CHAPTER 1

INTRODUCTION

1.1 Background

The new electricity markets consider reactive power support as an essential system support service. In order to procure reactive support competitively from the markets, one needs to quantify the value of the various VAR sources available in the system. The qualification and procurement of reactive power support service is becoming an urgent. From the perspective of generator owners, proper compensation of an individual generator's reactive power output and reserve provides a clear market signal for them to balance the need for real and reactive power generation. From the perspective of transmission administrators, it is critical to recognise and capitalise on the varied importance of different reactive power sources so that the transmission system security and stability can be maximised through a competitive pricing mechanism.[1]-[2].

It is difficult to evaluate reactive support allocations accurately and it is also difficult to computation for reactive power. From the problem above, therefore, studies the allocating reactive power transfer between generators to load are needed. This thesis will use two cases a five-bus sample system and 21-bus system in central I of Electricite Du Lao (EDL) in Lao PDR system [3],[4],[5], The five-bus sample system is shown in Figure.1.1, single diagram of central-1 area system network is shown in Figure 1.2 and Figure 1.3. There are 4 generator buses, 15 load buses and 2 transfer buses.

1.2 Problem Solving Method

Artificial neural network (ANN) is one of the most widely used among the variable paradigms, which have been applied successfully in application studies. ANN models may be used as an alternative method in engineering analysis and prediction. It can learn the relationship between the input parameters and the controlled and uncontrolled variables by study the previous record data. Given an input pattern, ANN produces an associated output pattern. Another advantage of using ANN is their ability to handle large and complex system with many interrelated parameters. Therefore, problem solving method for this thesis will present a procedure for allocating reactive power using artificial neural network with back-propagation algorithm.
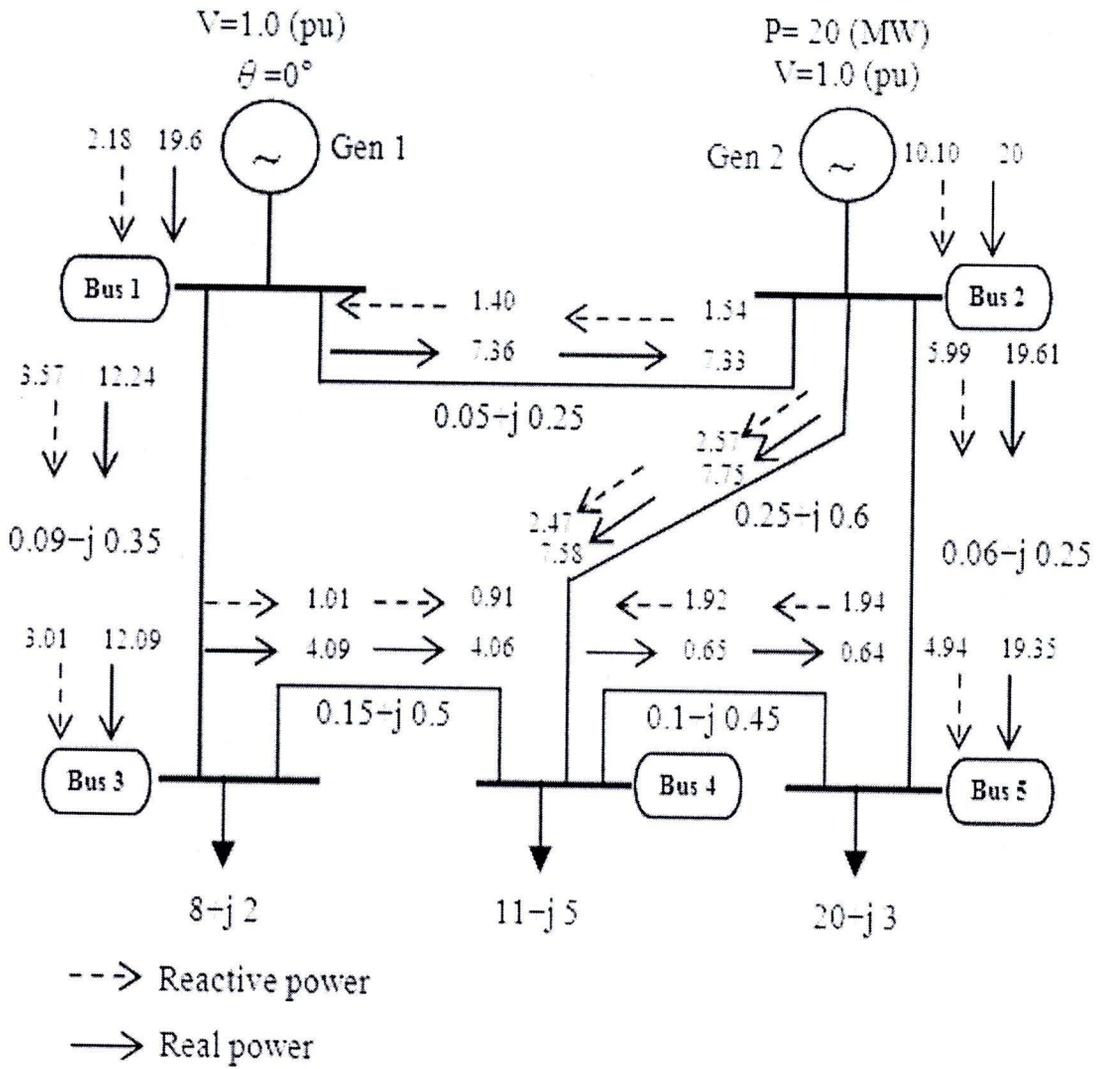
V=1.0 (pu)
$\theta = 0°$

P= 20 (MW)
V=1.0 (pu)

2.18   19.6   Gen 1

Gen 2   10.10   20

Bus 1

Bus 2

3.57   12.24

1.40   1.54

7.36   7.33

0.05−j 0.25

5.99   19.61

0.09−j 0.35

2.57
7.75

0.25−j 0.6

2.47
7.58

0.06−j 0.25

3.01   12.09

1.01   0.91

4.09   4.06

1.92   1.94

0.65   0.64

4.94   19.35

0.15−j 0.5

0.1−j 0.45

Bus 3

Bus 4

Bus 5

8−j 2

11−j 5

20−j 3

- - > Reactive power

⟶ Real power

Figure 1.1 Five-bus sample systems [3]

Figure 1.2 Single diagram of 21-bus system in Central I of Electricite Du Lao (EDL) in Lao PDR system [4]-[5]
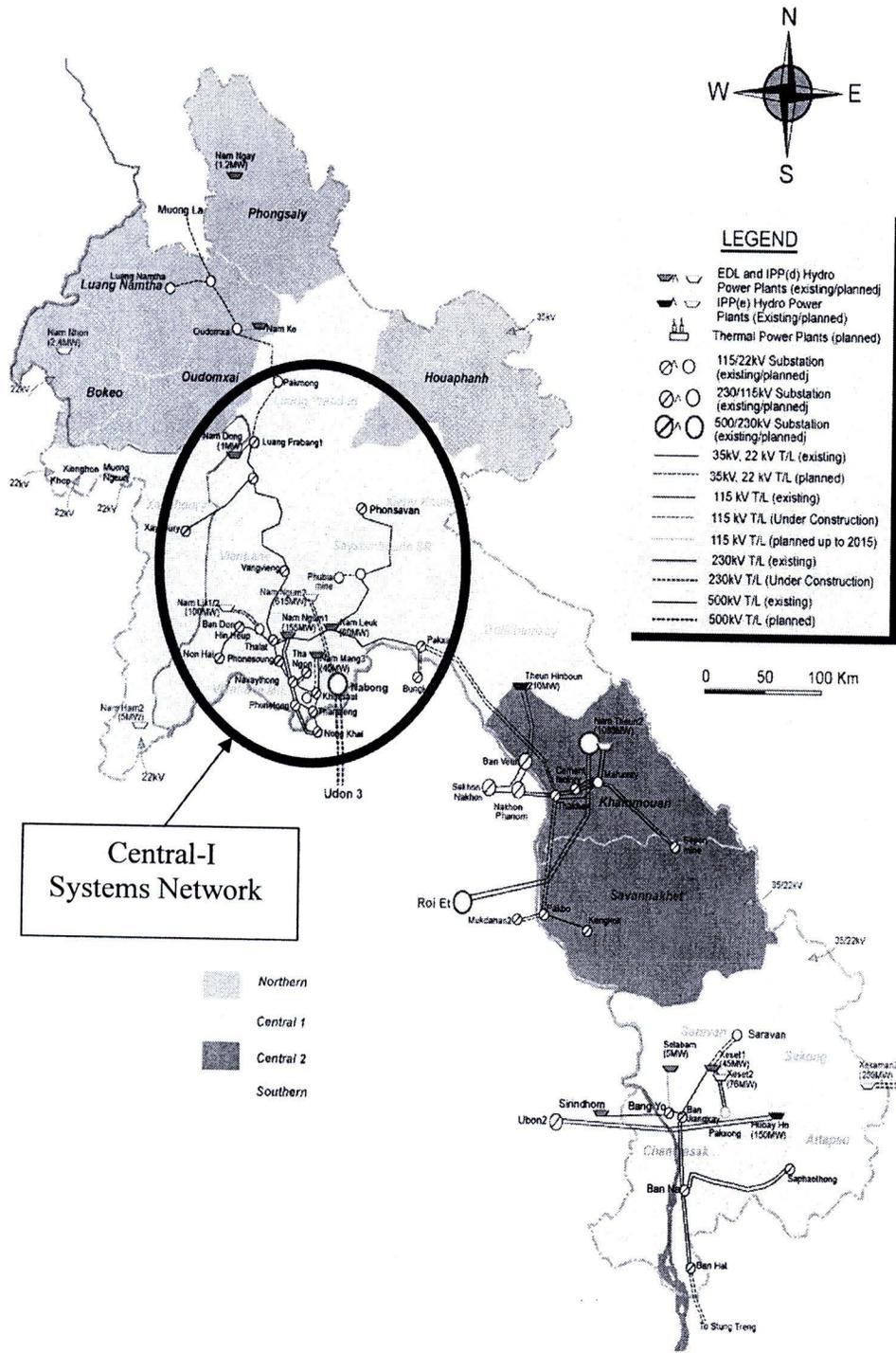
Figure 1.3 Transmission system in Laos (Existing/Planning) [4]-[5]

1.3 Objectives of Study

1.3.1 To find the allocating reactive power transfer between generators and load.

1.3.2 To apply artificial neural network for determining reactive power transfer between generators and load.

1.4 Scopes of Study

1.4.1 To find the allocating reactive power for five bus sample system and twenty one bus system in central I of Electricite Du Lao (EDL) in Lao PDR with artificial neural network and Y-Bus matrix method.

1.4.2 Compare performance between artificial neural network and Y-Bus matrix method.

1.5 Benefits of Study

1.5.1 To attain neural network approach for determining reactive power transfer between generators and load.

1.5.2 The proposed method can apply in planning of generation, transmission and distribution system.

1.6 Literature Review

As electric power industries move from regional monopolies to globally unbundled competitive structures, there is a necessity for separately pricing such components of electricity production and delivery as power generation, transmission, distribution, and ancillary services. Reactive power support is essential for system security and voltage control. A fair and adequate method for allocating the costs may help the market participants make appropriate and efficient investments of reactive power sources. An approach of a reactive power market for procuring reactive power service has recently been presented [6]-[7].

It is difficult to evaluate reactive support allocations accurately. Therefore, it required to use circuit theory, equivalent reactive compensation method, sensitivity indices and tracing methods for reactive power allocation. The use of admittance-(Y) based, impedance (Z)-based or artificial intelligent allocation and pricing methods has recently received great attention as follows.

J. A. Conejo, *et al.* [8] has proposed a procedure for allocating transmission losses to generators and loads in the context of pools operated under a single marginal price derived from a merit-order approach. The procedure is based on the network Z-

bus matrix; although all required computations exploit the sparse Y-bus matrix. One innovative feature and advantage of this method is that, unlike other proposed approaches, it exploits the full set of network equation and dose not requires any simplifying assumptions. The method is based on a solved load flow and is easily understood and implemented.

M.W. Mustafa, *et al.* [9] has proposed a new method to allocate real power loss caused by generators and loads using modified nodal equations. Based on solved load flow results, the method partitions the Y-bus matrix to decompose the current of the load buses as a function of the generators' current and load voltages. Then it uses the modified admittance matrix to decompose the load voltage dependent term into components of generator dependent terms. By using these two decompositions of current and voltage terms, the real power loss allocations caused by the generators are obtained.

A. Parastar, *et al.* [10] has proposed a method to allocate the power loss for transmission systems. The approach method is developed based on the basic circuit theory, equivalent current injection and bus equivalent admittance. For a given power flow, solution is determined using a modified bus admittance matrix which allows the power loss of each transmission line to be expressed in terms of load / generator.

Y.Ping Chen and W. C.Chu [11] has proposed a procedure for redistributing the Z-bus loss allocation in the open access transmission system. The proposed improvement not only identifies the contribution/attribution of the current flow between generation and load, but also figures out the responsibility of loss for each generator-load pair. The redistribution of the transmission loss based on Z-bus method can both closely reflect the relationship between generation and load and flexibly assign the loss to the selected bus.

S.Arunachalam, *et al.* [12] has proposed procedure for ANN based Z-bus loss allocation for pool dispatch in deregulated power system. The procedure is based on the network Z-bus matrix; although all required computations exploit the sparse Y-bus matrix. One innovative feature of ANN based Z-bus loss allocation is that, unlike other proposed approaches, it exploits the full set of network equation and dose not requires any simplifying assumptions. ANN based Z-bus loss allocation is based on a solve load flow and is easily understood and implemented. ANN based Z-bus loss allocation using a feed forward back propagation algorithm has been proposed.

M.W.Mustafa, *et al.* [13] has proposed a novel method to identify the reactive power transfer between generators load using modified nodal equations. On the basis of the solved load flow results, the method partitions the Y-bus matrix to decompose the current of the load buses as a function of the generators current and voltage .Then it uses the load voltage from the load flow results and decomposed load currents to determine reactive power contribution from each generator to load. Then, artificial

neural network is applied to solve the same problem in a simpler and faster manner. The basic idea is to use supervised learning paradigm to train the ANN.

J.Abayateye and A.Seker. [14] has proposed determination of optimal reactive power generation schedule using line voltage drop equations and genetic algorithm. The reactive power generation schedule in a power system determines the bus voltage profile. The available reactive power capabilities of the generators have to be optimally deployed so that bus voltages are kept within specified limits. While applying the standard power flow algorithms, the voltage and real power injection are set for a generator bus. After running the power flow analysis, or while running the power flow analysis, reactive power limit is checked and if violated the voltage setting is removed and the generator treated as a PQ bus. The final reactive power generation schedule is determined by such trial and error procedures. Further the reactive power from the slack or swing bus is left totally free to assume any value.