CHAPTER 1

Introduction and Literature Review

1.1 Background of the study

Electricite' du Laos (EDL), the state enterprise company that is responsible for transmission and distribution of electricity in Lao People's Democratic Republic (Lao PDR) has been engaged in an ambitious program of improving the situation by both enhancing access and the quality of electricity service.

The medium voltage (MV) distribution systems are principally of 12.7 kV, 22 kV, 25 kV, 34.5 kV and 35 kV. Those medium voltage feeders are extended to urban and rural areas from 115 kV/34.5 kV/22 kV substations. The low voltage (LV) distribution systems are generally of 400 V/220 V, 3 phase and 4 wires. The summary of electricity demand forecast for average growth rate of energy demand (including system losses) and peak load in period 2012-2015 as seen in table 1. The energy consumption by consumer type was classified into seven categories: industry, agriculture, enterprises, entertainment, government office, residential and embassies [1].

Table 1.1 The summary of electricity demand forecast for Vientiane Capital [1]

		Actual			Forecast			
Descriptions	**Units**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Energy demand sent out substation	(GWh)	960	1,079	1,164	1,595	1,680	1,775	1,889
Energy demand from bills	(GWh)	839	951	1,030	1,359	1,437	1,523	1,627
Energy losses	(GWh)	121	128	134	236	244	252	262
Percentage of losses	%	13%	12%	12%	15%	14%	14%	14%
Peak load	(MW)	197	215	261	322	335	350	375

The existence of EDL has divide six branches in Vientiane capital. Usually, to implement an effective set of technical loss reduction included: re-conductors from small to bigger in lines, added conductor, meters reading data entry errors, installed capacitor at medium voltage and low voltage, power theft, defective meters and etc. The statistic of energy losses decrease and increase depend on implement of losses reduction as seen in figure 1. The energy sent out from substations, received-bills and losses of Vientiane capital or Central in 2011 accounts for more than that of the Northern and the Southern regions as seen figure 2, although it's covering area is relatively small. This means that concentrated investment on this area would provide huge effects on technical loss reduction.

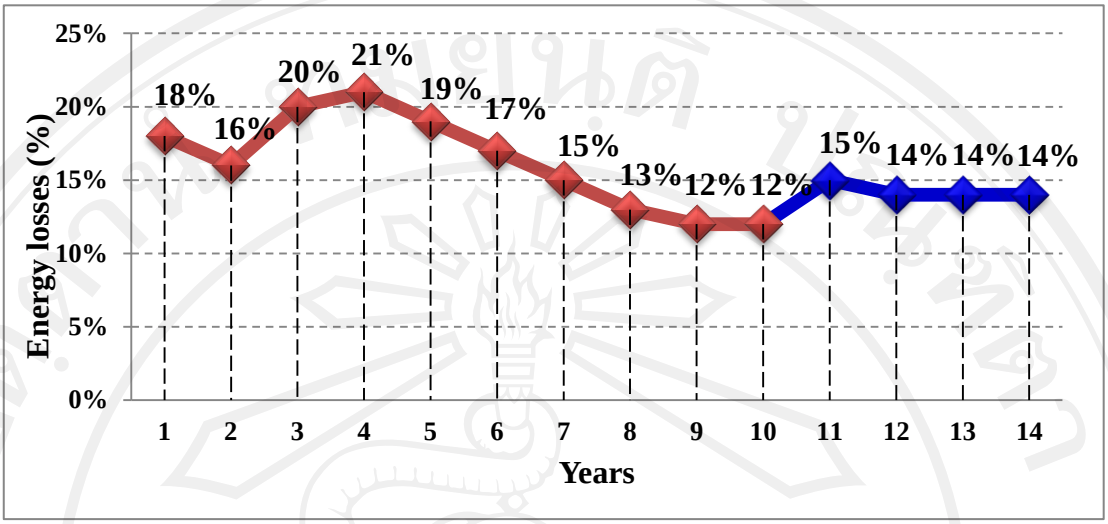
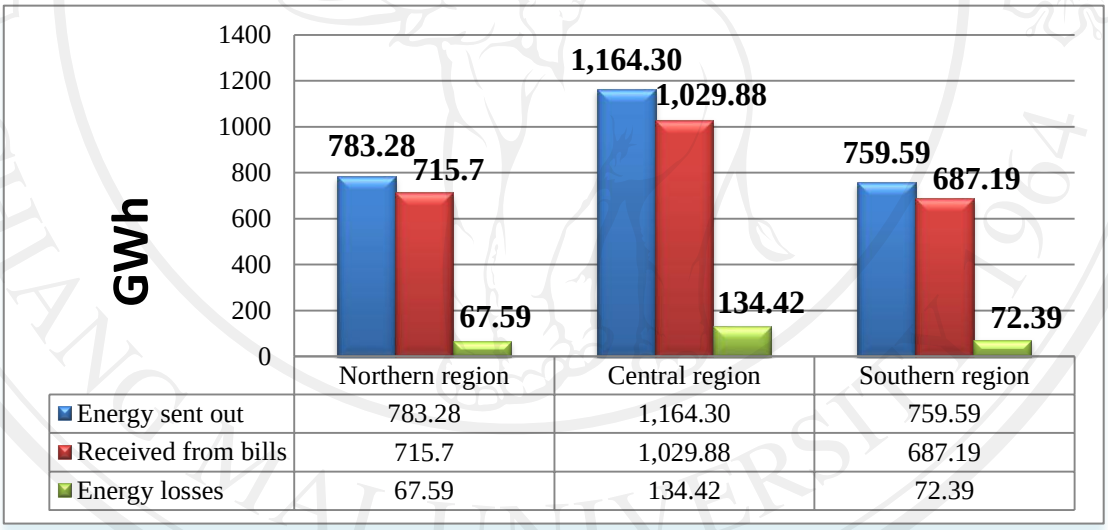


Figure 1.1 The statistic of energy losses for Vientiane capital [1]



	Northern region	Central region	Southern region
Energy sent out	783.28	1,164.30	759.59
Received from bills	715.7	1,029.88	687.19
Energy losses	67.59	134.42	72.39

Figure 1.2 The energy demand of Northern, Central and Southern in 2011.

In Vientiane capital consists of major network systems and largest number of consumers. There are three (3) major supply sources namely: Nam Ngum 1 (155 MW), Nam Leuk (60 MW) and Nam Mang 3 (40 MW). Nam Leuk supply energy 22 kV to Nam Ngum 1.These power plants supply electric energy to Vientiane capital or Central region and some parts to Northern region. The transmission system in this area is interconnected to EGAT's system via the 115kV system for the purposes of exchange power each other (import/exports).The existing substation in Vientiane capital has two types: 115 kV/22 kV has five substations and 22 kV has four substations as seen in table 2 and figure 3.

Table 1.2 Existing substations and feeders in Vientiane capital.

Type of substation	Name of Substation	Feeders
115kV/22kV	Naxaythong	4
	Tha Ngon	4
	Phonethong	6
	Khoksa-at	6
	Thanaleng	7
22kV	Sokphalaung	6
	Sisakhet	6
	Thatlaung	4
	Dongnasok	4
	Total	**47**

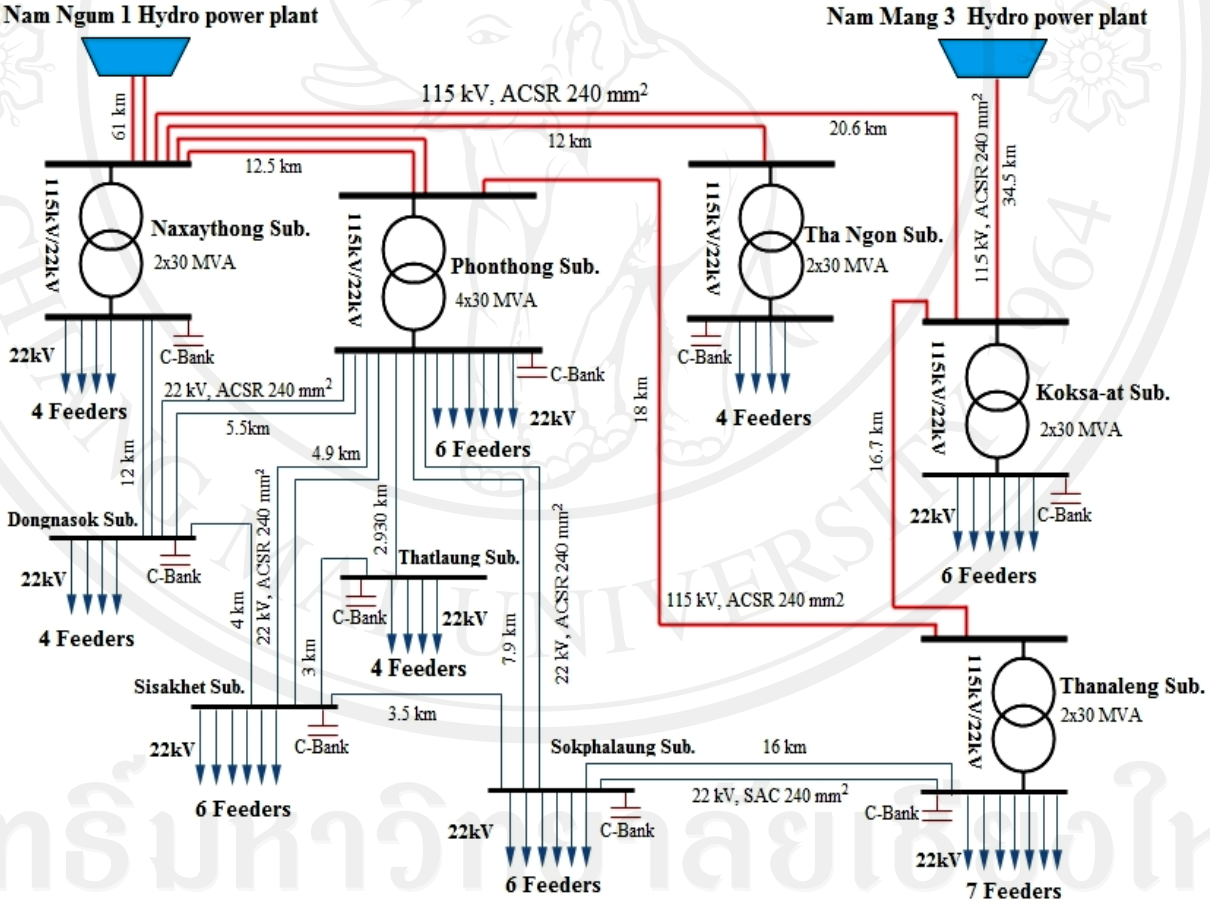


Figure 1.3 Existing single line diagram of the distribution system in Vientiane capital.

1.2 Rationale of the Study

In order to keep the distribution system reliably and continuously supply, the reinforcement of the distribution system is the key issue to be taken into consideration. The purpose is to continuously services and reduces distribution losses. Due to the demand of electricity has been increasing overtime. Replacing or increase installed capacity of the main transformer at each substation is very important issue. On the other hand some facilities have been put in operation long time it needed to check and replace. The energy loss in Laos is higher than other countries in Association of Southeast Asian Nations (ASEAN).

The purpose of this thesis will study line losses in Vientiane capital, after that to find a solution reduce power losses of distribution in Vientiane capital. The concepts of study as seen in figure 4 below.

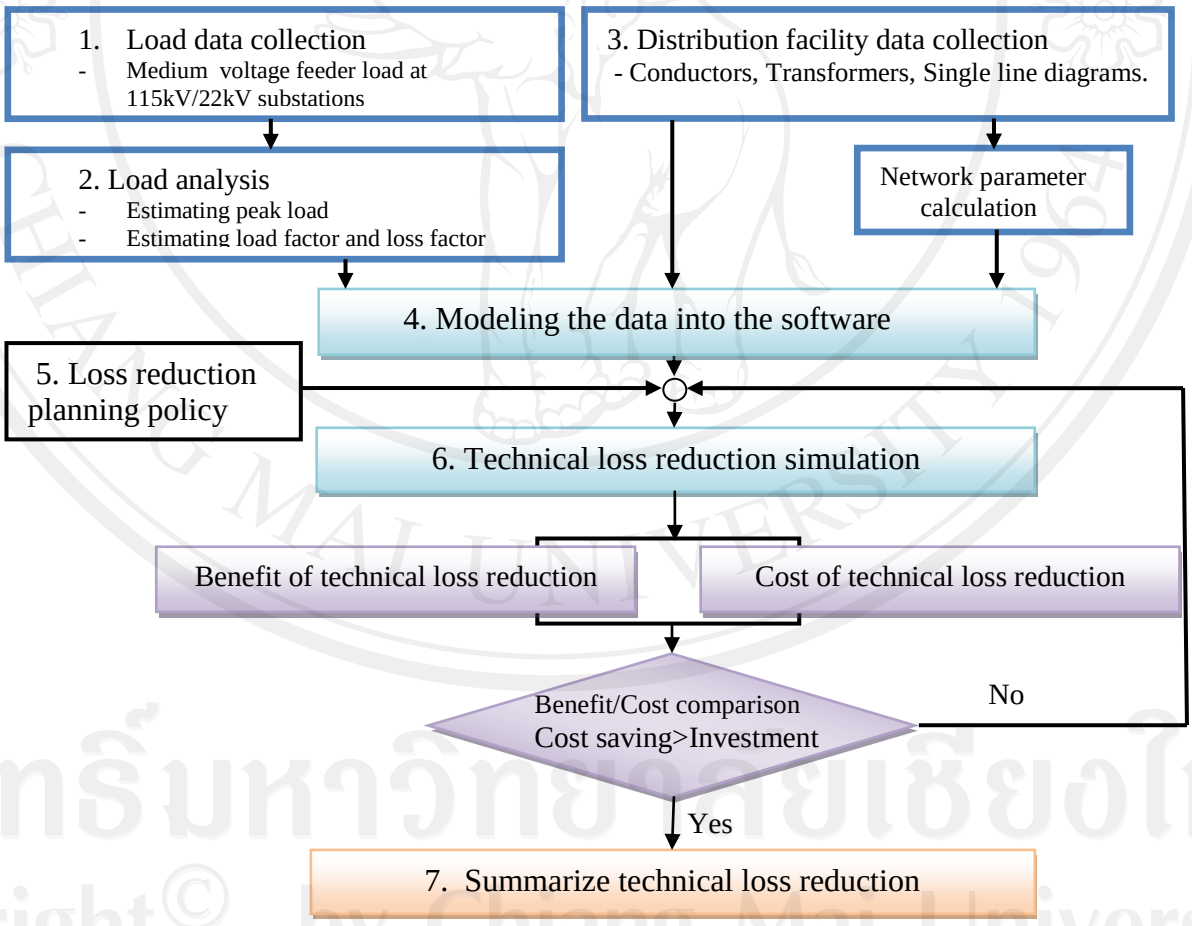


Figure 1.4 Outline of technical loss reduction.

This thesis contains three main parts: background of electric power and preventing problems in the Vientiane capital power distribution system, problem analysis, and results. In order to have a general view of electric power in EDL, the

historical background of the Vientiane capital electrical power distribution system is explained in the first part of the thesis. In historical background we see that when the power network was established and how it has grown in Vientiane capital. In addition, preventing problems of further growth of the system are evaluated. Also the current situation of the system will be discussed. In the second part, 22 kV will be analyzed at the medium voltage level. The evaluation method is such that we will divide consumers in composed of seven types: residential loads, governmental loads, office loads, industrial loads, agriculture load, embassy loads and business loads. The analyses simulate the system with (CYMDIST) software. Finally, the best result is recommended to implement in the Vientiane capital electrical distribution system.

1.3 Objectives of Study

The main objectives of this study are as follows:

1.3.1 To determine the technical losses of distribution system in Vientiane capital.

1.3.2 To evaluate investment with savings cost of the case study and make plans of appropriate technical loss reduction.

1.4 Scopes of Study

1.4.1 Consider technical losses of each feeder in Vientiane capital.

1.4.2 Consider monthly peak load to simulate power losses.

1.4.3 Consider technical losses reduction by following the procedure.

- Correction of unbalanced phase currents (load balancing)
- Power factor correction by fixed and switch capacitors or capacitor placement.
- Leveling of distribution load or switching optimization.

1.5 Expected Benefits

1.5.1 This study can reduce power losses of distribution system in Vientiane capital.

1.5.2 The results can be used as a recommendation to reduce power loss and improve the voltage profile.

1.5.3 This study will provide a plan for installation new network to customers, electricity service and control losses in Vientiane capital.

1.6 Literature Review

Reducing power loss is one of the biggest challenges in electric power utility of developing countries. The electricity demand has been grown rapidly. As a result, a poor voltage profile with higher loss has not reliability if no proper measures are put in place. While the utilities have no sufficient funds for expansion their grid and source, it is necessary to reduce power loss. This chapter will review the literature of power loss and methods to reduce the voltage drop and loss distribution system.

Electricité du Laos (EdL) has requested Tokyo Electric Power Company (TEPCO) to carry out the consulting service, This research was aimed to present the power distribution system loss reduction in Lao (PDR) 2004 [4]. Scopes of study are technical loss reduction and commercial (non-technical) loss reduction of Khammouan and Savannakhet provinces in Southern region of EDL. Technical loss reduction for MV lines by the combination of constructing new lines and switching loads taking an example of the case that was found as the most beneficial scenario applied for MV system in southern provinces, including interconnection and re-conductoring to transfer a portion of the load of Pakbo substation to Kengkok substation and Thakhek substation to Pakbo / Mahaxai substation. Power loss depends on the distance from a substation to a load center and the amount of loads of the feeder. When the large load exists far from the existing substation, the suitable construction of interconnection near the new substation would reduce losses effectively. The commercial losses have been identified as follows: metering, installation conditions need improving and meter inspections need organizing, meter reading, bill collection, theft control, customer control and problem solving.

Farzad Hosseinzadeh, et al. [6] has presented the purpose optimal operation of distribution network is one of the substantial matters in utilities. To achieve this, most of utilities intend to Distribution Automation System (DAS). One of the functions of DAS is fast and low cost network reconfiguration. Distribution Network Reconfiguration (DNR) is used for several purposes. The main propose of network reconfiguration is total network loss reduction. In this paper a new algorithm for reconfiguration of distribution network is proposed. The new algorithm has been test on several networks, including four feeders of distribution test network of Qom city and results are presented which show improved performance of the new algorithm.

Miran Horvat, et al. [7] have presented the proposed of the electricity distribution in densely populated urban areas are in order to increase the reliability of supply, usually designed as meshed networks, though they always operate in radial configuration. Reconfiguration of distribution networks is achieved through switching operations on switching devices of distribution network branches (switching on/off of a branch). It is often the case that the existing configuration is not the configuration with minimum power losses. With the new computer program, developed by our research team, it is possible to find the network configuration that enables operation with minimum losses. The program proposes the best network configuration to the dispatcher, and the latter makes his own decision whether to change the network

configuration or not. Mathematical algorithm for the network reconfiguration is presented in the paper, as well as results of the reconfiguration of the electricity distribution network of the city of Maribor. A simple iterative method for load flow calculation in radial networks is used in our program for network reconfiguration, which is for such networks much faster than well known iterative method for meshed networks, such as Newton-Raphson or Gauss-Seidel methods. The final conclusion of this study is that the investments in hardware and software would be quickly repaid in the new market conditions of the power system operation, which are to come in force in Europe in 1999, when it will be reasonable to optimize the distribution network configuration in real time.

H. Bagheri Tolabi, et al. [8] have proposed to get the distribution network to operate at its minimum loss optimum performance, reconfiguration was been proposed and researched. Considering, however, that optimum performance implies minimum loss, no overloading of transformers and cables, correct voltage profile and absence of phase voltage and current imbalances, network reconfiguration alone is insufficient. It has to be complemented with techniques for phase rearrangement between the distribution transformer banks and the specific primary feeder with a radial structure and dynamic phase and load balancing along a feeder with a radial structure. This paper contributes such a technique at the medium voltage level of distribution network with reconfiguration. This paper introduces a CYMDIST based analysis for the phase balancing/loss minimization problem. An application example of the proposed analysis has been applied to Khorramabad city's MV distribution network.

Ching-Tzong Su and Chu-Sheng Lee, [9] have presented of the stress to elevate overall efficiency has forced utilities to look for greater efficiency in electric power distribution. This study presents an effective approach to feeder reconfiguration and capacitor settings for power-loss reduction and voltage profile enhancement in distribution systems. The optimization technique of simulated annealing (SA) can be relied on to solve the problem efficiently. The merit of the method is that it can provide a global or near-global optimum for feeder reconfiguration and capacitor settings. The objective of this study is to recognize beneficial load transfer, to take the objective function composed of power losses be minimized and voltage limits be satisfied. The proposed approach is demonstrated by employing an IEEE illustrative example. Computational results show that by taking into account feeder reconfiguration and capacitor settings simultaneously, one can minimize losses more efficiently than by considering them separately.

In distribution system, network reconfiguration and capacitor control, are use to reduce real power losses and improve voltage profiles. This paper, a joint optimization algorithm of combining capacitor control and network reconfiguration to minimize power losses while satisfying all constraints is proposed [10]. The computer program finds the network configuration with minimum power losses. This configuration can change open/closed of state switching devices on tie lines. In distribution system, network reconfiguration and capacitor control are used to reduce real power losses and to improve voltage profile as discussed in [11]-[13]. Electrical distribution system can be suitably modified to minimize the real and reactive losses.

It is normally unevenly loaded and hence often needs load balancing, which can also be achieved by suitably reconfiguring the network. The low voltage nodes obtained from the voltage drop calculation is solved by reactive power compensation or optimum capacitor placement analysis module using CYMDIST [14].

A new approach based on the reactive loss in a distribution system to decide the optimal location and sizes of the compensation shunt capacitor. This approach is implemented in two stages. First, a capacitor rated at the reactive power needed at certain busbar is directly connected at this busbar. The second is to connect a single capacitor rated at the total reactive power losses needed by the distribution system at certain bus. This approach is tested on two practical distribution systems with 9 and 34-buses respectively [15]. The general capacitor placement problem consists of determining the location, type and the size of capacitor to be installed in the nodes. The objective is peak power and energy loss reduction while keeping the cost of capacitors at a minimum [16].

Narong Mungkung, et al. [17] have presented of the technical loss analysis in Hatyai of Provincial Electricity Authority (PEA). This analysis uses calculation and PSS/Adept program. For considering the technical loss in distribution system included: transmission line losses, power transformer losses, distribution line losses and low-voltage transformer. The evaluation will be compared technical loss both 4 parts and compared technical loss from calculation and measurement. The theories of the load-flow analysis are characteristic of power system at steady-state to find appropriate work point. The result of technical loss from calculation was at 3.33 compared with loss from measurement which was at 4.23 has 78.72%. So in controlling or decrease technical loss have to select appropriate and correctly method by must investigate both cost and most worthily.