CHAPTER 1
INTRODUCTION

1.1 Rationale and Historical Background

Generally speaking Lao People's Democratic Republic (Lao PDR) policy is devoted to assure additional generating energy from renewable Source. In particular with hydropower scheme, it is not only the cleanness energy and environmental friendly but also can contribute with a cheap source.

As we all know, the electricity is an important source of energy for human life, not only for their industrial and agricultural activities but also on the others. Since the old times, hydropower generation has been developed worldwide utilizing natural river water. The development of electrification firstly began with local power generation on small/mini/micro scale, and then progressed to the large scale power generation according to an increase of power demand.

Hydropower plant in Lao PDR is so famous, called as a term "the batteries" of South East Asia. Although the Lao PDR has a theoretical hydroelectric power potential of 26,000 MW in estimation, there is currently developed only 3% of the total [10]. Therefore, the hydropower plant has been developed significantly at an accelerated rate.

Recently, the Lao PDR has a total power installed capacity of approximately 689.8 MW, by which 98% is from a hydropower plant, and 2% is from the diesel generating plant. The total capacity is divided into the following responsibilities: Electricite' Du Laos (EDL) has a power capacity 308.7 MW (45%), Independence Power Producer (IPP) is 360 MW (52%) and Local Authority's is 21.1 MW (2%)[1].

Accordingly, to Laos has hydropower potential condition. Thus, the government of Laos (GOL) has to achieve a goal target of the national electrification, be raised up to a rate of 90% toward the year 2020 and be aiming for poverty alleviation in the rural area.

[1] System Planning office, " Power Development Plan (2007-16)", EDL, March 2008

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At present, there are more than 40 existing small/mini and micro-scales hydropower plants. The total installed capacity is about 7,600 kW out of the large scales, scattered around the country of Lao PDR. Their installed capacity is almost less than 1 MW and they are almost at places in the Northern Province where the area is steep and mountainous areas to the capital Vientiane by which and almost people (72%) living in. The developing economic areas and the livelihood (90%) of their own selves depend directly on the natural resource base. The electricity are supplied by a local power source (Small and micro-scales electricity generation), which are almost as the isolated grid system.

Luang Prabang (LPB) province locates in center of Northern Laos 8 provinces, and the center area has been electrified by Nam Dong small-hydro plant (1,000 kW) since 1971. The EDL's grid has been connected to center of LPB province since 1994, and the power supply from Nam Ngum 1 hydropower plant has been started, and there are two other micro-hydropower plants (MHPs), Nam Pa MHP (16 kW) in 1998 and Nam Mong MHP (70 kW) in 2000 which are both isolated grid system. In order to raise the electrification rate to eastern area, the EDL has plan to extend the grid to the district to meet the government targeting for raising the household's electrification rate of LPB province from 31% by 2003 to 75% to ward the year 2020 concentrated to the LPB power center [10]. Therefore, the imbalance of energy generation and energy consumption influences the stability and reliability of energy supply of LPB province, where the existing micro-hydropower plants as the main electric power sources provide only 10% of total energy consumption. Moreover, they have been operated on the practical limitation and continued to decrease theirs role of the electrification due to the expansion of the national grid that is more reliable of the energy supply. Therefore, the method for promotion the government strategy is not only improved of power plant machine but the installation of grid connection system.

The objective of this study is to demonstrate the effective cost and prove economic feasibility of an improvement and rehabilitation the existing micro-hydropower plants in LPB province of Lao PDR. The achievement of an improving their efficiency of operating performance is a concept for sustainable development for the micro-hydropower plant, and lead more reliable supplying of electricity energy in region of LPB province. Theirs location out line is shown in figure 1.1.

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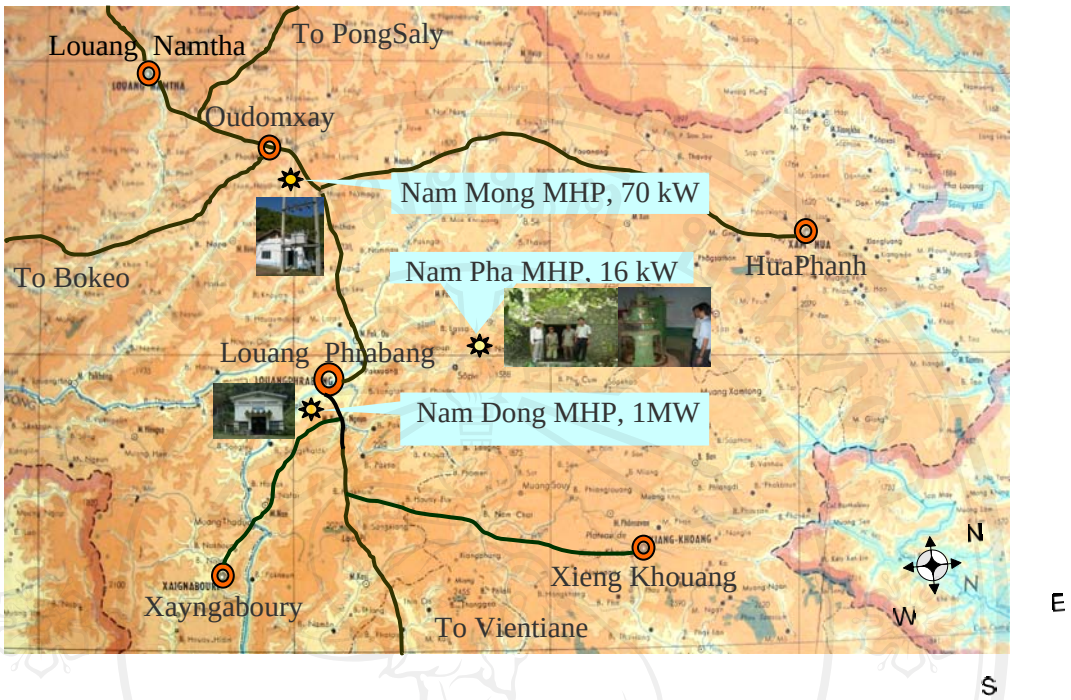

Figure 1.1 Location of the existing micro-hydropower plant in Luang Prabang province.

1.2 The Status of Existing Small and Micro-Hydropower Plant in Lao PDR

Micro-hydropower plants are most cost-effective and plentiful energy source. However, very few percentage of the country's potential has presently developed. The development of country's micro hydropower capacity is about 7,665 kW. Within the recommendation of provincial authorities and data from Department of Electricity (DOE), the information presented the situation of each project (See in Table 1.1) are as follow :

1) Non-experienced operators on operation and maintenance,

2) Lack of financial support from local Government to rural people for operation and maintenance.

3) Many of existing micro hydropower projects are completely disables.

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Table 1.1 The Existing Small and Micro-Hydropower Plant in Lao PDR.

No.	Project Name	Installed capacity (kW)	The Year of completion	Electrified status	Authority	Situation	Status
PONGSALY PROVINCE							
1	Nam Khoun*	1 x 5	1996	I	D	PS	N
2	Houay Kha*	1 x 5	1996	I	D	PS	N
3	Nam Boun	2 x 55	1996	I	P	OP.T/S	Y
4	Nam Ngaiy	2 x 600	2002	I	P	OP.T/S	Y
LUANG NAMTHA PROVINCE							
5	Nam Noun*	1 x 40	1998	I	D	PS	N
6	Nam Leu	1 x 46	1994	I	D	PS	Y
7	Houay	2 x 40	1998	I	D		N
OUDOMXAY PROVINCE							
8	Houay	1 x 75	1998	I	D		Y
9	Houay	2 x40	2004	I	D		Y
10	Nam Ko	3 x 500	1996	C	EDL		Y
LUANG PRABANG PROVINCE							
11	Nam Pha*	1 x 16	1998	I	D		N
12	Nam Mong	1 x 70	2000	I	OP.T/S		Y
13	Nam Dong	3 x 336	1970	C	EDL		Y
XAYABURY PROVINCE							
14	Nam Ham*	2 x 90	1992	I	D	PS	N
HUAPHAN PROVINCE							
15	Nam Hang*	1 x 6	1994	I	D	PS	N
16	Nam Soy*	1 x 12	1993	I	D	PS	N
17	Sop Long*	1 x 20	1970	I	D	PS	N
18	Nam Long	1 x 24	1987	I	D	PS	Y
19	Houay Men*	1 x 24	1989	I	D	PS	N
20	Nam Poun 1*	2 x 48	1969	I	D	PS	N
21	Nam Poun 2*	1 x 48	1969	I	D	PS	N
22	Nam Puen	1 x 40	1986	I	D	OP.T/S	Y
23	Nam Et	1 x 80	1998	I	D	OP.T/S	Y
24	Nam La	2 x52	2002	I	D	OP.T/S	Y
25	Nam San	1 x 110	1995	I	D	POP.T/S	Y
26	Nam Sat	2 x 125	1999	I	D	OP.WLD	Y

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Table 1.1 (Continued)

XIENGKHUANG PROVINCE							
27	Nam Tan 1*	1 x 55	1994	I	D		N
28	Nam Tan 2 *	1 x 8	1995	I	D	PS	N
29	Ban Poung*	1 x 5	1995	I	D	PS	N
30	Nam Ka 1	1 x 12	1987	I	D		Y
31	Nam Ka 2	1 x 81	1995	I	D		Y
32	Nam Ka 3	1 x 5	1995	I	D		Y
33	Nam Ko*	1 x 12	1988	I	D		N
34	Nam Poui*	1 x 24	1995	I	D	PS	N
35	Ban Nong*	1 x 40	1995	I	D	PS	N
36	Nam Ma	1 x 55	1995	I	D		Y
37	Nam Tain*	1 x 75	1996	I	D	PS	N
38	Nam Chat*	1 x 100		I	D		N
VIENTAINE PROVINCE							
39	Nam Phay*	1 x 200	1999	I	D	PS	N
BOLIKHAMXAY PROVINCE							
40	Nam Phao*	2 x 800	1995	I	D	PS	N
SAVANNAKHET PROVINCE							
41	Houay Saloy	1 x 75	1996	I	D		Y
CHAMPASACK PROVINCE							
42	Houay Champi*	1 x 40	1999	I	D	PS	N
ATTAPEU PROVINCE							
43	Houay Samong	1 x 136	2004	I	D		Y
Total		7,665 kW					

Source : [9].

Note: * Project completed disable,

I Electrified by Isolated gird system,

C Electrified by grid connected,

N The projects are completely disabled,

Y The projects are operation properly,

D The project is under authority of district,

P The project is under authority of province,

EDL The project is under authority of Electricite' du Laos

PS Poor Situation (All part of plant facilities are very poor)

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OP.T/S Operation with (technical problem/electricity supply problem), and
OP.WLD Operation with less than water supply in dry season.

From the table 1.1, it can identify the situation of the existing micro-hydro power plant in Lao PDR. There are only two projects connected to the EDL's grid and more than 50% of which 43 projects are disable with the installed capacity of 2,596 kW [9]. The small and micro-hydropower plants status are summarized in table 1.2.

Table 1.2 Summary the Small and Micro-Hydropower Plant Status.

Installed Capacity	Operated	Disable
0~100 (kW)	12	20
101~1000 (kW)	5	2
More than 1000 (kW)	3	1

Source : [9].

1.3 Literature Review

Many studies have suggested the principle concern and are adopted fore this study. They are summarized as follows :

A.AIT ALLA. V. B & ME. LOUATSI (1997) [1] studied the rehabilitation of small hydropower station project in RUSSIA the requirements suitable hydropower equipment and mechanical equipments for the small hydropower station was studied. The principle list should be met for the requirements such as minimum expense for installation, easy to construct, adaptable to different operating condition, have a simple layout and flexible its quick repair and replacement.

H. RaMOS, et, al., (2004) [7] studied about generating energy from renewable source, in particular with hydropower schemes which can contribute with a cheap source, as well as it can encourage internationally competitive for small industry across wide range of energy source option. Small/Micro-hydropower plant is one of the most valuable to answer the question of how to offer isolated or rural communities the benefit of electrification. The importance of small hydroelectricity fills the gap of decentralized production and for private and municipal activity production or for sale

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to general grid delivery or alternatively to furnish energy to industry, even to isolated zone. Therefore, the small hydropower plant, with its multiple advantages is a low-cost and reliable form of energy. It is therefore, in the forefront of many countries to achieve energy self-sufficiency.

JICA (2005) [10] presents guidelines for identifying, planning, designing, and evaluating the small hydropower schemes. The subjects were preliminary planning, Per-Feasibility, begins manual of small hydropower plant, and O&M manual for small hydropower plant. The small hydropower planning was divided in to two steps, the first step was a preliminary study (So- called a desk study or a resource assessment study) to define the potential site. The second step was a Pre-Feasibility study to identify technically and economically feasible hydropower site close to the load center. Furthermore, improvement of electrification rate, the poverty alleviation, and the economic growth targeting of the 8 Northern provinces of Laos PDR were studied. Therefore, the manual for small hydropower plant can be used various technical levels. It can be practical and available for all users.

Martin Sintak, Jeanne Hilsinger (2004) [12] presented about the development as solution to maximize the power generated at the site, using as much of the original structure as possible. The Caborundum electricity plant was used in this study. The study was in 2001. The hydro mechanical equipment was studied where the design process began with inspection of hydro mechanical equipments such as turbine, generator and gear box, then the weir and other structures were investigated for the damage to repair them. Furthermore, powerhouse, electrical and control system aspect were studied for renovation .The finding of the rehabilitation after the solutions was significant. The install output increased from 56 kW to 1 MW in an environmentally sound with minimum investment.

Micro-hydropower systems, (2004) [13] are receiving increasing interest from homeowners and others who have property that is not served by the electrical grid. This buyer's guide helps decide if micro-hydropower is a viable option. It :

1) Introduce the basics of how a micro-hydropower system works,
2) Offer pointers on how to assess how much energy and power needed,
3) Introduce the principal components of a micro-hydropower system,

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4) Outline how to determine if a micro-hydropower system makes economic sense, and

5) Offer some practical examples of micro-hydropower systems.

This guide helps introduce when considering micro-hydro systems for remote off-grid residential homes, and small communities as well as first nations communities that are not connected to an electrical grid. Micro-hydropower systems can be complicated, site-specific, require expertise to set up and need some degree of maintenance. A qualified person is needed to determine the feasibility of the system and its design and set-up before the final decision.

The concept design for new micro-hydropower plant should be considered by following components :

A water turbine that converts the energy of flowing or falling water into mechanical energy that drives a generator, which generates electrical power is the heart of a micro-hydropower system :

1) A control mechanism to provide stable electrical power,

2) Electrical transmission lines to deliver the power to its destination Depending on the site, the following may be needed to develop a micro-hydropower system,

3) An intake or weir to divert stream flow from the water course,

4) A canal/pipeline to carry the water flow to the forebay from the intake,

5) A forebay tank and trash rack to filter debris and prevent it from being drawn into the turbine at the penstock pipe intake,

6) A penstock pipe to convey the water to the powerhouse,

7) A powerhouse, in which the turbine and generator convert the power of the water into electricity, and

8) A tailrace through which the water is released back to the river or stream.

Mohamed T. El-Ashry (2005) [14] studied rehabilitation and expansion of small hydropower plant on the river Raba. The subject was considered of high priority by the major and population nearby the cities, as the project would help to improve the environmental condition at sites, and would contribute to effort of flood protection on the Raba River. Two mini-hydropower plants (Kormend and Csorotnek) of 10 remaining plants were subjects to rehabilitation with the framework of this project.

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They were taken in operation since 1919s, but have not been operated for the last ten years. The summary of investment and cost estimation of the components such as the generators and water intake for two sites were considered for new installation. The new generators of water turbine and electrical control have to be rehabilitated.

P.SEANJUN (2005) [15] presented the economic analysis by installation the synchronous system for micro-hydropower plant by connecting to the Provincial Electricity Authority (PEA) Grid system of Thailand. With the electricity transmission line of PEA that has been extended and assessed to the local areas, the role of mini/micro-hydropower plants which are almost the isolated grid system have been decreased. The objective of study is to maintain the use on them where the synchronous system was setup to connecting to PEA grid system. The project started from improvement the Mea Kham Pong micro-hydropower plant (40 kW) at Mea Onn district, Chiang Mai province. The result shows that, the return on investment of the project is beneficial and can be strategic planning for suitable preservation of micro hydropower plant in the communities.

P. Intub (2003) [16] studied the Village-scale hydropower plant where there are more than 100 Village-scale hydropower plant over in Thailand, their designs are different in size and generating capacity depend on the terrains and communities need. The aim of the study was to determine the standard size where it can reduce the expenses design, operation and maintenance (O&M). 97 projects of village-scale micro-hydropower plants in the Northern region of Thailand were completed. Turbines were grouped into three sizes, small, medium, and large size. A cross flow turbine was selected. The results of study were shown that the suitable generating capacities plant was classified into two sizes, i.e., 20KW and 40 KW. Therefore, grouping turbine for standard group can reduce the expenditure for maintenance more than 50% a year. It is recommended that the result of this study is useful for improving and developing of the existing village-scale micro hydropower plants for the rural communities.

PREGA (2006) [17] concentrated on rehabilitation of destroyed small hydro power plants and construction of micro-hydropower plants (MHP), near villages, towns, industries and enterprises of social type. The example of a priority project is a micro hydropower plant on the river Issykata for energy supply of the resort Issykata.

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The small size of the project makes it attractive for investors. The duration of construction is only 6 months, the cost of investment is small, the contracts are mostly already determined and do not require many new agreements with relevant authorities. The success of the MHPP project of the resort Issykata would demonstrate the technical viability of the utilization of small rivers' potential of Kyrgyzstan for electricity production and would prove the possibility of economic implementation. Therefore, such an approach could be widely disseminated. This study has showed that this project on hydro energy is financially and technically feasible. Moreover, the local administration has manifested their high interest in the proposed project.

Tong Jiadong, et al, (1996) [18] introduced the mini/micro-scales hydropower practice and emphasize the important role of MHP in rural areas for decentralization electricity energy supply to meet the demand. The stated advantage of using the mini/micro-hydropower plant (MHP) is the suitability for development, fully using materials and appropriate technology with participation of local people. Moreover, they are easy to maintenance and reliable with little environment impact during construction with some positive environmental impact in the materials of local residents. The study mentions the fundamental theory of hydropower generation such as: calculation of the power output of a particular MHP project, selection of an exploitation scheme suitable for the particular physical condition of an area that will meet the economic and social requirement, selection of the most suitable type of power supply to meet the load and financial requirement of particular location. It is also mentioned calculation of the power output of cascade development for the small rivers.

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1.4 Criteria for Selection Project of The Study

According to the previous study and report by Department of Energy and Mining of Ministry of Energy and Mining of Lao PDR for the existing MHP in Northern provinces of Lao PDR is shown in previous section (Table 1.1), there are many different electrification status and problems during operation. Therefore, the criteria for selection the priority of the project is led by the objective of this study. The following criteria have been taken into account as follows :

1.4.1 The project site should be located in Louang Prabang province or vicinity, and supply the electricity energy to LPB province,

1.4.2 The project site should be located as isolated areas, where could be closed to the national power transmission line or Electricite' du Laos (EDL) power transmission line,

1.4.3 Possibilities of multipurpose water uses are preferable, and

1.4.4 The projects are authorized by EDL and have priority areas of LPB province.

Therefore, Nam Mong, Nam Dong and Nam Pha MHP are selected for the study. Table 3.1 illustrates their information :

Table 1.3 General Information of the Existing Small and Micro-Hydropower Plant in Luang Prabang Province.

No.	Project Name	Installed Capacity (kW)	Year of Completion	Electrification Status	Electrified
1)	Nam Mong	70	2000	Isolated System	7 Villages
2)	Nam Dong	1000	1971	Grid connection	LPB Power Substation
3)	Nam Pha	18	1998	Isolated System	1 Village

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1.5 Objective of Study

1.5.1 The objective of this study is to study the feasibility of rehabilitation and improvement of existing micro-hydropower plants in Luang Prabang province of Lao PDR.

1.6 Scope of Study

1.6.1 Three (3) existing micro-hydropower plants in Luang Prabang province of Lao PDR are investigated which are Nam Mong, Nam Dong and Nam Pha micro-hydropower plants.

1.6.2 In case of Nam Mong MHP, the feasibility study for setting up the synchronous system is investigated while cases of Nam Dong and Nam Pha MHP, the feasibility study for development a new micro-hydropower plant and rehabilitation for the nonproductive electricity energy are considered.

1.6.3 The main topic of this study focuses on the engineering economic. The affecting parameters, i.e., Net Present Value (NPV), Benefit-Cost Ratio (B/C) and Internal Rate of Return (IRR) of each project are evaluated and used for the consideration of suitability of projects.

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