CHAPTER 3
RESEARCH DESIGN

3.1 Introduction

In general, micro-hydropower systems operate as “Run-of-River type” which means that neither a large dam or water storage reservoir is built nor is land flooded. A fraction of the available stream flow at a given time is used to generate power, and this has little environmental impact. The amount of energy that can be captured depends on the amount of water flowing per second (the flow rate) and the height from which the water falls (the head).

The existing micro-hydro power plants in Luang Prabang operate as isolated grid system and they have different problem during operation and make high cost of maintenance. Further more, they are no reliable in supplying the electricity and get low energy generating or lower plant efficiency.

The objectives of this study are to demonstrate their problems and to conduct feasibility study incases of improvement and rehabilitation for three existing MHPs in LPB province. The hydro technical and economical key indicators such as Net Present Value (NPV), Benefit-Cost ratio (B/C) and Internal Rate of Return IRR were used to evaluate the project viability.

3.2 Work Flow of the Study

The concept of study consists of two particular parts. The first one is the technical study which identifies the situation of the project. The second one is the economical feasibility study of the project. The work flow of the study is shown in figure 3.1.

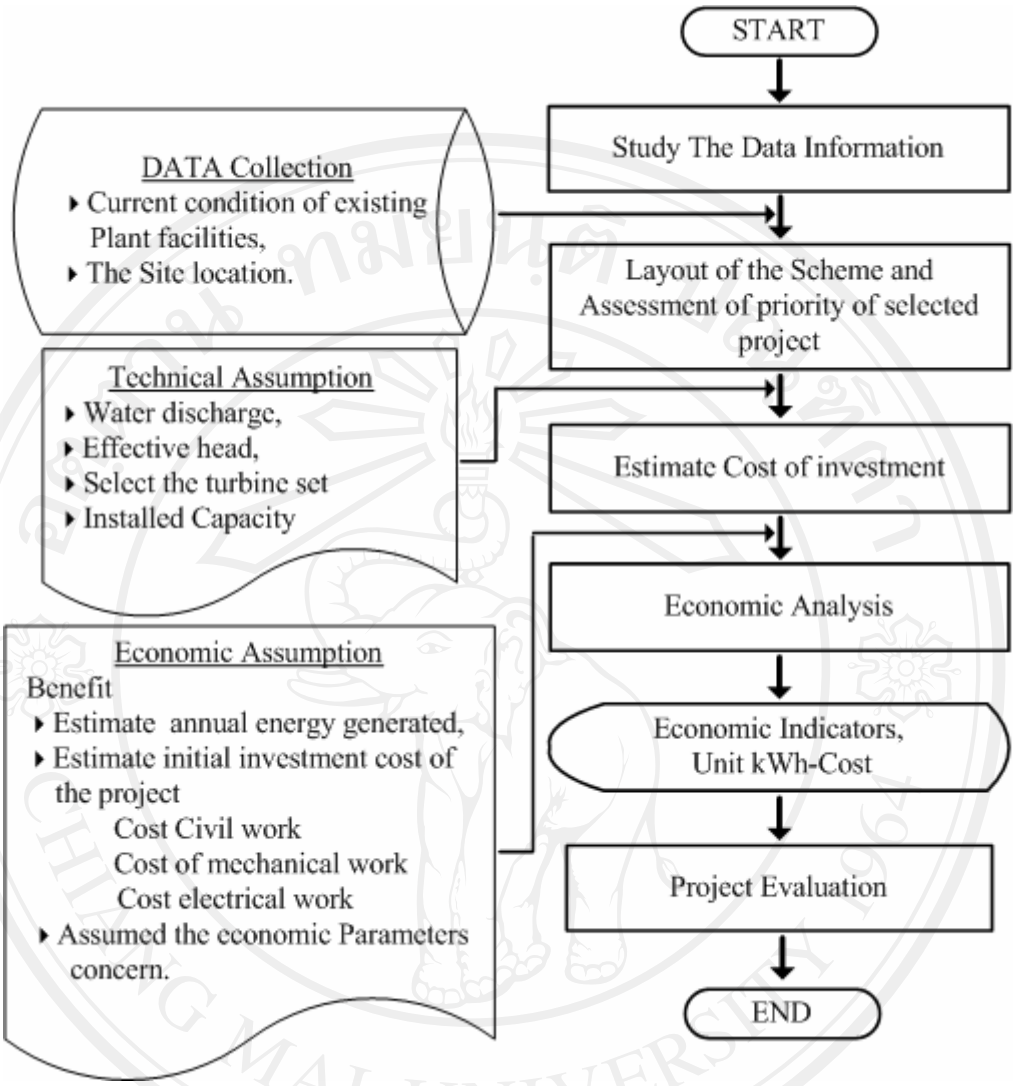

Figure 3.1 The research flow chart.

3.3 Scope of Study

3.3.1 Case Study 1 (Improvement for Nam Mong Micro-Hydropower Plant)

Although, Nam Mong micro-hydropower plant (70 kW) operates with good plant condition, it has an energy surplus in day time and is converted to heat due to the demand that is less than capacity of plant causing its annul energy generated that is less than the design capacity. The objective of this study is to conduct the feasibility study for setting up the synchronous system to connect to the EDL's grid. The energy surplus of 35% of reality energy generation is used to consider for the

benefit of the project. The work of this case is consisted of two main parts that describes by the following :

1) Technical Study

a) The data energy generation plan data was collected,

b) Study the technical feature such as mechanical and electrical part and

c) Select the synchronous system.

2) Economic Analysis

a) Estimate initial investment cost of an improvement of the project such as equipment cost and installation cost. Beside this, the maintenance cost is only considered for the synchronous system. Others activities due to shut down maintenance service are excluded in calculation,

b) Economic feasibility of the project adopts the discount cash flow using the economic key indicators.

3.3.2 Case Study 2 (Development for New Nam Dong Micro-Hydropower Plant)

The small existing Nam Dong hydropower plant has an installed capacity of 1 MW. It electrified to the center area of Luang Prabang province. It is a dam and waterway type which is usually applied to obtain the large water storage and higher water head. The level of intake and tailrace are 603 m.s.l and 486 m.s.l. respectively. Based on this condition, the idea for installation the new micro-hydropower plant (MHP) after the existing plant is more facilitate with out the complicated structure, less of investment cost and also use the natural source with the maximum utility.

The objective of this study is to demonstrate the technical viability and economic feasibility for the New Nam Dong MHP by using the water out flow from the existing small-hydropower plant in.

The work of this case is consisted of two main parts that describes by the following :

1) Technical Study

a) Study the characteristic of water supply capacity for New Nam Dong MHP.

b) Conceptual design for New Nam Dong MHP and the work project of the project is consist of the following work parts :

- Mechanical work include Turbine and its control system, and
- Electrical work include main transformer, transmission line,
- Civil work consist of the intake wall, powerhouse and tailrace and
- Piping work includes layout pipe line and pipe support.

c) Study the energy out put

2) Economic Analysis

a) Estimate initial investment cost of development of the project such as equipment costs and installation cost. Beside this, Operation and maintenance (O&M) cost is considered for the project.

b) Economic feasibility of the project adopts the discount cash flow technique using the economic key indicators.

3.3.3 Case Study 3 (Rehabilitation for Nam Pha Micro-Hydropower Plant)

Nam Pha micro-hydro plant (18kW) was developed in 1998 by the donation of Mini promotion for Local Project (European Union), and under authority of Ministry of Agriculture and Forest of Lao PDR. The main objective of this project is as multipurpose system such as irrigation and electricity supply.

This project is however completely disabled. The objective of this study is then a feasibility study in case of rehabilitation by modification the plant structure, Electro-Mechanical equipments and other necessity to minimize the cost of the project. The study is conducted in the following stages :

1) Technical Study

a) Study the previous technical data of the project such as water flow rate and water head which is used to select the type of turbine and estimate the plant capacity.

b) Study the reality plant condition, and proposes rehabilitations scheme by the concept of simplify plant structure design, easy to operation and maintenance to minimize cost of the project. The work flow of this study is assumed as follows :

- Modify civil structure,
- Change the part of mechanical work such as turbine and control system,

- Change for new electrical equipment such as generator, transformer and control system.

2) Economic Analysis

a) Estimate initial investment cost of rehabilitation of the project such as equipment costs. Beside this, Operation and maintenance (O&M) cost is considered for the project.

b) Economic feasibility of the project adopts the discount cash flow technique using the economic key indicators.

3.4 Commissioning a Feasibility Study

3.4.1 Data Collection

This activity is a very important because it sets up for all other following activities. Documents collected from each hydropower plants included development plan, information, plant location, electricity generation feature. The collected data and documentation were then reviewed and analyzed to determine the present condition of each plant. Their status will be evaluated to determine the level of rehabilitation or improvement on them. Each plant was visited giving a visual review of each facility and its current condition such as civil work, mechanical and electrical equipments.

3.4.2 Study the Power Capacity and Energy Generation

The energy generated is a very important and influence to the Unit energy Cost (Unit kWh-Cost) which it can provide a guide for determining selling price of energy of the project and also to demonstrate the project benefit. Estimation of the energy generation of the project is based on the reality of generation plan of three existing MHP in LPB province and the following parameters are expressed by the equation 2.9 and 2.18 in Chapter 2.

- Installed capacity or power output,
- Total energy generation annuity, and plant factor.

The electricity generated of these project will be sold to Electricite' Du Laos (EDL), the electricity price offered depend upon the import tariff rate from PEA Thailand 0.0563 US$/kWh) [6].

3.5 Economics Study

3.5.1 Estimation Costs of the Project

How much will each project cost? There is no standard answer to the question because costs depend on site conditions and on how much work that prepares for the system. In general, with current technologies the total cost can range from $1,500 to $2,500 per kilowatt of installed capacity, depending on the system's capacity and location for development the new MHP [14]. The costs of each project study will be consisted of two categories such as initial investment cost and operation and maintenance (O&M) costs.

1) Initial Investment Costs

The cost of improvement or development and rehabilitation of these micro-hydropower project is divided into four sections [10] :

a) Machinery

Generally speaking, machinery cost or cost of mechanical equipment. This group includes the turbine, generator and water inlet control vale.

b) Civil Works

This includes the intake, the pipeline, turbine house and machinery foundation, and the tailrace channel to return the water to the river.

c) Electrical Works

The electrical system will involve the control panel and control system, the wiring within the turbine house, and a transformer, plus the cost of connection to the electricity system or connect to the grid.

2) Running Cost

In order to the study an improvement and rehabilitation the existing micro-hydro power plant, it is therefore, focused on maintenance and service. As known, modern, automatic equipment requires very little maintenance. The cost of routine and annual service should be no more than 2.5 % of the capital cost [14] of the scheme. As the machine ages there will eventually be extra cost associate with replacing but should not be occur for at least 5 years.

3.5.2 Capital Growth Factor

1) High economic growth causes high investment. It also affects employment increment and high wage rate which can be seen on economic growth (GDP growth rate) that has been continually expanded since 2005 and expanded 2007 at 7.9 % in year 2007. As a result, it can affect the high employment as well as high wage rate.

2) If inflation rate is high or low, it causes the money value since the most of expenses cost depended on the money value. Financial institutes as Bank of Laos reported the economic growth and inflation rate beforehand to estimate the economic trend for investors and their projects in the future.

Table 3.1 Economic Key indicators of Lao PDR.

Annual percentage change	2003	2004	2005	2006	2007
GDP growth rate	5.80	6.90	7.30	8.30	7.90
Inflation rate	15.56	10.55	7.15	6.85	4.52*

Source : Bank of Laos, 2007.

Note: * The average of inflation rate 4.5% was used for this study.

3.6 Economic Analysis

3.6.1 Economic Assumption

The economic assumption is based on the recommendation from the previous study such as Master Plan Study on Small-Hydropower Plant in Northern province of Lao PDR 2005, and the experience of Electricity generating Authority of ThaiLand (EGAT) study on micro-hydropower project (case study Mea Ngut MHP). Further more, many literatures presented information for development MHP. Therefore, the economic assumption for this study is expressed by the following :

1) Economic project Life

Civil work	20 years,
Mechanical work	20 years, and
Electrical work	20 years.

2) Estimate investment cost of the project is based on cost of the project in the (2005),

3) Short term of Construction by means that is not more than one and a half year period,

4) Operation and Maintenance (O&M) cost,

The principle items in term of the Operation & Maintenance cost are applied annually. They are considered by the following parameters [16],

a) Cost of operation is equal to 1% of direct construction cost,

b) Annual maintenance,

- Civil work cost is equal to 1 % of total cost of civil work,
- Mechanical and electrical work is equal to 1.5% of total cost of mechanical work and electrical work, and
- Transmission system is equal to 1% of total transmission line.

3.6.2 Economic Evaluation

Economic viability of the projects uses term of the economic Net Present Value (NPV), Benefit-Cost ratio (B/C) and Internal Rate of Return (IRR) for evaluation the economic project benefit and costs and the sensitivity will be used for evaluation on each project study. The economic parameter has been standard practice for the major donor such as the World Bank to use i.e. IRR, for evaluation of economic viability of project in Lao PDR [10].

1) Project with an IRR of at least 10% can be considered acceptable,

2) Project with IRR between 10% to 12% may be accepted if additional unvalued (Unquantifiable) benefit are sufficient demonstrated, and

3) Project with and EIRR below 10% are not accepted.