification in the future, appropriate technologies, operation methods and institutional structures were analyzed.

Regarding the study of small hydropower development, no pilot project was in the scope of work. Instead, we studied the potential for hydropower development in the two provinces and, then, developed model plans for two candidate sites.

2. Work Schedule

In the original study schedule, the draft of the final report was scheduled for September 2000. In the middle of the study, it was revealed that rural villagers highly appreciated solar systems. Hence, JICA extended the study to facilitate early implementation of solar-based rural electrification projects by strengthening the capability of the counterpart engineers. An additional PV project was planned and implemented under the initiative of the counterpart. A brief history of the study is shown below:

Preparation work in Japan : Information and data gathering / Inception report

(Sep.1998) Relevant data and information regarding the study were gathered to understand socio-economic conditions, the structure of electricity demand and supply in Laos. Documents and materials about PV and small hydropower generation were prepared for the first seminar. An inception report, which included objectives/ basic concept/ items/ method/ schedule of the study, was completed.

First survey in Laos : Study of current electricity supply / Pilot site survey

(Sep.~Oct.1998) A seminar was held to explain the basic concepts and framework of the study. The current electricity tariff system and relevant regulations were studied, analyzing gathered data and information concerning power supply. As for PV, preliminary field surveys were conducted in seven proposed candidate villages to understand the current situation of energy use and geographic conditions to get ideas for PV pilot projects. Regarding small hydro development, a questionnaire survey on potential sites was conducted.

Study #1 in Japan : Analysis of the first survey / Planning for pilot project

(Nov.1998) Analyzing the result of the first survey in Laos, basic specifications of PV systems and ideas for a pilot management system were discussed. Results of the questionnaire survey on the inventory of small hydro resources were examined.

Second survey in Laos : PCM Workshop / Detailed survey of pilot villages

(Jan. ~ Feb. 1999) Through discussions between the study team and village people during PCM workshops at four pilot villages, the village people gained a better understanding of the pilot project. Both parties reached an agreement on a tariff system and establishment of a Village Electrification Committee. After the workshop, every PV applicant signed a contract. As for small hydro development, a field survey was conducted at each potential site.

Study #2 in Japan : Examination of PV installation work/ Progress report I

(Mar.1999) Specifications of PV systems and a standard work procedure for system installation were formulated, assuming that local contractors would be subcontracted to do the work. Progress report I , based the result of the second survey, was completed.

Third survey in Laos : PCM Workshop / First stage of PV installation

(May ~ Jun.1999) PV systems were installed in three villages (first group) out of the four villages where the PCM workshops were completed. At the same time, technical training sessions about VEC management were held targeting the VEC members. At the two remaining villages, PCM workshops were conducted and PV applicants singed contracts. Generation costs and the current tariff collection system were examined. Regarding small hydro development, zoning of target areas and a site survey were carried out.

Fourth survey in Laos : Second stage of PV installation / PV monitoring 1

(Sep. ~Oct. 1999) PV installation and guidance for the VEC were conducted at the remaining three villages (second group). At the first group of three villages, a PV monitoring survey was conducted to understand how villagers use and operate PV systems. Based on the result of the

monitoring survey, solutions to problems and points to be improved were submitted to the VEC from the study team and C/P.

Study #3 in Japan : Examination of PV manual / Progress report II

(Nov.1999) Examining the results of the monitoring survey, a draft of the PV installation and maintenance manual was prepared. Based on the survey results, the future demand of PV systems in rural Laos was estimated. Progress report II addressing the previous two surveys in Laos was completed.

Fifth survey in Laos : PV monitoring 2 / PV promotion seminar

(Feb.~ Mar. 2000) Relevant policy issues were discussed with the Lao government. A framework for the PV manual was formulated. The PV monitoring survey was conducted in all of the six pilot villages and necessary consultation was given to the VEC members. A PV promotion seminar was held to improve awareness of PV, inviting officers of concerned ministries and 11 provincial governments of Northern Laos.

Study #4 in Japan : Interim report

(Mar. 2000) An interim report was completed. In the report, the results of the pilot project, ideas on maintenance and management system and a draft of the PV manual were highlighted.

Sixth survey in Laos : Impact survey / Evaluation of pilot project

(May ~ Jun. 2000) Village meetings were held at all the pilot villages to get an evaluation of the pilot project from the villagers. A PV impact survey was also conducted at the same time. The maintenance and management mechanism of PV was focused on, and follow-up training sessions were organized to improve the maintenance and management capability at the village level. As for small hydro development, two model plans were completed.

Study #5 in Japan : Preparing a draft of the final report

(Jun. ~ Jul. 2000) A rural electrification master plan for the next decade was examined and the outline of the draft of the final report was completed.

Seventh survey in Laos : Capacity building--PV installation project by C/P

(Sep. ~Oct. 2000) By managing PV electrification projects, from site survey to installation and monitoring, at three new pilot villages under the supervision of the JICA team, the C/P gained experience to strengthen their capability of project management. In addition, the draft of the PV manual was revised to reflect new findings obtained by the C/P.

Study #6 in Japan : Evaluation of PV installation project by C/P

(Sep. ~Oct. 2000) The results of the additional PV project were evaluated. The

capacity building of the C/P was addressed in the draft final report.

Eighth survey in Laos : Draft final report / Seminar on Rural Electrification Master Plan by Renewable Energy

(Dec. 2000) The draft final report was presented at a seminar focusing on the rural electrification master plan using renewable energy to the ministries and agencies concerned.

3. Study Team

The counterpart of the study is the Department of Electricity (DOE) of the Ministry of Industry and Handicraft (MIH), headed by Mr. Houmphone Bulyaphol as Director. At first, Electricite du Laos (EdL) was considered as the prime executing body of rural electrification in Laos. However, in the course of the study, EdL declined to undertake off-grid rural electrification projects because of the difficulty of getting a good return on investment. On the other hand, DOE, recognizing their responsibilities for promoting rural electrification, stated a strong commitment to implementing rural electrification projects on their own. They established the Rural Electrification Division (RED) in DOE in September 1999. The staff of the Rural Electrification Division learned from scratch, with high motivation, about solar systems and the management of rural electrification projects from the JICA team. Although few in number, they are all capable and dedicated. They have grown so much through the joint work during the study, and now they are able to plan and manage solar-based rural electrification projects by themselves. Owing to their cooperation and dedication, this JICA study was able to generate very good results beyond expectations.

This study was conducted by a team of two Japanese companies, Proact International, Inc. and Shikoku Research Institute, Inc., which was designated by JICA. The study team members and their responsibilities are as follows:

Responsibility	Name
Team Leader/Rural electrification master planning	Katsuhiko Otaki
Photovoltaic technology	Hideo Semba
Photovoltaic equipment /Installation	Koichi Iwabu
Rural socio-economic survey	Hiroshi Yoshimura
Rural socio-economic survey (B)	Masayo Kojima (until March 1999)
〃	Chiyoko Miyata (from May 1999)
Institutional development/ Participatory approach	Izumi Atsuta
Small hydropower development	Kazunari Oshima
Economic analysis/Financial management	Shinji Omoteyama

Chapter 1

Outline of the Lao P.D.R.

1-1 General Information

1-1-1 Nature and Resource

Laos is an inland country located in the center of the Indochina peninsula, and surrounded by Vietnam, Thailand, Myanmar, Cambodia and China. The land area of Laos, 80% of which is mountainous, is almost the same as that of Honshu of Japan. The tropical monsoon climate is dominant in most of Laos. The rainfall varies from region to region; in southern Laos there is more precipitation. Laos is rich in forest and water resources; the Mekong River and many other rivers are running in the country. Hence, lumber products and electricity from hydropower are the main export items. Although, Laos has a lot of mineral resources, they have not been exploited due to underdeveloped infrastructure and insufficient capital.

General Information of Laos			
Capital	Vientiane	Religion	Buddhism 60%, Animism/others 40%
Land area	236,800km2	Political system	People's Democratic Republic
Climate	Tropical monsoon	Independence	October, 1953 (Transformation to present political system : December 1975)
Population	5,040,000 (1996)		
Language	Lao language (official)	Currency	kip (1USD=7,500kip May 2000)
Ethnic group	49 ethnic groups 4 linguistic families: Lao-Tai, Mone-Khmer, Tibeto-Burmese, Hmong-Ioumien	GDP	1,846 million USD (1996) Per-capita GDP: 368USD (1996)

1-1-2 Politics and Economy

Laos became fully independent from France in 1953. After that, Laos experienced civil wars and interventions from outside powers. Overcoming those difficulties, the Lao People's Democratic Republic, which is the present political system, came into existence in December 1975. The Lao PDR has been pursuing a policy of peace, independence, friendship and cooperation with all nations regardless of their political and social systems. This is based on the principles of mutual respect for each other's independence, sovereignty, equality and mutual benefits. Since 1979 the Lao government has been undertaking economic reform with the introduction of the New Economic Mechanism. Laos retains its socialist system, but is liberalizing the domestic economy and has attracted considerable amounts of foreign investment. The trade volume has increased and the number of tourists has risen. Laos became a member of the Association of Southeast Asian Nations (ASEAN) in

1997. Laos had high economic growth in the 1990's, 6 to 8% per year on average, before the Asian economic crisis, owing to aid and direct investment from overseas. The currency crisis of the Thai Baht in 1997 triggered high inflation in Laos and a plunge of the kip. However, the Lao economy is now in stable condition.

1-1-3 Rural Society

The population of Laos is the smallest among the Indochina countries, less than 10% of that of Thailand or Vietnam. More than 80% of the Lao population are engaged in agriculture and live in rural areas. Agricultural and forestry production accounts for more than 50% of GDP. Agriculture in Laos is centering on rice, which accounts for about 80% of the cultivated land. The agriculture is still at subsistence level due to the underdevelopment of infrastructure and poor market mechanism.

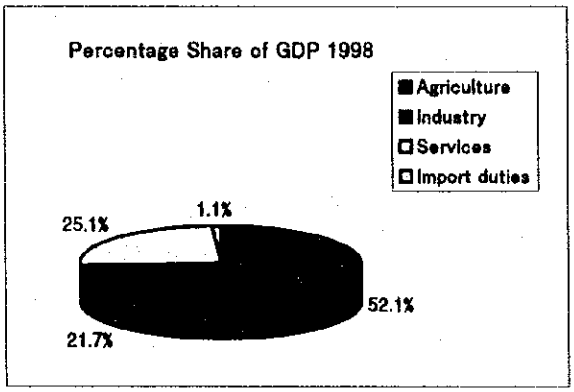
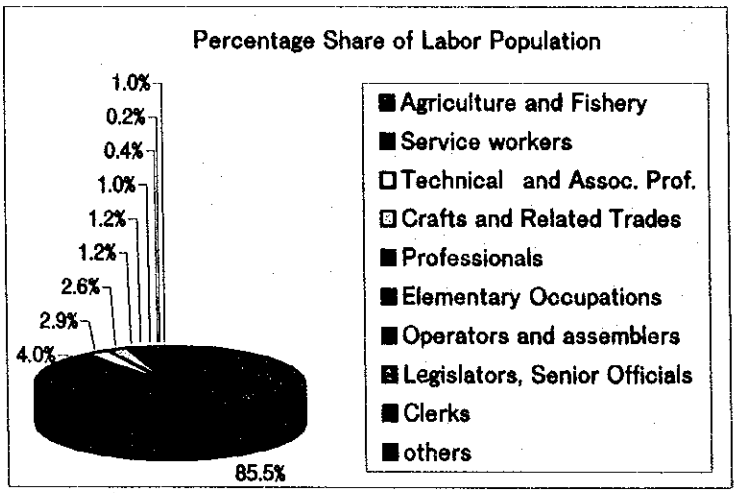


Figure 1-1-1 Make-up of GDP



Source : Basic Statistics about the socio-economic development in the Lao P.D.R 1999

Figure 1-1-2 Make-up of labor population

1-2 Electricity Supply

1-2-1 Current situation of rural electrification

Rural areas of Laos are not electrified except for limited areas near populated cities where the grid was already extended. At present, approximately 20% of the villages and 35% of the households are electrified in Laos, mainly covered by the national grid. The low electrification rate at present is attributed to insufficient national budget, low population density, underdeveloped road network and mountainous land. Some areas located along the Mekong River depend on electricity imported from Thailand. In some cases, people use diesel generators that can provide electricity for only two or three hours a day. The fuel supply for diesel is difficult because of high imported oil price and bad road conditions.

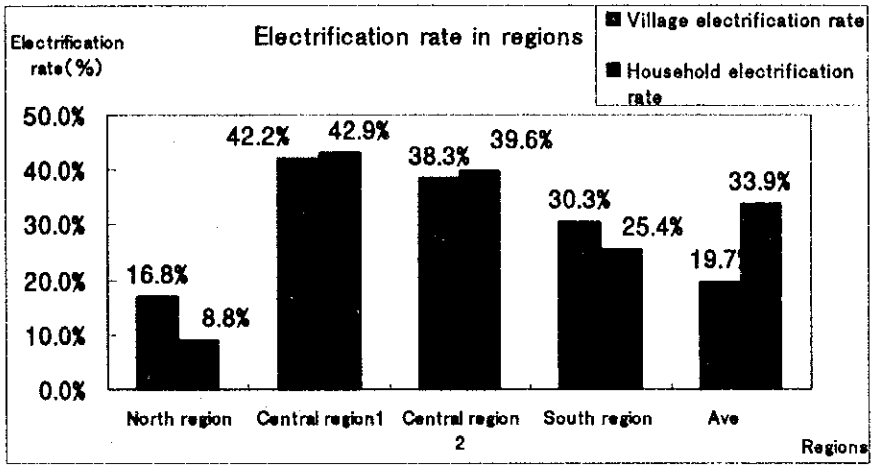
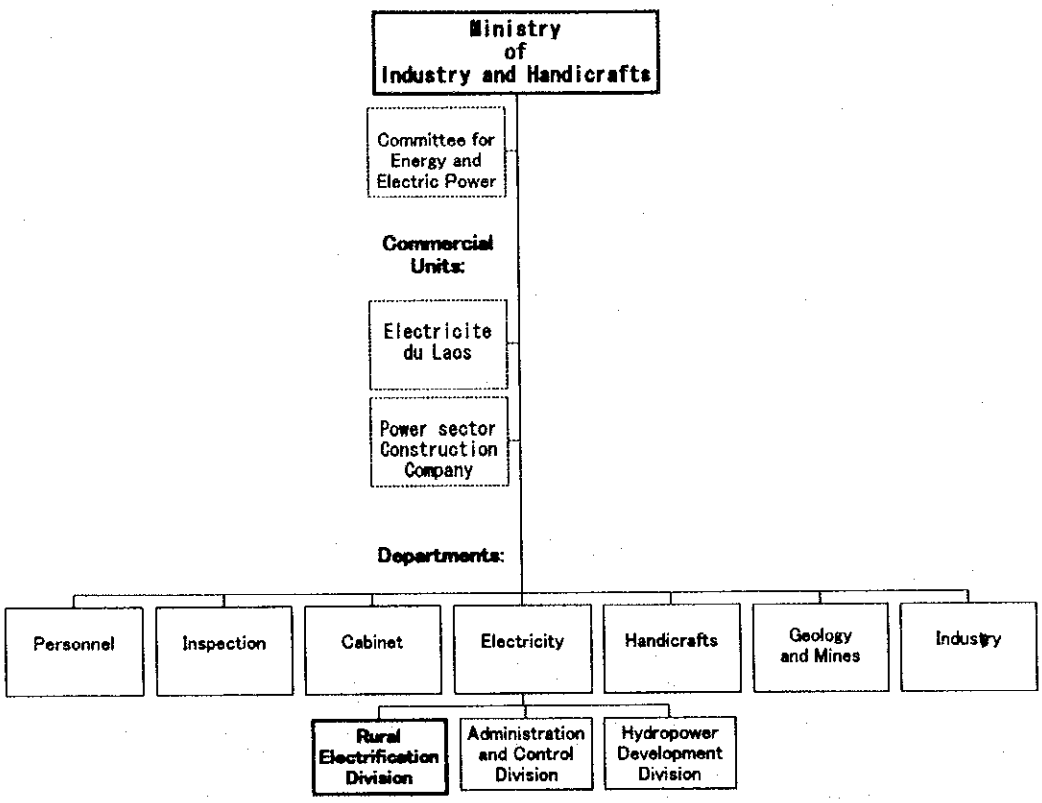


Figure 1-2-1 Electrification rate in each region of Laos(1999) Source: MIH data

So far rural electrification was primarily promoted by grid extension. As for the grid, EdL formulates a basic plan and implements it. And as for distribution lines for each village, each EdL provincial office manages the actual work. Although decentralized (off-grid) electrification by diesel or small hydropower is in practice in some villages, there wasn't a basic plan; it had only scattered support from aid projects or from government budgets. At present EdL is promoting rural electrification by grid extension with the World Bank and ADB funds.

1-2-2 Electricity enterprise

The Electric Power Agency was established as the first electric utility in 1950 under the French regime. At that time, the Agency belonged to the Ministry of Public Works and developed power plants and grid networks. The Agency was transformed into the Electricite du Laos (EdL), as a state company in 1962. EdL remained unchanged even at the time of the formation of the Lao PDR, and serves as the sole power supply entity under the Ministry of Industry and Handicraft.



(September 2000) Source :MIH

Figure 1-2-2 Organizational framework of electricity supply

(1) MIH/Department of Electricity (DOE)

The Ministry of Handicrafts and Industry (MIH) was established when the Lao PDR was born. The ministry is responsible for the development of natural resources, industries and electricity supply. As for the electricity supply, the Department of Electricity (DOE) is in charge and oversees the overall development of power stations and grids. Until recently there was no division in the DOE that specialized in rural electrification. But in 1999, the Rural Electrification Division (RED) was established to strongly promote rural electrification.

(2) Electricite du Laos (EdL)

EdL is operating under MIH as the state-owned power company undertaking power generation, transmission and distribution. Also EdL trades electric power with Thailand. However, EdL's involvement in rural electrification has been limited.

Chapter 2

Socio-economic Conditions of the Pilot Villages: Rural Electrification in Laos

2-1 Pilot Villages among unelectrified villages

2-1-1 Status of Vientiane and Borikhamxay provinces

In Laos, 83% of the population lives in rural areas where people's livelihoods depend on subsistence-level agriculture. The population and economic activities are centered along the Mekong River and the Thai border in the south and in the Vientiane-Luang Prabang corridor in the north[1]. Vientiane province is located along the Vientiane-Luang Prabang corridor, and Borikhamxay province is located between the Vientiane-Luang Prabang corridor and southern Mekong.

The socio-economic indicators show that Vientiane province is relatively more urbanized than the rest of the country and has better socio-economic indicators than Borikhamxay province, where the mountainous area is relatively large.

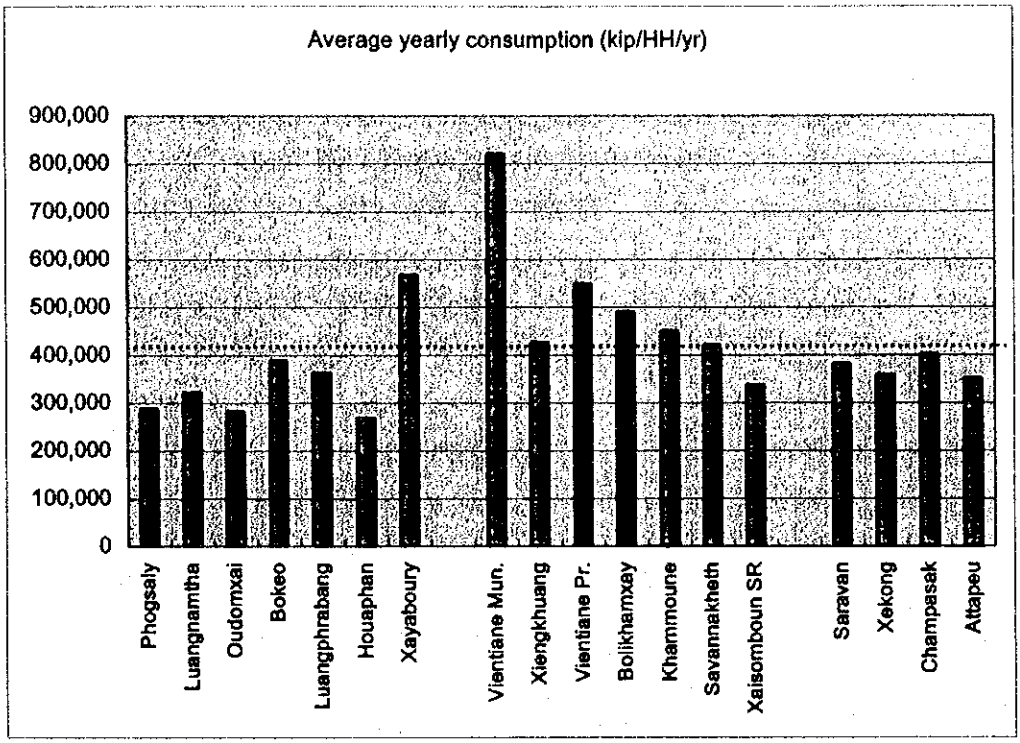
Table 2-1-1 Socio-economic indicators of Vientiane and Borikhamxay provinces

	GDP 1996		Population 1995			GDP per Capita (kip/person)	GDP per household (kip/HH)	Literacy rate 15 years and above (%)			Infant mortality rate (0/00)	Life Expectancies	
	Amount in current price (million kip)	Share in country	Population	Share in country	Rural population rate (%)			Total	Male	Female		Male	Female
Whole Country	1,707,551	100.0%	4,574,848	100.0%	82.9%	373,248	2,239,486	60.2%	73.5%	47.9%	104	50	52
Vientiane Prov.	100,297	5.9%	286,564	6.3%	82.5%	350,000	2,100,000	72.2%	83.6%	60.7%	102	52	54
Borikhamxay Prov.	21,757	1.3%	165,589	3.6%	92.6%	131,390	801,479	64.9%	77.6%	52.6%	136	48	50

Source: National Statistical Centre, Basic Statistics 1997.
National Statistical Centre, Results from the Population Census 1995.
GDP of Borikhamxay: Brikhamxay Provincial Office, Statistics of Borikhamxay 1996.
GDP of Vientiane: hearing from Vientiane Provincial Office, February 1999.

Major income sources of rural villagers are from farming and selling livestock. Figure 2-1-1 shows the average yearly household consumption of each province, which roughly indicates the economic conditions of provinces. From this graph, it can be said that Vientiane and Borikhamxay provinces fall in the high-income group in the whole country.

[1] UNDP, World Bank Energy Sector Management Assistance Programme (ESMAP), Laos Institutional Development for Off-grid Electrification, September 1998.



Source: National Statistical Center, The households of Lao PDR, Social and economic indicators Lao Expenditure and consumption survey 1997/98 (LEC 2)

Figure 2-1-1 Average consumption per household

2-1-2 Characteristics of pilot villages

To capture the characteristics of the pilot villages among unelectrified villages in the country, a comparison is made between the data from the socio-economic survey of pilot villages, and the data on unelectrified villages from the World Bank rural survey[2], which was conducted from April to May 1997 (See Table 2-1-2).

(1) Income and energy expenditure

1) Income level

It was revealed that the average income of the pilot villages in Vientiane province is 1,600,000kip/year/HH, which is quite high compared with the national average, and that in Borikhamxay province is 450,000kip/year/HH, which is a little less than the average.

2) Energy expenditure

The average monthly household energy expenditure of Vientiane pilot villages is

[2] UNDP, World Bank Energy Sector Management Assistance Programme (ESMAP), Laos Institutional Development for Off-grid Electrification, September 1998.

5,000 kip/mo/HH, which is about 3.7% of income, and that of Borikhamxay pilot villages is 4,500 kip/mo/HH, which is about 12% of income. This result shows that the household energy expenditure is almost constant throughout the country.

Table 2-1-2 Income and energy use of unelectrified households

	Province	Energy expenditure and income			Energy Sources (% of households)					Energy expenditure by sources (kip/mo/HH)				
		Energy Expenditures of off-grid villages (kip/mo/HH)	Percentage of income	Annual income (kip/year/HH)	Kerosene/ Diesel	Car or cycle batteries	Small generator			Kerosene/ Diesel	Car or cycle batteries	Small generating system		
							Buy from others	Diesel	Pico-hydro			Buy from others	Diesel	Pico-hydro
North	Phongsaly	3,918	10.4%	452,077	82%	2%	0%	1%	14%	1,097	4,250	0	14,000	5,531
	Luangnamtha	3,997	14.3%	335,413	97%	3%	7%	2%	0%	1,417	6,250	1,204	9,050	0
	Bokeo	9,430	13.6%	832,059	91%	67%	23%	10%	0%	1,199	5,510	2,928	14,575	0
Central	Xiengkhuang	5,182	7.4%	840,324	97%	2%	18%	2%	30%	1,819	6,000	2,981	3,750	328
	Khammuane	3,235	10.7%	362,804	98%	48%	0%	2%	0%	1,241	1,620	0	7,200	0
	Savannakhet	4,376	9.9%	530,424	65%	95%	0%	0%	0%	518	3,909	0	0	0
South	Saravane	4,408	6.7%	789,493	62%	75%	2%	0%	0%	1,415	3,120	0	0	0
	Attapeu	4,196	7.0%	719,314	92%	16%	0%	6%	0%	1,463	2,995	0	10,000	0
	Whole country	4,936	10.4%	569,538	88%	28%	7%	3%	7%	1,380	4,037	2,594	11,564	2,302

Source: UNDP, ESMAP, Laos Institutional Development for Off-grid Electrification, September 1998. Survey was conducted in April, May, 1997.

Pilot Villages	Vientiane	4,968	5.7%	1,615,000	78%	59%				3,385	2,887			
	Borikhamxay	4,504	12.0%	449,000	90%	43%				2,730	3,792			
	Average	4,813	4.7%	1,226,000	83%	54%				3,167	3,055			

Source: Socio-economic survey conducted in October, 1998 and February, 1999.
Note: Inflation between the both two survey is not adjusted.

(2) Energy sources

As for lighting, kerosene and diesel are used most frequently throughout the country, which is also observed in the pilot villages. On the other hand, usage of batteries and small hydro generators (pico hydros) depends on regional conditions. Many people in the central region of Laos use batteries while people in the northern region hardly use them. From the result of the socio-economic survey, 59% of households in Vientiane province have batteries and 43 % have them in Borikhamxay province. This can be interpreted as meaning that, in the central region, rural people have higher cash income and also various electric appliances which can work by battery are available in the market. In the mountainous northern region, we can see many pico hydros that can be applied to those villages where small streams are running. Diesel generators are used in some remote villages, but usage hours are limited because of rising fuel costs.

The pilot villages have relatively high economic and good geographic conditions, which is favorable for solar system introduction. But the price of energy from a solar system will be more competitive in the northern region where high cost systems such diesel are often used.

2-2 Rural Development Policy

2-2-1 Rural development

Although more than 80% of the population live in rural areas of Laos, their income level is only about 25% of that of town areas, because of their dependence on conventional agriculture. Therefore the Lao government, viewing rural development as one of the most important issues, established the "Rural Development Committee" as a special organization for the promotion of rural development in 1994. It was reformed into an administrative organization under the Prime Minister's Office in 1996.

2-2-2 Basic concepts of rural development policy

Rural development policy in Laos is based on a resolution concerning rural development passed by the national congress in 1994. In the resolution they said it is important to make use of the potential of rural areas in the aspect of nature and society. Besides it is said that all the ethnic groups should change their old agriculture style to a new one in order to improve their lives. In particular they take a Focal Site Approach to realize their objectives. In this approach, an average of three areas (villages) are set aside as model areas for development, and development is intensively promoted in those areas.

Eight subjects (Infrastructure, Agriculture, Education, Health, Village Consolidation, Community Development, Income Generation, Focal Site Management and Emergency Relief) were picked up as significant issues in the National Rural Development Plan (1996-2000). Although the importance of each subject depends on the situation of focal sites, the main subjects are infrastructure and agriculture development. Infrastructure development is indispensable for improving access to social services and markets (to sell agricultural products). That is why most of the focal sites devote a large share of their budgets to infrastructure development. Moreover, they make an effort to introduce new production technologies, large-scale agriculture and irrigation projects.

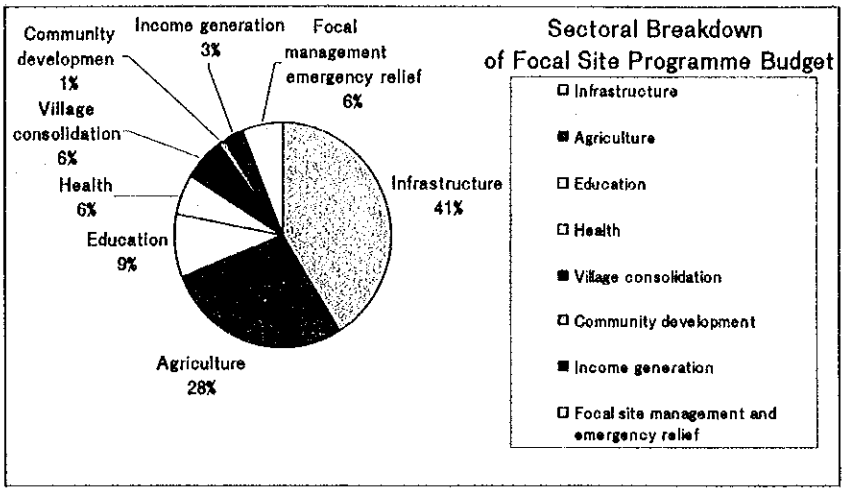


Figure 2-2-1 Sectoral breakdown of Focal Site program budget

2-2-3 Relationship between rural development policy and rural electrification

As described above, infrastructure development has been focused on rural development. In particular, road construction, electricity supply and development of communication network are priorities.

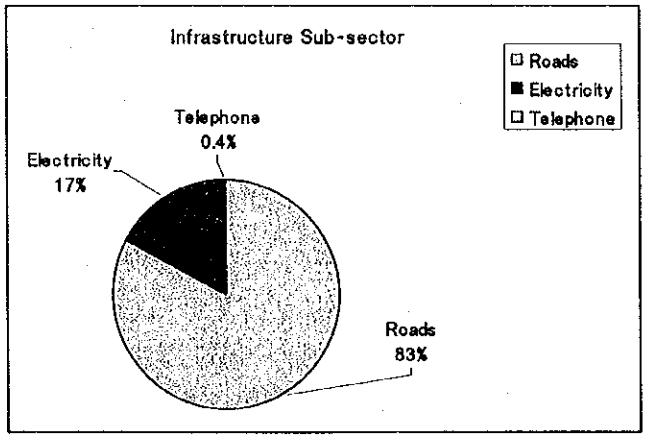


Figure 2-2-2 Composition of infrastructure sub-sector

In the first Rural Development Plan (1996-2000), achieving 50% village electrification was set as the goal for focal sites, which was to be done primarily by grid extension. Once electrified, medical and educational facilities in the villages will be improved and people will have better access to information through radio and TV. In addition, electricity can be used for irrigation and household industry, which will contribute to higher productivity and rural development.

Thus, rural electrification goes along with the rural development policy of the Lao government and should be intensively pursued. However, grid extension alone will not lead to satisfactory results because of geographical and financial difficulties. Therefore, off-grid rural electrification by renewable energy sources also should be adopted as a viable alternative of grid extension, and should be planned and implemented to meet the needs of remote villages.

Chapter 3

Pilot Project in Rural Laos

3-1 Framework of Socio-economic Survey

At the beginning of this study, seven pilot villages were proposed; four villages—Donsayoudom, Houaypong, Nongpen, and Mai—in Vientiane province, and three villages—Namai, Samsanouk and Natong—in Borikhamxay province. However, two villages—Samsanouk and Natong—were turned down in the course of the study. Instead we added Paksoun in Borikhamxay province later (See Figure 3-1-1, 3-1-2).

3-1-1 Objectives of survey

The objectives of the socio-economic survey were to gather and analyze data before and during the pilot project to formulate a feasible model of solar-based rural electrification. The survey consisted of (1) Baseline survey, (2) Monitoring survey, and (3) Impact assessment survey.

3-1-2 Framework of socio-economic survey

The framework of the socio-economic survey and survey items are summarized as follows (See Table 3-1-1~4).

Table 3-1-1 Framework of Socio-economic survey

Stage of Study		Basic Study Stage			Monitoring Stage			Master Plan Stage
Survey		Baseline Survey	Workshop	Application Survey	Monitoring 1	Monitoring 2	Monitoring 3	Impact Assessment
Theme		Situation of Villages	Consensus making	Features of Applicants	Situation at installation	Change in lifestyle (after 3 months)	Change in lifestyle (after 6 months)	Impact on Society and Lifestyle
Timing		Oct-98	Feb-99		Jun-99	Oct-99	Feb-00	Jun-00
Donsayoudom		Base	WS	AP	M1	M2	M3	Impact
Houaypong		Base	WS	AP	M1	M2	M3	Impact
Nongpen		Base	WS	AP	M1	M2	M3	Impact
Mai		Base			WS AP	M1	M2	Impact
Nase	Reference		Ref				Ref	
Namai (BCS)		Base	WS	AP		M1	M2	Impact
Paksoun (BCS)	New				Base WS	M1	M2	Impact
Bothun	Reference		Ref					Ref
Kanyong	Reference		Ref					
Samsanouk	Out of project	Base						
Natong	Out of project	Base						

Base Baseline Survey WS Workshop AP Application survey Ref Reference village survey
M1 Monitoring survey 1 M2 Monitoring survey 2 M3 Monitoring survey 3 Impact Impact Survey

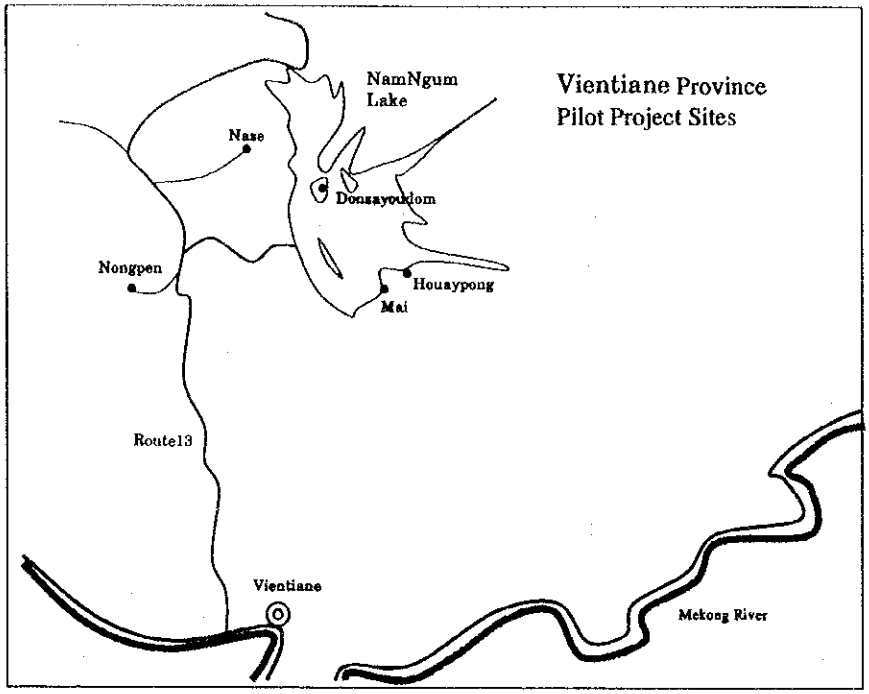


Figure 3-1-1 Pilot project sites in Vientiane Province

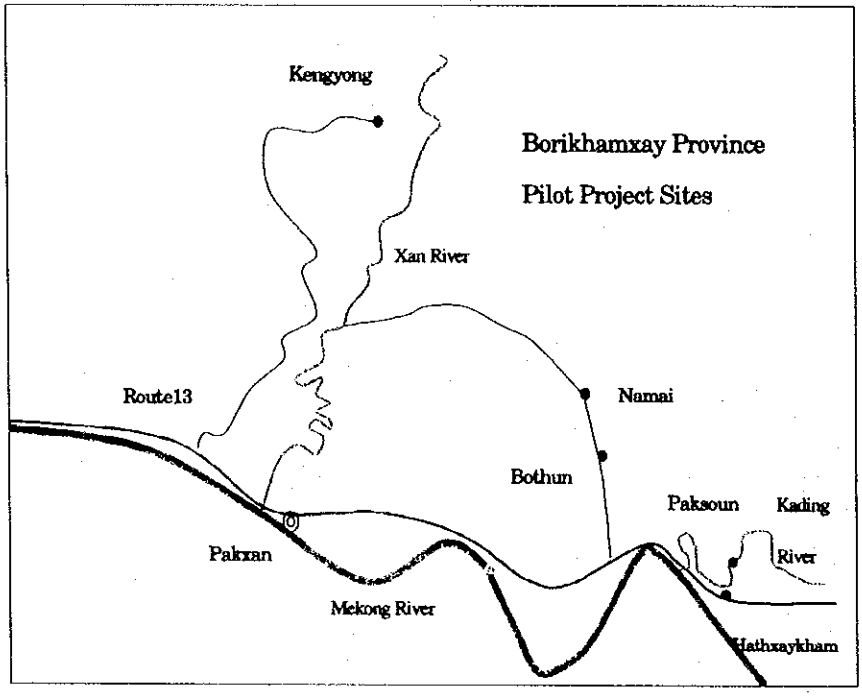


Figure 3-1-2 Pilot project sites in Borikhamxay Province

Table 3-1-2 Questions for the baseline survey

	Village Level Survey	Household Survey	Applicants Survey
Item	A Description Village 1 Number of households 2 Population 3 Ethnicity 4 History 5 Village organization 6 Major income source 7 Average income 8 Land and asset holding 9 Educational level 10 Health condition and medical service 11 Access to town 12 Relationship with District, Provincial government 13 Water supply 14 Life cycle of Villagers B Demands for electricity 15 Energy source for lightening 16 Battery holding 17 Electric appliance holding 18 Public institution 19 Expectation of electricity	A General 1 Name 2 Family size 3 Number of rooms 4 Land holding and asset 5 Occupation 6 Income and its source B Energy consumption and expenses 7 Source of lightening and expense 8 Battery holding and its usage, expense 9 Holding and usage of electric appliances C Expectation of electrification 10 Expected electric appliances to use 11 Expected activities 12 Willingness to pay	1 System applied for 2 Reason to choose 3 Expected electric appliances to use 4 Expected activities 5 Education of children 6 Life cycle

Table 3-1-3 Questions for the monitoring survey

	Monitoring 1	Monitoring 2	Maintenance Monitoring
Theme	Reaction to installation	Change of life(3 months)	VEC organization and activities
Sample	Sampling	Sampling	All VEC
Villages	Donsayoudom, Houaypong, Nongpen, Mai, Namai, Paksoun	Donsayoudom, Houaypong, Nongpen	All villages
Item	1 System to choose 2 Size of batteries 3 Number of batteries 4 How to prepare money for the initial payment? 5 Is the initial payment expensive? 6 Do you accept inflation adjustment? 7 What kind of electric appliances do you have? 8 Do you plan to buy new appliances? 9 Are you satisfied with the solar system you chose? 10 Others	1 Does the solar system work well? 2 Easy to operate? 3 Who checks water level of your battery? 4 What service do you want to get from the VEC? 5 Are you satisfied with the solar system you chose? 6 Do you charge another battery? 7 Do you pay the monthly payment on schedule? 8 Is the monthly payment expensive? 9 Did your monthly living expense increase? 10 Did your income increase after PV installation? 11 Did you cut any expense to pay for PV ? 12 Did you buy any new electric appliance? 13 Are you still buying kerosene, after PV installation? 14 Which is better for lighting in your house, PV system or kerosene lantern? 14.1 What is good point for PV compared with kerosene lantern? 14.2 What is good point for kerosene compared with PV? 14.3 Which is better, SHS or BCS? Why? 14.4 Which is better, charging battery in town or BCS? Why?	A Profile of members 1 Position 2 Responsibility 3 Educational level 4 Work experience 5 Technical/electrical experience 6 Social group B Details of work plan 7 Method 8 Payment method 9 Maintenance service 10 BCS operation 11 User training

Table 3-1-4 Questions for the impact assessment survey

	Questions for SHS	Questions for BCS
Items	1 Operation of SHS	1 Membership
	2 Satisfaction	2 Possession of batteries
	3 Possession of electric appliances	3 Charge
	4 Use of electric appliances	4 Charge by others
	5 Purchase of electric appliances	5 Reasons not to use BCS
	6 Improved points by SHS	6 Possession of electric appliances
	7 Change of income	7 Purchase of electric appliances
	8 Worsened points by SHS	8 Use of electric appliances
	9 Cost of living	9 Satisfaction
	10 Use of kerosene	10 Improved points by BCS
	11 Charge of other batteries	11 Change of income
	12 Charge of other house's batteries	12 Worsened points by BCS
	13 Improvement of life	13 Cost of living
	14 Inspection of system	14 Use of kerosene
	15 Cleaning of panels	15 Improvement of life
	16 Filling battery water	16 Income
	17 Important point of the VEC	17 Income source
	18 Periodical check by the VEC	
	19 Expectation of the VEC	
	20 Income	
	21 Income source	

3-1-3 Change of pilot villages

In the early stage of this study, we came into a situation to reconsider the proposed pilot villages in Borikhamxay province. After examining future plans of grid extension in the region, we reached a conclusion to cancel two villages and add a new village instead. As a result, the original plan for the pilot project was modified as follows.

(1) Reasons for cancellation of Natong and Samsanouk

During the second survey, it was revealed that Natong was included in a candidate area of early grid extension. Also, we came to know that Samsanouk would merge with a neighboring village and move. Even MIH, our counterpart, did not get such information when this study was started. Communication between local authorities and the central government is not so smooth as expected. This revealed an important point that local information can only be obtained on site or from villagers.

(2) Addition of Paksoun

In order to gather as much information as possible, we searched for new pilot villages in Borikhamxay province to compensate for the cancellation of the two villages. In the end, we decided to pick Paksoun in Pakading district because the village has good conditions for introducing solar systems.

(3) Project modification at Namai

Because the grid seemed likely to be extended to Namai within 10 years, we decided to modify the pilot project at Namai after soliciting consent from the villagers. Namely, we canceled the original plan to install a SHS at each household, but rather proposed to build a BCS which was to be shared among the villagers. The reason for this change was to collect more monitoring data on BCS, and also to prepare for the relocation of solar systems in the case of grid extension to this village. BCS can be easily removed.

3-1-4 Overview of Pilot Villages

An overview of pilot villages is shown in the following.

Table 3-1-5 Characteristics of Pilot Villages

Pilot Project Villages	Change of HH number			Characteristics of Villages
	Oct-98	Oct-99	Feb-00	
1 Donsayoudom	134	126	127	Fishermen's island. High income and expenditure.
2 Houaypong	44	42	44	Fishery and agricultural village on the Nam Ngum Lake. Close relationship with Mai.
3 Nongpen	50	46	49	Thaideng's weaving village migrated from Xiengkhuang. Isolated from the main road due to bad road condition.
4 Mai	57	68	71	Fishery and agricultural village on the Nam Ngum Lake..
Vientiane Pilot Village Sub total	285	282	291	
5 Namai	42	76	75	200 year long subsistence-level agricultural village. New road improved access to town. Merged with Boki in January 99.
6 Paksoun	96	96	95	200 year long agricultural and fishery village. Separated by river.
Samsanouk	32			(Cancelled)
Natong	37			(Cancelled)
Borikhamxay Pilot Village Sub total	207	172	170	
Total	492	454	461	

(1) Four villages in Vientiane province

1) Donsayoudom

This village is one of the biggest villages in the Nam Ngum reservoir area. After the completion of the Nam Ngum dam, people came from all over the country and settled to form this village. There is no rice field and the villagers live on fishing. Their income is higher than other pilot villages, but also they must spend more for fuel for their boat engines and for rice. Their educational background is high; 30% of the heads of household received a high-school education.

2) Nongpen

This village consists of refugees who were evacuated from the northern region during the civil war. There are large rice fields in Nongpen, which has rivers and forests nearby. The production of rice is mainly for self-consumption. Weaving, which many women are engaged in, is the biggest income source. That is why there is strong demand for electricity that will enable nighttime work. Nongen is located relatively near the grid so that battery charging service is available. Therefore, many villagers are using batteries for lighting and for TV/radio.

3) Houaypong

This village once moved to the town near the Nam Ngum dam due to inundation, and moved back again to the current location on the lake 20 years ago. Located at the foot of steep hills, the cultivated land area is only 11 hectares, where rice for self-consumption is raised. People's main income source is fishery and livestock. The relationship between Houaypong and its neighboring village —Mai—is strong because many families are relatives.

4) Mai

Mai moved to high land when the Nam Ngum dam was completed for the same reason as Houaypong. They settled in the current location in 1982. They farm rice for self-consumption. Their main industries are fishery, raising livestock and agriculture. They get cash income from sales of livestock, fish and vegetables such as bananas.

Table 3-1-6 General Information of the four pilot villages

			Donsayoudom	Houaypong	Nongpen	Mai
Village organizations			Village chief 1, Deputy chief 2, section group (4~6) , Fishermen's union, Women's Union, Youth union, Police/Security group, elder group, PTA etc.			
Transportation			Engine boat only (1~1.5h to the dam)		Motorbike, tractor (6km rough road)	Same as Houaypong
Water Supply			Well	Water from Mt.	Well	Well
Public Facilities	School	Kinder	1	—	—	—
		Primary	1	1	1	1
		Secondary	1	None	None	None
	Clinic		1(Doctor1, Nurse1)	None	None	None
	Temple		2, No monk	1, No monk	None	1, No monk
	Others		Fishermen's office	None	None	None
Education	Teachers		16	4	5	4
	Ratio of school enrollment	Primary	100%	100%	100%	100%
		Secondary	100%	30%	50%	10 personnel
		High	25%	10%	20%	4 personnel
	Literacy rate		99%	98%	80%	—
Health	Birth rate		4 (1998)	28/past 5 years	3~4/year	—
	Mortality rate		2~3/year	1~2/year	2~3/year	—
	Infant mortality		0 (1998)	0 (1998)	3 (1998) 0 (1996,1997)	—

(2) Two pilot villages in Borikhamxay province

1) Namai

This village has a 200-year history. People are engaged in subsistence level agriculture. They get cash income from selling livestock or river fish only when they need to buy something. Therefore their income level is lower than other pilot villages. The grid has been extended to the next village—Khambone—which is only four kilometers away from Namai.

2) Paksoun

This village was formed 200 years ago and is in isolation because we can reach it only by boat. The direct distance from the national road is short, but there is a wide river—the Kading River—in between. People make a living by subsistence level agriculture and get cash income by fishing. Most households own boats with or without an engine. The boats are indispensable for fishing and for transportation.

Table 3-1-7 General information of the two pilot villages

			Namai	Paksoun
Village organization			Village chief 1, Deputy chief 2, section group (3～8.), Women's union, Youth union, Police/Security group, elder group, PTA etc.	
Transportation			2hr to Pakxan by tractor (Feb. 2000)	10～15min by engine boat to Route 13
Water Supply			Water pipe from Mt.	Well (pump type)
Public Facilites	School	Primary	1 (1st to 3rd grade)	1
		Secondary	Go to Nong Boua village	Go to Pakading town
	Clinic		None (only place for vaccination)	None
	Temple		1, No monk	1, No monk
	Others		Rice stock center	
Education	Teachers		2	5
	Ratio of school enrollment	Primary	100%	100%
		Secondary	10%	Almost all
		High	0% (Pakxan)	－(Pakxan,Pakading)
	Literacy rate		About 95%	Almost 100%
Health	Birth rate		4～5/ year	－
	Mortality rate		2 (1998)	－
	Infant mortality		2 of 9 died (1998)	－

A summary of the baseline survey results is shown in Table 3-1-8.

Table 3-1-8 Overview of survey results

	Households (HH)	Population	Field area (ha)	Average income (1000kip/year/HH)	Kerosene lamp (--)	Battery (--)	Tube Light (--)	TV (--)	Average energy expense Amount (kip/month)	% of Income
Donsayoudom	125	708	8	2,823	83%	66%	27%	66%	9,114	3.9%
Houaypong	43	252	11	1,513	72%	58%	49%	28%	3,215	2.5%
Nongpen	48	336	38	863	65%	79%	67%	42%	4,965	6.9%
Mai	57	394	24	1,262	83%	87%	28%	37%	2,578	2.5%
Vientiane average	68	423	20	1,615	76%	59%	43%	43%	4,968	3.9%
Namai	76	436	87	191	96%	83%	14%	18%	1,205	7.6%
Paksoun	96	571	13	707	54%	54%	32%	38%	7,802	13.2%
Borikhamxay average	86	504	50	449	75%	43%	23%	28%	4,504	10.4%
All villages	74	450	30	1,236	76%	54%	36%	38%	4,618	6.1%

*Estimate for Donsayudom.
*Energy expense includes lighting and electric appliances such as TV.
* Surveyed in October 1998, June 1999 for Paksoun

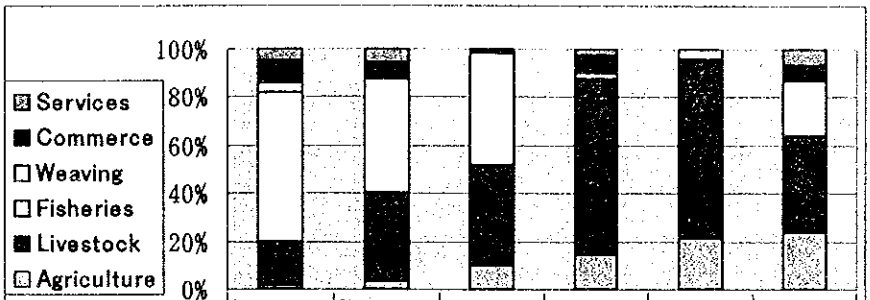
3-1-5 Income and energy expenditure

(1) Income level and cash economy

Income levels differ among the pilot villages; Donsayoudom has the highest average income of 2,800,000kip per year per household, while Namai has the lowest of 190,000 kip/year/HH. This does not necessarily indicate the disparity of economic conditions of pilot villages, rather it implies how much the cash economy has penetrated each village. In Borikhamxay province, the traditional farming style is common so that the penetration of the cash economy is limited.

(2) Income source and saving

Rural households in Laos, in general, depend on subsistence level of agriculture. They raise mainly rain-fed rice, and upland rice in the dry season. They harvest rice primarily for self-consumption and sell surplus rice in the market. Major cash income sources are from farming and livestock. The pilot villages in Borikhamxay province are such cases, while those in Vientiane province differ. The Vientiane pilot villages get cash from various sources. For example, Nongpen depends on weaving, while Donsayoudom, having no rice fields, depends on fishing for their cash income. Keeping livestock is a way of saving money in rural areas because bank deposits are meaningless due to the high inflation rate as well as the subsistence economy. The major cash income sources of the pilot villages are as shown in the figure below.



	Donsayoudom	Houaypong	Nongpen	Mai	Namai	Paksoun
Services	5%	6%	0%	2%	0%	6%
Commerce	9%	5%	2%	6%	0%	7%
Weaving	4%	1%	46%	1%	3%	0%
Fisheries	62%	47%	0%	2%	1%	22%
Livestock	18%	36%	41%	65%	59%	39%
Agriculture	2%	3%	10%	13%	17%	23%

Figure 3-1-3 Cash income sources of Pilot Villages

(3) Energy expenditure and willingness to pay for PV electrification

People in the pilot villages, except Namai, responded that they were willing to pay between 2,000 and 3,000kip every month for a solar system. The villagers of Namai, where cash income is the smallest, said they were able to pay only 1,000kip. Their opinions were probably adjusted by the influence of village leaders. Therefore, we studied their actual energy expense, as a better indicator of willingness to pay, which, we considered, suggests to what extent they were really able to pay for electricity. According to Table 3-1-8, households in the pilot villages pay from 1,200 to 5,000kip per month except for Donsayoudom. Households in Donsayoudom pay around 9,000kip per month, which includes diesel fuel for boat engines. Energy expenses as a percentage of income are 2.5 to 8 % across the pilot villages. Nongpen has relatively high percentage of energy expense because they use battery lighting for weaving.

3-1-6 Energy consumption pattern

(1) Energy sources

Lighting hours at the pilot villages are around three hours from 6:00PM to 9:00PM. Major energy sources for lighting are fuels, such as kerosene, and automotive batteries.

(2) Battery possession and its usage

In general, the battery possession rate increases as income grows as shown in Figure 3-1-4. At Nongpen, however, the battery possession rate is unusually high, which means that women there want to work in the evening for weaving, so they need electric lighting despite their lower cash income. This is supported by the fact that 98% of the households in Nongpen own looms, while 46% in Houaypong and 13% in Namai own them.

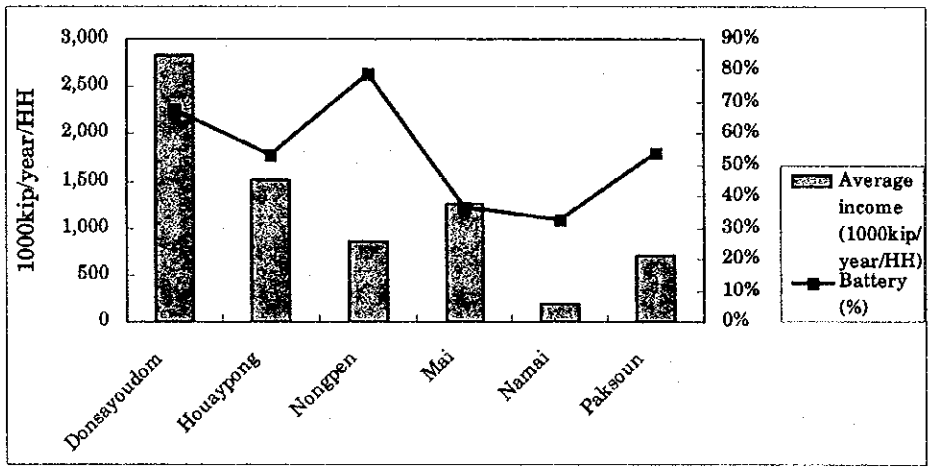


Figure 3-1-4 Income and battery possession

The correlation between battery and electric appliance possession and income level is obvious as shown in case of Donsayoudom. (See Figure 3-1-5)

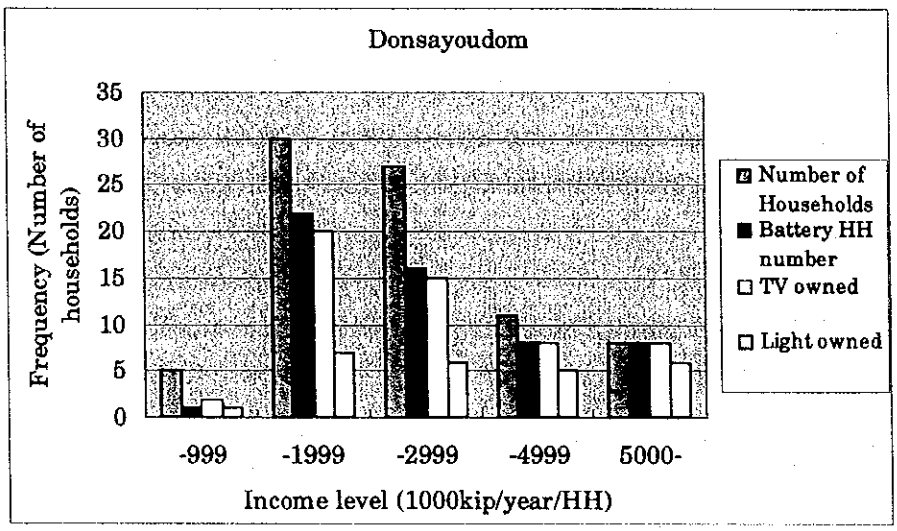


Figure 3-1-5 Income and possession of batteries and appliances

(3) Villagers' expectation of PV electrification

Electric lights are most strongly desired, chosen by 80% of respondents. (See Table 3-1-9) The villagers want to use electric lights to work and study. Especially, at Nongpen, 91% of the villagers showed their expectation to do weaving under lights.

Table 3-1-9 Expectations of electricity

(% of households)

Expectation to PV electrification	Vientiane					Borikhamxay				
	Nongpen	Mai	Houaypong	Donsayoudom	Sub total	Samsanouk	Namai	Nathong	Sub total	Total
Expected electric appliances										
Use light	98%	93%	91%	47%	77%	81%	82%	92%	84%	80%
Watch TV	73%	90%	65%	41%	64%	59%	42%	68%	52%	60%
Listen to Radio	80%	84%	72%	42%	66%	69%	55%	62%	60%	64%
Use fan	41%	55%	84%	40%	52%	81%	21%	27%	36%	46%
Activities under the light										
Work	91%	33%	74%	27%	50%	44%	39%	0%	30%	42%
Study	61%	7%	84%	37%	43%	34%	21%	30%	26%	36%
Safe night		24%	77%	41%	35%	59%	46%	81%	58%	44%

(4) Characteristics of applicants

In the first round of soliciting applications for solar systems, which took place in February 1999, many villagers of the four villages—Nongpen, Houaypong, Donsayoudom and Namai—submitted applications beyond our expectations. (See Table 3-1-10) At Nongpen, where the demand for electricity is high, 92% of households applied for SHS. The application rate was also high at Donsayoudom and Houaypong. A significant issue is that people already using batteries favored solar systems. (See Figure 3-1-6)

Table 3-1-10 Applications for PV systems (1st round)

	House holds	Battery holding	SHS application				BCS application	
		% of HH	55W	110W	total	(%)	50-70Ah	120Ah
1 Donsayoudom	125	68%	34	34	68	54%	7	3
2 Houaypong	43	53%	21	1	22	51%	1	2
3 Nongpen	48	79%	39	5	44	92%	0	0
4 Mai	57	37%						
Vientiane Sub total	273	61%	94	40	134	62%	8	5
5 Samsanouk	32	59%						
6 Namai	76	33%	17	6	23	30%	1	0
7 Nathong	37	27%						
Borikhamxay sub total	145	37%	17	6	23	30%	1	0
Pilot Village Total	418	53%	111	46	157	54%	9	5

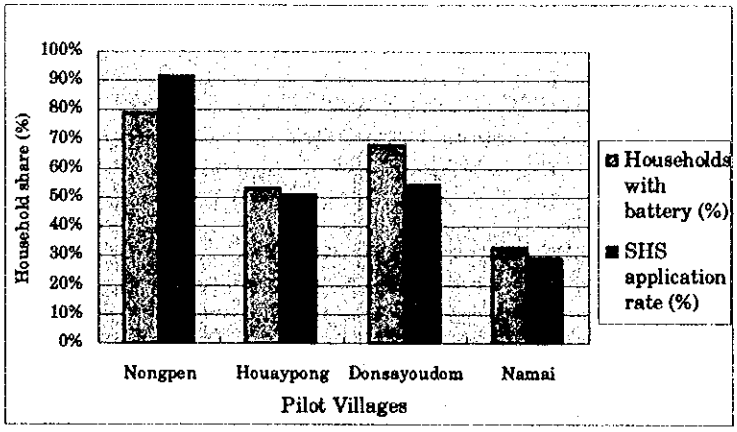


Figure 3-1-6 Application and battery possession

To analyze the driving factors for solar system application, the case of Donsayoudom was studied more precisely. The relationship between income and application is shown as follows. (Figure 3-1-7) This gives a clear indication that the higher income segment is more likely to select more expensive systems. The richest segment preferred 110W SHS to 55W SHS.

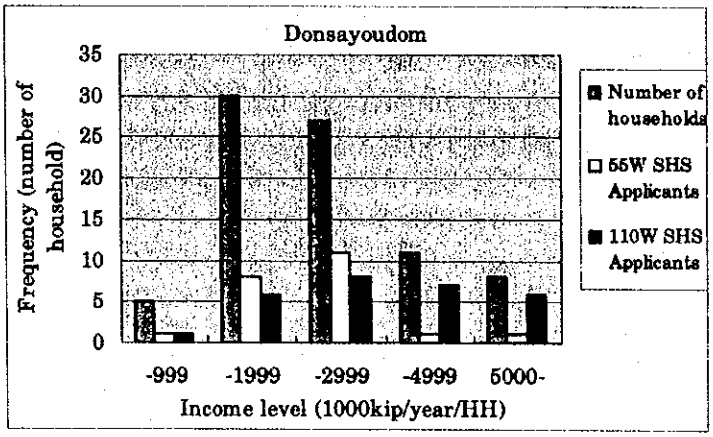


Figure 3-1-7 Income group and PV application at Donsayoudom

3-2 Monitoring of Pilot Villages

3-2-1 Situation of pilot villages

As a result of the socio-economic surveys conducted in the six pilot villages, some common points were found. First of all, rising prices were observed at all the villages. However, the villagers did not suffer so much because their life was basically supported by a self-sufficient economy. They just reduced the consumption of goods that they needed to buy. Secondly, we found that 6V rechargeable batteries

are widely used. People use them for hunting and fishing at night. Those 6V batteries need frequent charging, which costs about 500kip per charge. The spread of this 6V battery suggests the following points.

- **There is demand for lighting to work at night, and expenses for doing that become significant in a typical household.**
- **It is desirable if they can charge their 6V batteries within the village, instead of carrying the batteries to town.**
- **Familiarity of using 6V batteries will serve as a basis for solar system introduction.**

During the third and fourth field surveys, we encountered some notable changes at some of the pilot villages as follows:

(1) Impact of inflation – Donsayoudom

The price of fish went up twice as much because of strong demand and inflation. As a result, people could get more cash income from fish sales than before. Of course, they needed to pay more for fuel and rice, but they were generally better off thanks to the sharp increase of fish prices.

(2) Role of women traders – Houaypong

Fish traders, mostly women, in this village were playing a key role in the village economy. As most men were engaged in fishing or farming, women were supposed to buy and sell fish in this village. They purchase fish from fishermen and sell at the market near the Nam Ngum Dam. On average, they make about 500kip/kg. Money being circulated in the village is brought about by these female traders.

(3) Collective work – Nongpen

An extraordinary collective work was observed at Nongpen in the farmer's busiest season. People help each other plant rice. Since it takes one to two days in finishing each household's rice field, the collective work continues for about two months in total. This shows the solidarity of Nongpen, which owes to its unique historical and ethnic background.

(4) Increase of new immigrants– Mai

Recently, the number of households coming from the outside was on the rise

because the newcomers were forced to move from nearby Don Mua (village), where a resort club was to be constructed with investment from Malaysia. When people want to move into this village, they need to go through interviews by the village chief or elders. New families started making a living by fishing and upland rice cultivation.

(5) Opening of new road— Namai

The improvement work of rough roads in the village was finished and a new road from Pakxan through Namai to Pakading was opened, completely changing the picture of the village. The new road will significantly change people's life in the village. For example, access to schools, neighboring villages and towns will become much easier. Boki (village), which was located next to Namai, merged with Namai in February 1999, and the Boki villagers moved closer to the new road following advice from the provincial government.

(6) New pilot village—Paksoun

In the dry season, the water level of the Kadding River, which is running in front of the village, goes down significantly and people have difficulty in fishing and transportation. Therefore, most villagers make a living by raising vegetables during the dry season.

3-2-2 Results of PV Monitoring

(1) Monitoring during installation (Monitoring 1)

Collection of the initial payment for SHS and an interview survey targeting solar system users were conducted by the study team before the completion of solar system installation. (Exchange rate : 1$=7,115kip as of May 1999)

1) Source and affordability of initial payment

The villagers at the pilot villages secured enough cash primarily by selling livestock (Nongpen), or fish (Donsayoudom, Houaypoung and Mai) to pay the initial charge; 100,000kip for 55W-SHS, and 150,000kip for 110W-SHS. Some people paid from their cash income from weaving such as in Nongpen.

Table 3-2-1 Sources of initial payment for PV

	Livestock	Crop	Fish	Handicraft	Ordinary Income	Saving
Donsayoudom	17%	4%	87%	9%	4%	9%
Houaypong	11%	6%	83%	0%	17%	11%
Nongpen	55%	0%	0%	18%	18%	9%
Mai	20%	53%	85%	3%	0%	48%

To the question of "How did you feel about preparation of initial payment?", most of them answered, "Not difficult". (See Table 3-2-2) Although the value of the kip was declining at that time, their answers indicated that people could somehow secure that amount of money. This is supported by the fact that there was no household that failed to pay the initial charge.

Table 3-2-2 Affordability of the initial payment

	Easy	Not difficult	Difficult	Very difficult	Impossible
Donsayoudom	17%	78%	0%	0%	0%
Houaypong	11%	72%	6%	0%	0%
Nongpen	27%	55%	9%	0%	0%
Mai	0%	100%	0%	0%	0%

2) Inflation adjustment

As for the proposed idea of inflation adjustment for the monthly fee of SHS (55W: 5,000kip, 110W:10,000kip in 1999), almost 100% of households answered "acceptable". As we discussed this issue during the PCM workshop held at each pilot village, people recognized the necessity of reviewing the monthly charge once a year.

(2) Monitoring after 3 to 6 months of installation (Monitoring 2 & 3)

1) Energy demand

① Application: demonstration effect of pilot project

Additional SHS applicants showed up after the 1st round of installation. By October 1999, the total applications at the four SHS villages reached surprisingly 90% of the total households. (See Table 3-2-3) In the previous survey, we pointed out that the number of applicants depended on the status of battery possession. However, many households who had never used batteries applied for solar systems this time. It was clear that many households decided to apply after checking the benefits of solar systems. For example, the installation of SHS started in Mai (second group) three months after the first group was finished so that the villagers of Mai had enough time to see the operation of SHS. All the households in Mai ended up applying for SHS. Among them, half of the applicants selected the 110W system. It can be said that the initial installation had a strong impact on those who could not make up their minds and created new demand.

Table 3-2-3 Application for SHS

Application for SHS (Applicants /Total HH)	HH Oct-99	HH with battery Share (%)	SHS application (Feb. 99)				SHS application (Jun. 99)				SHS application (Oct. 99)			
			55W	110W	Total	Share (%)	55W	110W	Total	Share (%)	55W	110W	Total	Share (%)
1 Donsayoudom	126	67%	34	34	68	54%	35	52	87	69%	44	61	105	83%
2 Houaypong	42	55%	21	1	22	52%	28	1	29	69%	38	1	39	93%
3 Nongpen	46	83%	39	5	44	96%	32	6	38	83%	36	8	44	96%
4 Mai	68	31%					28	28	56	82%	34	34	68	100%
5 Namai	76	33%	17	6	22	29%								
6 Paksoun	96	49%					81	0	81	84%				
Total	454	44%	111	46	156	54%	123	87	210	74%	152	104	256	91%

*Application in Paksoun is for BCS, not counted in total.

*In Namai applied for SHS in Feb. 99.

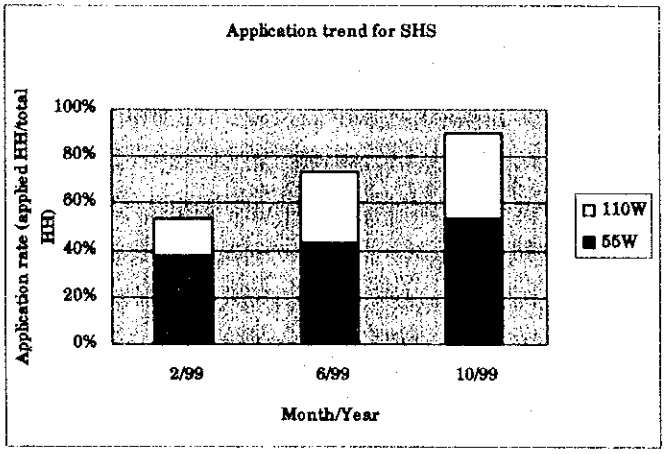


Figure 3-2-1 Trend of SHS application

Similarly, in the past, somebody brought in a car battery for the first time into his village to use it for lighting. After a few months, many villagers followed and started to use batteries. Battery use quickly spread within the villages. This story implies that there was strong potential demand for electricity borne out by the latent demand for SHS.

② Energy consumption and expenditure

The table below shows the data of kerosene use and frequency of battery charging of SHS pilot villages at two different times; October 1998 and October 1999. Such conventional energy consumption decreased dramatically and was replaced by SHS. However, some households were still using kerosene lanterns to supplement SHS.

Table 3-2-4 Change in kerosene use and battery charging

Kerosene use, battery charging times and those share of HH						
Villages	Energy in kind	Oct-98		Oct-99		Change of consumption per HH (Share of 99's consumption as of that of 1998)
		HH	Use	HH	Use	
Donsayoudom	Kerosene	98%	3.5 (l/mo)	37%	1.8 (l/mo)	19.6%
	Battery	68%	4.0 (times/mo)	19%	2.0 (times/mo)	13.6%
Houaypong	Kerosene	86%	3.9 (l/mo)	8%	1.0 (l/mo)	2.3%
	Battery	53%	2.2 (times/mo)	15%	3.0 (times/mo)	38.9%
Nongpen	Kerosene	73%	2.2 (l/mo)	17%	0.8 (l/mo)	8.2%
	Battery	76%	3.6 (times/mo)	28%	1.9 (times/mo)	19.4%
Total	Kerosene	88%	3.2 (l/mo)	24%	1.2 (l/mo)	10.3%
	Battery	66%	3.3 (times/mo)	21%	2.3 (times/mo)	21.9%

Table 3-2-5 compares the energy expenditures in October 1998 and those in October 1999. These expenditures include above-mentioned energy consumption and the monthly payment for SHS. Data for October 1998 were adjusted to prices in October 1999. According to the table, the average household energy expenditure decreased in real terms.

The price elasticity of energy consumption is known to be high in general. Therefore, if energy prices sharply increase, households will cut energy consumption to lower their energy bills. Without SHS, the households of the SHS pilot villages would have been forced to cut their energy consumption; limiting the use of kerosene lanterns from two hours to one hour, for example. In reality, they did not cut lighting hours. Rather, they enjoyed longer and brighter lighting at smaller costs. (See Figure 3-2-2) Their living standard was dramatically improved.

Table 3-2-5 Comparison of energy expenses per household

Home energy expenses per HH (kip/mo)			
		1998/10	1999/10
		Real price of Oct. 99	Real price of Oct. 99
Donsayoudom	Kerosene	8,503	1,667
	Battery charge	5,921	509
	SHS fee *1	0	8,148
	Total	14,424	10,324
Houaypong	Kerosene	8,372	192
	Battery charge	2,609	577
	SHS fee	0	5,417
	Total	10,981	6,186
Nongpen	Kerosene	4,056	333
	Battery charge	5,916	528
	SHS fee	0	6,111
	Total	9,971	6,972
Total	Kerosene	6,977	731
	Battery charge	4,815	538
	SHS fee	0	6,559
	Total	11,792	7,827

*1: SHS fee employ weighted sum of 55W (5,000kip) and110W (10,000kip).

*2: Battery charging price employs weighted sum of BCS in vfillage and battery charging price at the dam in Oct. 1999.

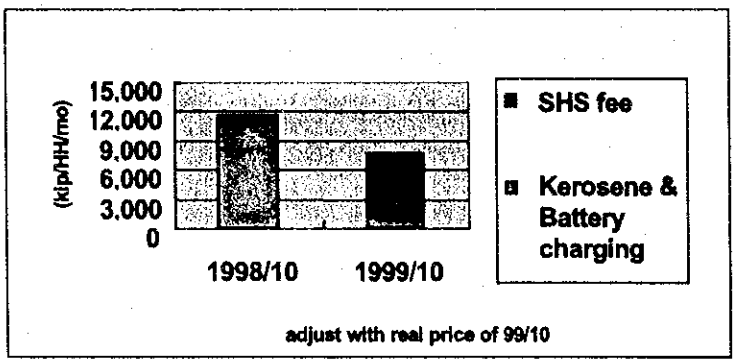


Figure 3-2-2 Change in energy expenses in the three pilot villages

Prices of kerosene and battery charging, which were replaced by SHS, increased sharply during the pilot project, while the monthly fee for SHS remained unchanged. This led to a higher application rate for SHS because SHS looked relatively inexpensive. According to the interview survey in 1999, 90% of households responded that the SHS monthly charge (55W: 5,000kip, 110W: 10,000kip) was not expensive, which was a drastic change compared with one year before (See Table 3-2-6).

Table 3-2-6 Reaction to the monthly fee

	Villagers reaction to Monthly fee				
	Not payable	very expensive	expensive	not expensive	cheap
Donsayoudom	0%	2%	4%	91%	0%
Houaypong	0%	5%	5%	85%	5%
Nongpen	0%	0%	0%	96%	0%
Total	0%	2%	3%	91%	1%

Note : % of respective households/ total households

2) Effect and impact

The introduction of PV has benefited the villagers because they are able to use more electricity than before. Are they satisfied with PV? Table 3-2-7 shows the answer to this question. Almost 90% of the households answered "satisfied". The problems are " taking much time to charge" or "cannot use desired electric appliances".

Table 3-2-7 Satisfaction and benefits of PV

	Satisfied with PV	Good points of PV							Good points of Kerosene		
		Cost perfor mance	Conven ience	Saving time	Safety use	No smell	Status	Others	Cost perfor mance	Insect guard	Others
Donsayoudom	83%	62%	91%	47%	66%	32%	19%	6%	4%	60%	0%
Houaypong	90%	75%	95%	70%	85%	60%	40%	0%	0%	15%	0%
Nongpen	100%	25%	96%	14%	14%	7%	0%	11%	0%	71%	0%
Total	89%	54%	93%	43%	55%	31%	18%	6%	2%	54%	0%

Note : % of respective households/ total households

One of the good points for the PV system is "convenience". Over 90% of the households chose this answer. We can easily understand it. For the villagers living on the Nam Ngum Lake, it takes one day to go to charge batteries at the dam; they can't do any work on that day. With SHS, they can save the opportunity cost of having to go for charging, which is a big advantage for them. Furthermore, they don't have to worry about abrupt black-outs. They can enjoy longer lighting hours since they are free from the worry and the inconvenience of having to go for charging. A shop owner said that he was making more money because he could keep his shop open until late at night.

On the other hand, a preferred effect of blocking insects by the smell and smoke from kerosene lanterns disappeared. However, this merit did not offset the benefits

of PV. We further studied the impacts of PV introduction on living expenses. In total, only 10% of PV users responded that their living expenses increased. At Houaypong, 30% of PV users said their living expenses rose because they had to charge their second batteries at charging shops, which pushed up their total monthly bills.

Table 3-2-8 Impact on household economy

	Cost of living Increased	Where to charge existing battery? (Share of HH)					Income Increased	Sources of Income Increased (Share of HH)			
	Share of HH	own SHS	neighbor SHS	BCS town	BCS village	others	Share of HH	handicraft	weaving	fishing	others
Donsayoudom	2%	40%	0%	2%	15%	2%	74%	4%	6%	17%	21%
Houaypong	30%	10%	15%	25%	25%	0%	90%	10%	5%	30%	10%
Nongpen	11%	14%	43%	0%	0%	0%	96%	0%	36%	11%	11%
Total	10%	27%	15%	6%	13%	1%	83%	4%	14%	18%	16%

Note :% of respective households/ total households

On the other hand, there were households whose income increased, such as weaving in Nongpen and night fishing in Houaypong and Donsyoudom. There were also cases in which people increased their incomes by making fish balls, running tailor shops and other shops at night. Also in Nongpen, houses with 110W-SHS started a battery charging business. Some households bought new electric appliances. As can be seen in the table below, once one light is installed, electricity demand expands because people want to have another light, a cassette player, TV and audio system.

Table 3-2-9 New appliances bought

	New appliances bought (Share of HH)					
	Another light	Radio	Cassette	TV	Fan	Others
Donsayoudom	25%	0%	15%	8%	0%	4%
Houaypong	0%	0%	15%	5%	5%	5%
Nongpen	4%	0%	4%	7%	0%	4%
Total	14%	0%	12%	7%	1%	4%

Note : % of respective households/ total households

In Paksoun, where a 3kW BCS was installed in February 2000, the share of households having batteries increased from 50% before installation to over 90% after installation.

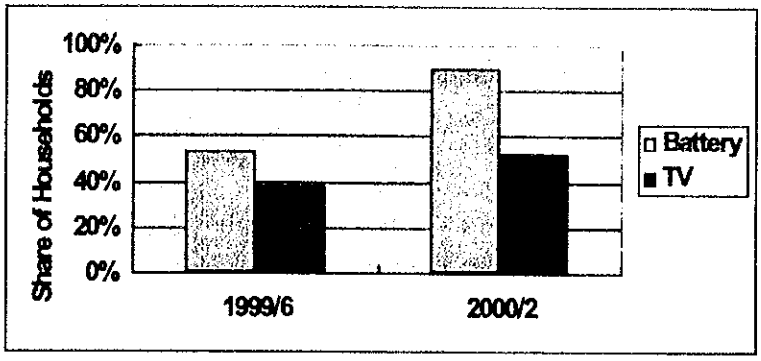


Figure 3-2-3 Batteries and TVs in Paksoun

3) Change of life style after PV installation

Typical comments expressed after three months of PV installation by core members of the pilot villages are presented below.

- [Everyone has recognized how convenient it is to have a solar system !]

"Neighboring village people also want to have a solar system." This is a message often heard in the pilot villages. The pilot project turned into a demonstration for the local people of the unfamiliar but beneficial "PV" technology. Some people who did not apply for SHS due to uncertainty of their capacity to pay now regret it. The proposed SHS tariff seems to be close to the upper limit for them.

- [Solar system contributes to income generation.]

It is said in a World Bank report that small-scale PV would not contribute to any "production". However, people's responses include, "customers come to buy until late at night because we have lights on (at shop)", "able to work at night (a tailor)", and "fish net repairing business also prospers". Unlike in the previous situation where people had to save battery electricity, now PV users can use electricity more freely without worrying about battery charging.

- [We watch TV longer.]

Similar comments include, "we sleep less", "it is wonderful to have a light for taking care of new born baby", "many people are planning to buy new TVs, radios and Karaoke machines" and "we feel safe on stormy nights because we can see where the rain comes into the house".

- [What is your next dream after SHS? A water pump and a refrigerator.]

The monthly fee collection has been done smoothly by the VEC. Furthermore, some villagers start to save money for some purposes such as buying a TV rather than spending all the money earned, which was common in the pilot villages.

4) Maintenance by villages and the village electrification committee

Villagers get used to using batteries and 97% of the respondents answered that they are "easy" to use. When villagers cannot take care of their batteries for themselves, the Village Electrification Committee (VEC) will support the villagers. The expectations placed on the VEC by villagers are sales of spare parts, repair work, and user training.

Table 3-2-10 Operation of PV and expectation of VEC

	PV Operation	Distilled Water Check			Expectation of VEC				
	Easy	Self	Neighbor	VEC	user training	spare parts	advice	repair	others
Donsayoudom	94%	9%	0%	85%	19%	85%	4%	30%	2%
Houaypong	100%	35%	0%	65%	25%	55%	10%	50%	10%
Nongpen	100%	21%	0%	93%	21%	86%	0%	64%	4%
Total	97%	18%	0%	83%	21%	79%	4%	44%	4%

Note : % of respective households/ total households

3-2-3 Impact Survey

An impact survey was conducted in June 2000 at each pilot village, and additional workshops were held at the four SHS pilot villages: Donsayoudom, Nongpen, Houaypong and Mai. This survey was aimed at assessing the change of life, positive and/or negative effects of PV.

Figure 3-2-4 shows the comments made at the workshops. Many villagers responded "good for nighttime study/work", "comfortable/ happy". At Nongpen many comments related to study and work were made, which illustrated the diligence of Nongpen people.

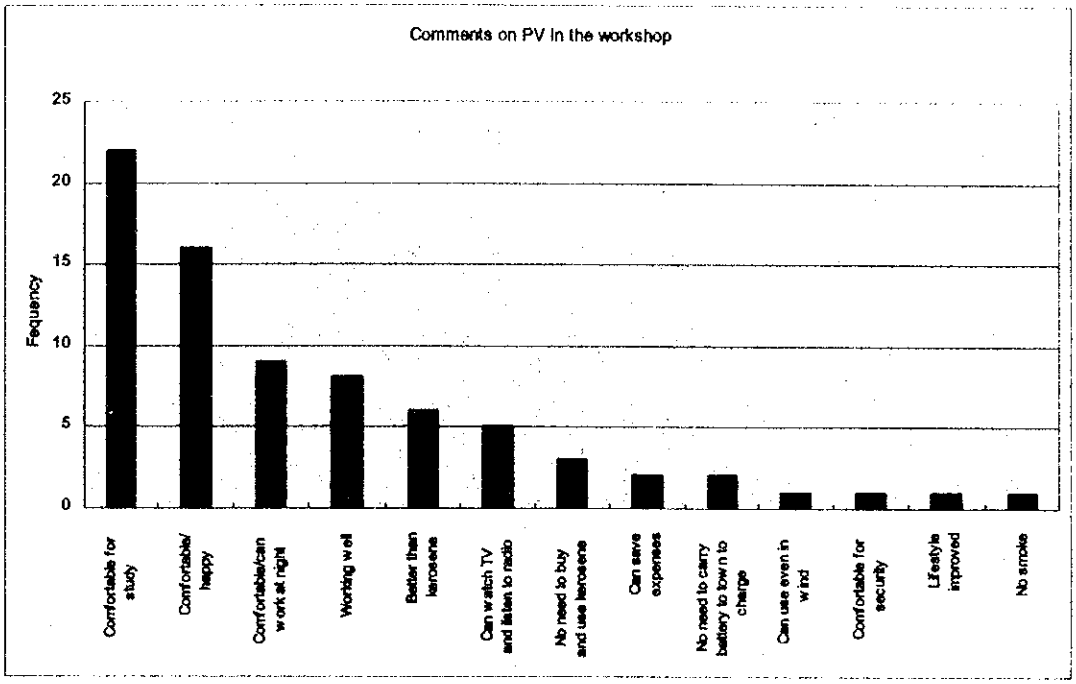


Figure 3-2-4 Comments at workshops

The villagers also commented on their desires and problems with PV (See Figure.3-2-5~6). There were technical needs such as "want more lamps", "need technical support", and "need spare parts". Regarding the comment of "more salary for VEC", we asked the villagers to resolve that by themselves. Also, some comments on difficulties were made, especially problems of florescent lamps. Based on these comments, the counterpart and the JICA team gave technical instructions to the villagers.

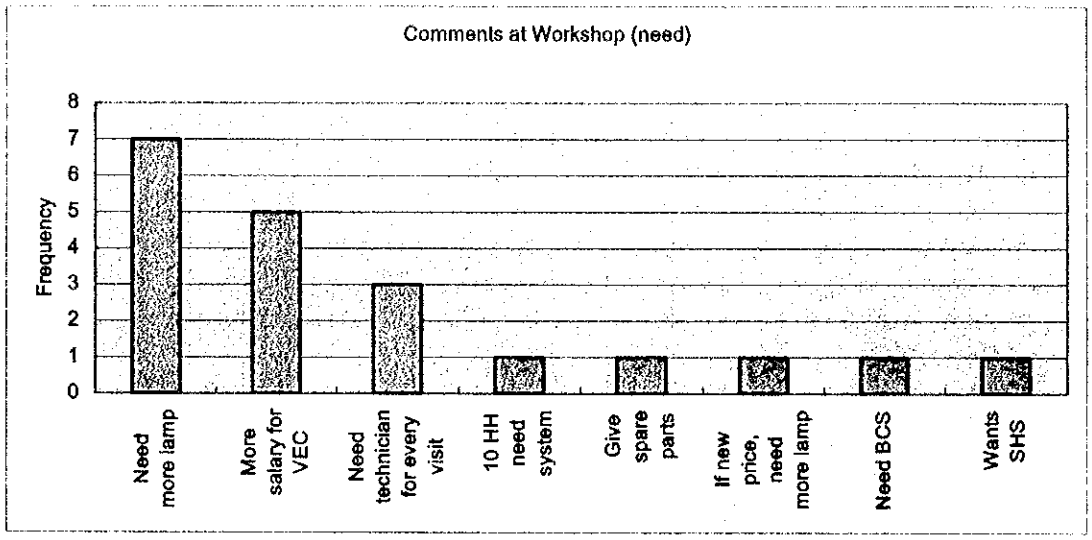


Figure 3-2-5 Comments at workshops (needs)

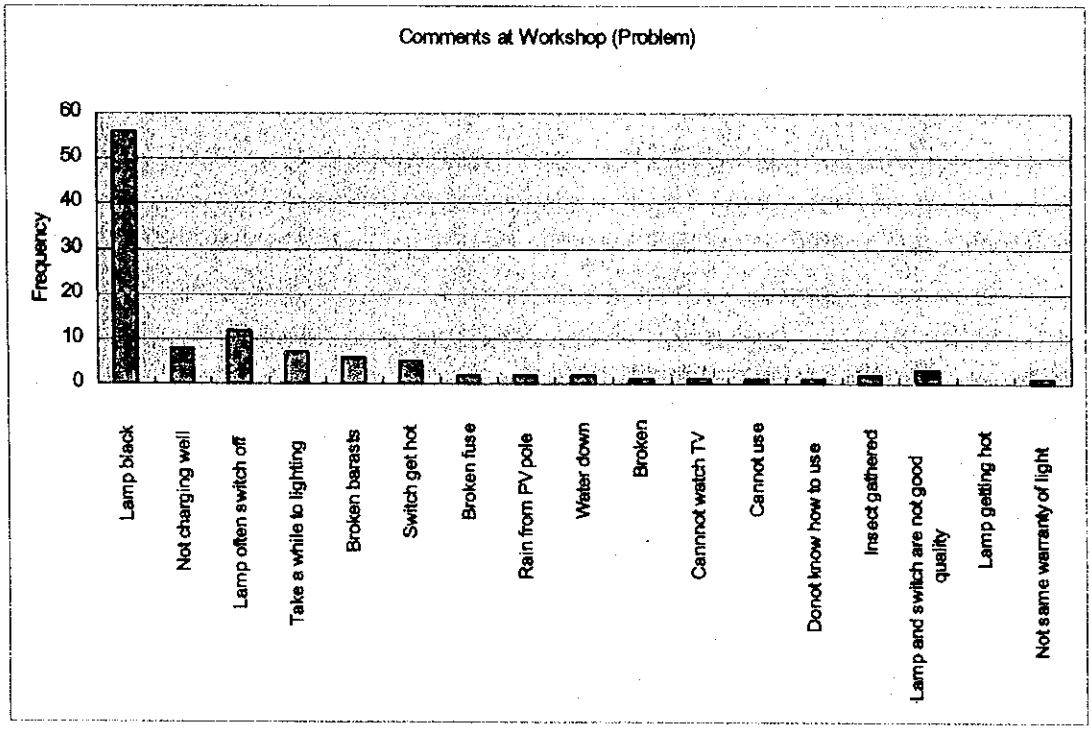


Figure 3-2-6 Comments at workshops (problems)

According to the questionnaire survey at SHS pilot villages, many villagers gave positive comments such as "cooking is easier", "energy expenses are saved", reflecting women's views. Other major comments are "getting safer at night", "studying at night easier", and "getting information from radio/TV". Especially, "energy expenses are saved" was the most frequent answer related to the benefits of PV. We can understand the economic benefits of PV after one year of use. On the

other hand, as negative effects of PV, people answered "shorter sleeping hours", "insects gather to light", "increase of living expenses" and " noise of speakers". A few answers like these might show the modernization of villages by PV.

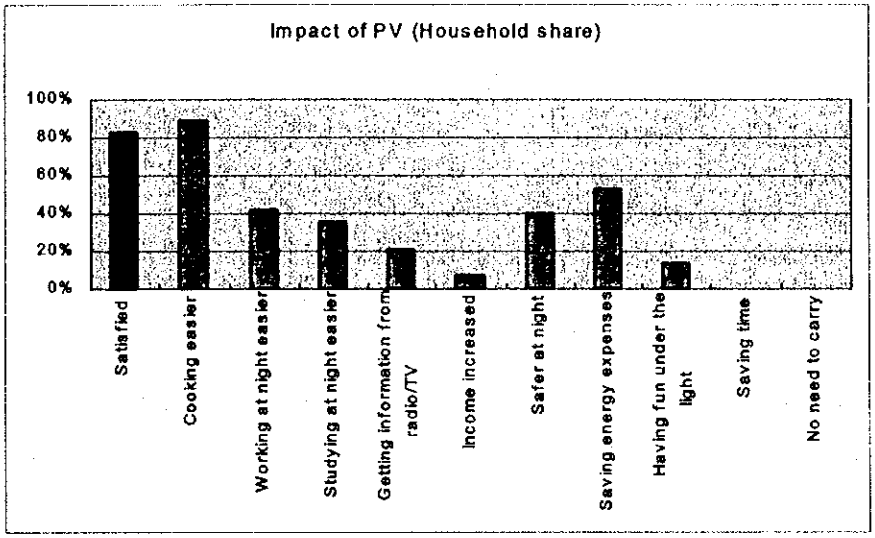


Figure 3-2-7 Impacts of SHS

Only a questionnaire survey was conducted at the two BCS pilot villages: Namai and Paksoun. As for positive effects, they, like the SHS villages, frequently answered "easier cooking", "saving energy expense", "safer at night", "working/studying at night easier", and "getting information easier". As negative effects, few people answered "shorter sleeping hours", and "insects gathering".

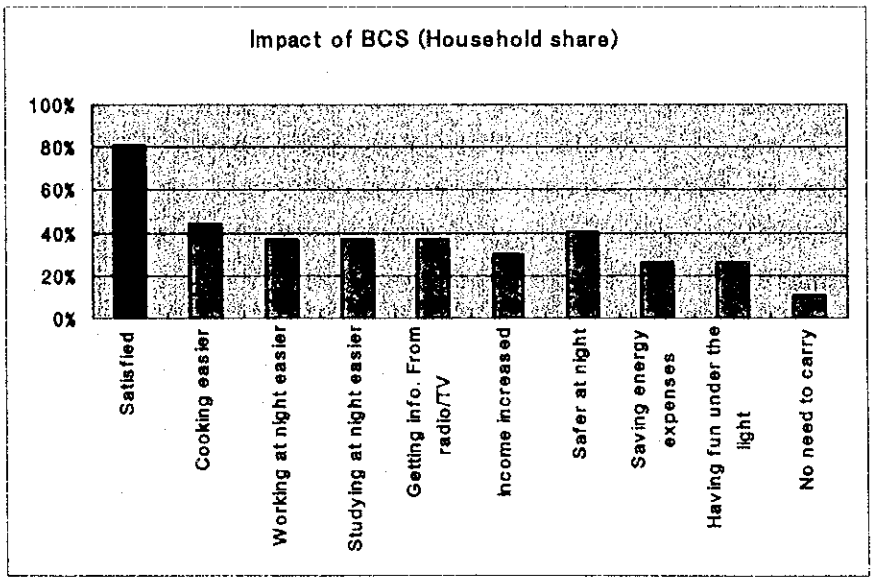


Figure 3-2-8 Impacts of BCS

3-2-4 Activities of Village Electrification Committee

The concept of VEC is the key to success of solar-based rural electrification. As the activities of the VEC are addressed in Chapter 6, here we focus on the VEC members. Actually the VEC needs to get technical and operational assistance before and after PV installation. In order to provide effective assistance, it is important to understand what background the VEC members have and what villagers expect of the VEC. That is why another interview survey was conducted in the pilot villages.

(1) Member selection and task sharing

Most VEC members, three or four persons in each village, were recommended by others and selected in the village meeting. Each VEC is basically composed of a leader, a cashier and a technician. However, fee collection and maintenance work are assigned to two or three core members.

(2) Background of VEC members

The final education level of VEC members is secondary or high school. Their present occupations are fisherman or farmer. However, some of them have other occupational careers such as teacher or carpenter. Although most members have no experience of electrical work, they usually repair their boat engines. It means they are relatively used to machinery work. As for their positions in the village, most of them belong to village organizations such as the village leader group or other social groups. Considering these points, villagers seemed to have common criteria for VEC member selection as follows.

- **Educational level:** Average level or higher level of education background.
- **Technical background:** Experience of machinery work.
- **Position in the village:** Belonging to a village organization or occupying a village leader position.

As the JICA team didn't give any instruction to the pilot villages concerning the selection of the VEC members, these features represent villagers' expectations on how the VEC members should work to manage the solar systems.