"I hereby declare that I have read through this report entitle "*Distribution Network Reconfiguration (DNR) and Distribution Generation (DG) Sizing Simultaneously based on Rank Evolutionary Particle Swarm Optimization (REPSO)*" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

Signature : .....

Supervisor's Name : MOHAMAD FANI B. SULAIMA
PENSYARAH
FAKULTI KEJURUTERAAN ELEKTRIK
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Date : 17/6/2014

DISTRIBUTION NETWORK RECONFIGURATION (DNR) AND DISTRIBUTION GENERATION (DG) SIZING SIMULTANEOUSLY BASED ON RANK EVOLUTIONARY PARTICLE SWARM OPTIMIZATION (REPSO)

NUR FAZIERA BINTI NAPIS

A report submitted in partial fulfillment of the requirement for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

I declare that this report entitle "*Distribution Network Reconfiguration (DNR) and Distribution Generation (DG) Sizing Simultaneously based on Rank Evolutionary Particle Swarm Optimization (REPSO)*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any degree.

Signature : .....

Name : NUR FADIERA BINTI NAPIS

Date : 17/6/2014

To my beloved mother and father.

ACKNOWLEDGEMENT

Millions of gratitude and praise towards The Almighty for His blessings and acquiescence that I am able to complete my final year project with ease and comfort. I would also like to address my family as it is for them I lay all my effort in assuring another step to acquire my Degree in Electrical Engineering (Power Industrial). Furthermore, I would like to utter my sincere thanks to all my administrators and fellow acquaintance in Universiti Teknikal Malaysia Melaka (UTeM), especially to my Project Supervisor, Mr. Mohamad Fani bin Sulaima for being the best mentor and for guiding me with such patience and sincerity, also to give me all of his attention and efforts without the constraints of time and still able to give me something critical and creative to developed my way of thinking and mind. Thanks for the encouragement, guidance critics and friendship.

I would like to present my special thank to my panel as they evaluated my project with dedication and enthusiastic, also to my fellow supervised friends, Mohd Fadhlan Mohamad, Siti Noratika Othman, and Murnie Shakilla Shidan for always helping me out with my stress and making my days of working my project fun and educational. Not forgetting the entire lecturer and students in Fakulti Kejuruteraan Elektrik (FKE) from all departments for their constant assisting and sharing of knowledge. Above all, I owe greatest appreciation to Universiti Teknikal Malaysia Melaka for giving me such incredible opportunity to experience a wonderful project working environment in the most sufficient amount of time. During these project times, I believe I have acquired the golden of all knowledge and skills to be used in my journey as an Engineer to be in an Industrial Power as my project complies with my course.

ABSTRACT

The detrimental of losses in the network can be solved by using Distribution Network Reconfiguration (DNR) and sizing the Distribution Generation (DG) concurrently. An energy policy promote the distributed power sources like power competencies, Distribution Generation (DG), power storage devices, and sources of renewable energy, increase the number of Distribution Generation (DG) installations and manufacturing resources, particularly variable as wind, solar, small hydropower and the combination of heat and power. In determining the optimal sizing of Distribution Generation (DG) and identifying the switching operation plan for network reconfiguration, an optimization method which is called as Rank Evolutionary Particle Swarm Optimization (REPSO) has been introduced. The main objectives of this study are to minimize the total power losses in a radial distribution network and to find the most suitable and acceptable size of Distribution Generation (DG). A comprehensive performance analysis has been carried out on IEEE-33 bus system to show the effectiveness of the Rank Evolutionary Particle Swarm Optimization (REPSO) over conventional Particle Swarm Optimization (PSO) and hybridization Evolutionary Particle Swarm Optimization (EPSO) method. The reliability of the proposed method will hope to help the power system engineer in reducing the distribution feeder losses and improve system security in the future by changing the switches status and give optimal size of Distribution Generation (DG).

ABSTRAK

Kemudaratan kerugian kuasa di dalam rangkaian pengedaran boleh di selesaikan dengan mengunakan kaedah Penyusunan Rangkaian Pengedaran (DNR) dan saiz Generasi Pengedaran (DG) serentak. Dasar tenaga menggalakkan sumber kuasa diagihkan seperti kecekapan kuasa, Generasi Pengedaran (DG), peranti penyimpanan kuasa, dan sumber-sumber tenaga boleh diperbaharui, menambah bilangan Generasi Pengedaran (DG) pemasangan dan sumber pembuatan, terutamanya angin, solar, kecil kuasa hidro dan gabungan haba dan kuasa. Dalam menentukan saiz optimum Generasi Pengedaran (DG) dan mengenal pasti pelan operasi pensuisan untuk rangkaian konfigurasi semula, kaedah pengoptimum yang di panggil sebagai *Rank Evolutionary Particle Swarm Optimization* (REPSO) telah di perkenalkan. Objektif utama kajian ini adalah untuk meminimumkan jumlah kerugian kuasa dalam rangkaian pengedaran jejarian dan mencari saiz Generasi Pengedaran (DG) yang paling sesuai dan boleh diterima. Analisis prestasi yang komprehensif telah dijalankan ke atas *IEEE-33* sistem bas untuk menunjukkan keberkesanan *Rank Evolutionary Particle Swarm Optimization* (REPSO) melebihi keberkesanan kaedah konvensional *Particle Swarm Optimization* (PSO) dan *hybridization Evolutionary Particle Swarm Optimization* (EPSO). Kebolehpercayaan kaedah yang dicadangkan akan berharap untuk membantu jurutera sistem kuasa dalam mengurangkan kerugian perantara pengedaran dan memperbaiki sistem keselamatan pada masa akan datang dengan menukar status suis dan memberikan saiz optimum Generasi Pengedaran (DG).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Motivation

An energy policy promote the distributed power sources like power competencies, distribution generation (DG), power storage devices, and sources of renewable energy, increase the number of DG installations and manufacturing resources, particularly variable as wind, solar, small hydropower and the combination of heat and power. Intermittent generation such as wind may lead problems in the grid, and adequacy the physical balance of power. Thus, there are two goals to integrate distributed energy resources and globally: the network management aspect and objective energy market [34]. Resolution for reducing problem caused by output variable intermittent sources is by adding power storage into the system, create more flexibility in terms of supply to minimize intermittency supplies and load changes, and by enhance the flexibility of the intermittency supply in the use of electricity which motivates in doing this research project.

1.2 Problem Statement

Demand for power is increasing day after day in power system as there are increasing in domestic and factories demands which gives an impact to the economic,

reliability and efficiency of the network. This has been a crucial and challenging task to electrical power engineer to give a benefits yet reliable network to the world. In heavy load, when a load current drawn from the sources increased; it will lead to an increased in system losses, also known as distribution losses, which will contributed to an inefficient performance of distribution system [34].

1.3 Objective

The main objectives of this research are:

i. To minimize the total power losses in distribution network system using Rank Evolutionary Particle Swarm Optimization algorithm.
ii. To determine the optimal size of Distribution Generation (DG) using Rank Evolutionary Particle Swarm Optimization algorithm.

1.4 Scope

This research only involve in determining the sizing of Distribution Generation (DG) with initial set of location for each DG for power loss reduction carry out on IEEE 33 bus distribution network system by using Rank Evolutionary Particle Swarm Optimization (REPSO) algorithm in the MATLAB environment.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

The literature review will be divided into four sections which are Distribution Network System, Distribution Generation (DG) Sizing, Network Reconfiguration and previous research finding. Details explanations of Distribution Network System, will be presented in this chapter, while, the importance of DG sizing, the reason for DG sizing in a Distribution Network System will be elaborated in details. Meanwhile, the Network Reconfiguration theory will be discussed future in terms of "importance to reconfigure the networks". While for the related previous work will provided for the findings on Network Reconfiguration for DG sizing to minimize the total power loss while provided the best size of DG for the distribution system using various type of optimization methods in a 33kV distribution system.

2.2 Distribution Network System

In designing the distribution system, three aspects must be considered which are layout, line size, and radial switching pattern. Layout is essentially the distribution pathways either split or re-split from few sources or substation busses to many

customers [1]. Line size mainly involve with the selection for conductor sizes, line types for each segment and number of phases. Radial switching pattern are for determining the normally open points within the network that force an electrical flow into a radial pattern. By considering and analyzing all these three aspects, real benefit can be gain and provided with suitable optimization method.

It is said that throughout the world is experiencing the major restructuring process in electrical power industries in undergoing and adapting with the deregulated market operation in many companies such as generation, transmission and distribution. Fuzzy multiobjective approach presented in [2] which involving deregulated environment for the power loss allocation to consumer connect in radial distribution network.

The distribution network usually comes in radial and the structure is exploiting using various techniques, while in [3] proposed a fast and flexible radial power flow (FFRPF). Power flow program is said an important role to analyze power system. The problem such as the calculation of active and reactive power, line loading and real and reactive losses in certain generation and load conditions, unspecified bus voltage angles and magnitudes are dealt with and obtain through iterative numerical methods for the testing of power system security constraints.

In [4] state that mostly all of electrical distribution systems their main operation is in radial configuration with two common types of switches that are sectionalizing-switches that remain normally closed, and tie-switches that remain normally open. For reducing power loss and increment load balance factor ant colony algorithm (ACA) is used in the study of reconfiguration for the distribution system with distributed generators. Distribution feeder reconfiguration that contributed to nearly minimization of real loss, voltage profile improvement, and overload network relieving is one of the several operational schemes in electrical distribution systems.

There also different types of configuration for distribution networks except radial, which are meshed as stated in [5]. Meshed configuration especially in urban areas for improving the supply reliability which is possibly configure for after power outage restoring the services affected customers by alternative ways of supply. A certain method, switching operation is used in computing sensitivities of state variables while obtaining estimation voltages and power flows in the network.

Power dispatch is manage to balance between the supply and the demand that also consider the DGs variability and loads with introduction of five types of autonomous agents. Multi-agent system (MAS) as proposed in [6] to effectively and dynamically manage the power dispatch.

2.3 Distribution Generation (DG) Sizing

DG technologies act as main vehicles to the contribution of carbon emission reduction, losses and deferment investment for network reconfiguration [7]. DG technologies are classified and categories into two based sources; renewable and fossil fuel. Distribution network that installed DG plays an important role towards best use of existing network infrastructure, as a certain coordinate need to be taken such that early connections do not effectively sterilize parts of the network by constraining the development of other, potentially larger, plant connections. To achieve all of these, the necessary of providing the distribution network operator the best tools, an ordinal optimization (OO) method in specifying the locations and capacities is presented and information provided could be transfer to potential developers in the form of spare connection sites and sizes.

It said that in [8] the important of sitting and sizing of DGs in a distribution system due to its increase in penetration. When a DG is inappropriately installed it may lead to many negative effects towards distribution concerned, such as voltage profile and network losses, and also relay system configurations. DGs benefit in postponing transmission investment, primary energy consumption reduction, and emission greenhouse gases decrease also alleviating global warming, while DG extensive penetration may lead to some risks to the secure and economic operation of power systems.

Benefits that DG-unit application contributed such as power loss reduction, environmental friendly, voltage profile improvement, postponement of system upgrading, and reliability increase had given a significant rise in interest by researchers in [9]. However, it is difficult in practical application of DG. There are several factors that affect

the final optimal solutions obtain such as social, economic, and political. Optimization tool is proved useful in solving different DG-unit problem.

The integration of DG in distribution level not only for normal but had increased to a high penetration levels [10]. The impact of DG can be seen on the voltage stability margin. DG units' location and sizes are determined using optimization tools within certain limits and constraints and the impacts can be seen on voltage profile and voltage stability. DG units are usually connected and work parallel with utility grid and placed depends on resources availability.

As known, the impact on voltage stability in electrical power system depends on the limitations of generation, transmission, and distribution of reactive power [11]. Not only that, but the location and size of DG also alters reactive power flow and paths in radial distribution network also affect the voltage stability. Therefore, the optimization method to identify location and size of DG is proposed for the voltage stability benefits.

2.4 Network Reconfiguration

One of the ways to save energy in a distribution system is by reconfigure the network for loss reduction [12]. However, its nature makes it an inherently difficult optimization problem. Because of the properties of the distribution system which critically links between customers and utilities, the protection and configuration management are control using the sectionalizing switches. It is design to be most efficient during peak load demand, and can be achieved by reconfigure the network according to the variation in load demand.

In [13], network reconfiguration in other words means is the topological structure of distribution feeder is altered, gives impact toward voltage stability during particular set of loads in distribution systems. Voltage stability enhance with new algorithm formulated by network reconfiguration. A certain growing interest for distribution networks in distribution system automation occurred. Distribution system usually configured in radial

by changing the sectionalizing switches to transfer loads from one feeder to another in order to improve the overall operating condition system.

By modifying the network structure of distribution feeder is the task of network reconfiguration. It acts by changing the open/close status of the sectionalizing switches while give impacts towards power loss reduction and overloading of network components. Hence, network reconfiguration is a vital task of distribution automation. Methods used for reconfiguration can be classified into mathematical and heuristic [14].

It is known that network reconfiguration is the process of changing the status of the switches which are designed for protection and configuration management. Therefore, a method of network reconfiguration that gives benefits in power loss reduction and voltage profile improvement by the improved mixed integer hybrid differential evolution (MIHDE) proposed in [15].

Safety of power system is the main task as a power system engineer. The issues that involve a black start which the power systems restore after blackout must be a prior consideration to engineers. Therefore, the main network need to be establish which also restore the loads quickly by a reasonable network reconfiguration, so people don't have to suffer a longer blackout. In evaluating the effect of reconfiguration, the efficiency, network structure is used in subject to restoration constraints. Therefore, improving efficiency also reliability of large scale power systems is proved through optimizing distribution of generation sources [16].

2.5 Related Previous Work

In solving for the optimal distribution generation (DG) sizing as in [17], the version of modified conventional Sequential Quadratic Programming (SQP) techniques is used. SQP incorporate with Radial Power Flow (RPF) to satisfy the power flow equation that is highly nonlinear is the main contribution for the proposed approach. Comparison of performances between Fast Sequential Quadratic Programming (FSQP) and conventional SQP employing the Newton approached is done in order to deal with nonlinear power flow

equality constraints. Proper DG sizing and integrate show that the active power losses is reduced to its minimal.

In [18], the optimal size and location of distribution generation (DG) as sources in distribution system were find using the optimization method of ant colony optimization (ACO) algorithm. In order to achieve the maximum benefits potential of distribution system, obtaining the proper capacity and location of DG is essential. The DG sources can only be turned on or off by the distribution system operator and their power production cannot be change because DGs are consider as constant power sources. The losses and total operation cost are reduced and also the thermal and voltage constraints are eliminated after the DG installation in the network.

In [19], Distributed Generation (DG) is said that to play an increasing role as emerged in power systems. For problem of discrete optimization of fixed shunt capacitor and DGs placement and sizing with voltage and current harmonics, genetic algorithm (GA) is used.

In [20], Distribution Generation (DG) need to be placed and sized carefully to achieve a minimum distribution losses or it will give a negative effect on losses and voltage profile. In achieving the optimum size of DG, dynamic programming was applied. In dynamic programming optimum solution, in accuracy study showed at the optimum solution or close to them at any initial set always converges. While the error in finding optimum solutions is very small depends on dynamic programming choice and convergence criteria's.

Particle Swarm Optimization (PSO) algorithm tested on 15-bus tested system in finding optimal location and size of distribution generation (DGs). Subject to some operating constraints the objective were minimizing total cost systems, power losses and number of DG need to installed. According to simulation results demonstrated, DG in optimum sizing and sitting reduce economic cost. It is indicated that PSO is effective in searching the optimum point and size of DGs on power system network which contributed to improve voltage profile; power losses minimize, and increase power transfer capacity [21].

A result of PSO algorithm applied in distribution network in order to have optimal allocation is presented in [22]. Demonstrated on the effectiveness through numerical

example of proposed algorithm in solving DG allocation is shown. Comparison between PSO and genetic algorithm (GA) were tested at Tehran city distribution test feeder. The results show the superiority of PSO compared to GA in terms of solution quality and number of iterations.

In [23], the distributed generation (DG) integration optimization problem is address using three developed genetic algorithm (GA) in order to minimize the power losses in the system. All the third GA were differentiated by their size and location either each one is given as a fixed value or both. The performances shows that lesser number of DG units in a system wills results to saturate of performances and increasing penetration, let says 3 units of DG in distribution system, the optimal level is 80% rather than 100%. The size and location of DG is solved using the GA optimization while achieve the minimum losses in the system.

The Ant Bee Colony (ABC) algorithm is proposed in [24]. The objective was to minimize power losses of the system and the simulation were conducted on IEEE 33-bus and IEEE 69-bus both radial distribution feeder system subject to either equality or inequality constraints. ABC successfully achieves the optimal size and location of DG and also compared to other method.

In [25], Firefly Algorithm (FA) is proposed in determining the optimal location and sizing of DG. This meta-heuristic algorithm method reacts exactly as the behavior of real firefly which used their flash to interact with each other and send signal. Tested on IEEE 69-bus distribution system gave results about the reducing of power losses while improving voltage profile by installing the DG with correct size and location. FA is compared with GA in terms of performance.

For continuous energy supply and energy management of the distribution system under peak load or over load condition, the real and reactive power services by local devices plays an important role in [26]. A Weight Improved Particle Swarm Optimization (WIPSO) algorithm is proposed and efficiently minimized the power losses in the system also voltage variance and improve voltage profile and system voltage within desired range. The method is expectable accurate in achieve the optimal size and location of DG and capacitor which reduced the real cost and reactive power.

In [27], the importance of optimal placement and sizing DG and capacitor is shown for loss reduction in distribution network. Two methods are proposed, Generalized Pattern Search (GPS) and Genetic Algorithm (GA) in solving for loss reduction. Between the both methods, GPS is said to have faster speed and improved voltage profile and loss reduction than GA.

The influence of distributed generation (DG) towards the changing economical and regulatory environment is emphasized because of its promises to supply reliable and better quality of electric power to consumers in distribution network [28]. Economic Index DG (EIDG) is proposed in solving for optimal location, size and type of DG in distribution system. The two major benefits obtained from the proposed method are large power loss reduction and voltage profile improvement.

In [29], in order to minimize the power losses, cost of active and reactive power in power generation, the optimal sitting and sizing of distributed generation (DG) is determined using two optimization methods that are Genetic Algorithm (GA) and Optimal Power Flow (OPF). But, the methods are divided by two purposes which are GA for sitting of DG and OPF for sizing of DG. Results show that the costs of active ad reactive power were reduced and a power loss is minimized.

A constrained optimization problem is defined in finding the suitable and best optimal location and sizing of distributed generation (DG) [30]. Power losses, VSI, and voltage profile is considered. PSO algorithm is proposed in solving this optimal problem which results in reducing of power losses and voltage profile improvement. The results are compared with GA.

In [31], an improved PSO algorithm with hybrid simulated annealing (SA) is proposed in solving for optimal location and sizing of distributed generation (DG). It is said that when DG is implemented in the network system, the network loss is reduced which give benefits in every aspects. The shortcomings such as long computation time in SA, and slow convergence precision and local searching in PSO, can be solved. Also, the optimal solution with the high converge speed and precision can be achieved with the proposed algorithm effectible and feasible.

Crucial factors are DG size and location in loss reduction has been presented in [32]. Fuzzy EP which involves the fuzzy method incorporated with EP algorithm is applied