I declare that this report entitle Distribution Network Reconfiguration via service Restoration By Using IABC Algorithm Considering Distributed Generation" 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 other degree.

Signature : .....

Name : .....

Date : .....

To my beloved mother and father

ACKNOWLEDGEMENT

First and foremost, I am grateful towards The Almighty for His blessings and mercy for giving me the time and energy to complete my final year project successfully. This project would not have been possible unless with the help of administrators and fellow acquaintances in Universiti Teknikal Melaka Malaysia Melaka (UTeM) especially to the most supportive person, my Supervisor, Mr. Mohamad Fani Bin Sulaima for his excellent guidance, patience, enthusiastic encouragement and useful critiques while completing on this project. It is an honor for me to work with him and may this friendship last forever.

Futhermore, my completion of this project could not have been accomplished without the support of my fellow friends and supervised team who always helping me to cope with all my questions and stress. They always giving me support and encouragement to finish this project. Not to forget, the entire lecturers and students Fakulti Kejuruteraan Elektrik (FKE) who have taught and share their experiences and knowledge with me whether directly or indirectly. I would also like to thank UTeM for giving me an opportunity that i would never forget to experience a working environment which will be useful for me in the road to become a good engineer in the future.

Above all, millions of gratitude I would like to give to my parents, my sister and brother for always be there for me, support me and encouraging me with their best wishes. They are my pillar of strength and it is for them I put all my effort to acquire my Degree in Electrical Engineering (Industrial Power).

ABSTRACT

Distribution network consists of several feeders with many switches. The feeder lines are often cut accidentally by heavy equipments, natural disaster or intentional attacks which causes blackouts along affected feeders. Therefore, by applying service restoration via network reconfiguration, it will able to revive as many loads as possible by transferring loads in inoperative areas to other distribution feeder via changing the switches status and will help to protect the load and overcome blackout to the consumers. Hence, distribution system must be properly equipped and planned so that consumers will get uninterrupted supply of power without interruption due to out of service area. The main idea of this technique is to alter the network topology by changing the switches state on feeders. Therefore, optimization method which is known from foraging behaviour of honey bee swarm called as Improve Artificial Bee Colony(IABC) has been introduced. The main objectives of this study are to restore blackout area distribution network by changing the appropriate switches state on the distribution feeders with proper size of DG while reduce power losses by employing improved ABC algorithm in distribution network reconfiguration. The study has been tested with IEEE-33 bus system by using the simulation in MATLAB environment. Hopefully by this proposed studies which is Distribution Network Reconfiguration with Service Restoration by using improved ABC algorithm will help in securing the network system while increasing the performance of energy supply in the future respectively.

ABSTRAK

Rangkaian pengedaran terdiri daripada beberapa feeder dengan banyak suis. Tanpa disengajakan, garis *feeder* sering terpotong oleh alat-alat berat, bencana alam atau serangan yang disengajakan di mana boleh menyebabkan terputusnya bekalan elektrik sepanjang *feeder* yang terjejas. Oleh itu, dengan menggunakan pemulihan perkhidmatan melalui rangkaian konfigurasi semula, ia akan dapat memulihkan sebanyak beban yang mungkin dengan memindahkan beban di kawasan yang tiada bekalan kepada *feede*r lain melalui perubahan status suis dan akan membantu untuk melindungi beban dan mengatasi bekalan elektrik terputus kepada pengguna. Oleh itu, sistem pengagihan mesti betul, lengkap dan dirancang supaya pengguna akan mendapat bekalan tanpa gangguan kuasa tanpa gangguan akibat daripada kawasan perkhidmatan. Idea utama teknik ini adalah untuk mengubah topologi rangkaian dengan menukar keadaan suis pada *feeder*. Oleh itu, kaedah pengoptimuman yang dikenali dari perilaku mencari makan dari kawanan madu lebah dipanggil sebagai *Improved Artifial Bee Colony* (IABC) telah diperkenalkan. Objektif utama kajian ini adalah untuk memulihkan rangkaian pengedaran kawasan tanpa bekalan dengan menukar keadaan suis yang sesuai pada *feeder* pengedaran dengan saiz DG yang betul disamping mengurangkan kehilangan kuasa dengan menggunakan algoritma IABC dalam rangkaian pengedaran konfigurasi semula. Kajian ini telah diuji dengan IEEE-33 sistem bas dengan menggunakan simulasi dalam persekitaran MATLAB. Mudah-mudahan dengan kajian yang dicadangkan ini iaitu Rangkaian Pengedaran Penyusunan Semula dengan Pemulihan Perkhidmatan dengan menggunakan algoritma IABC akan membantu dalam menyelamatkan rangkaian penyimpanan disamping meningkatkan prestasi bekalan tenaga masing-masing pada masa akan datang.

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CHAPTER 1

INTRODUCTION

1.1 Motivation

As the demand of energy is increasing rapidly and the rise in the environmental concerns, the power system company has to struggle to find the best solutions to overcome the problem related in the increasing power losses in distribution feeder. Moreover, the protection system is very crucial in electrical system, thus, service restoration is absolutely needed to protect load side when there is fault occurs and to minimize blackout area.

1.2 Problem statement

Normally, utility demand need to consider the demands for power and those demands is from domestic and industrial factories which will give bigger impact to them in terms of economic factors. The reason is because, in heavy load, when load current is drawn from sources increased, system losses will also increased, where it also kows as distribution losses [32]. Distribution losses will lead to an inefficient performance of distribution system.

However, distribution network reconfiguration technique has its limitations. If power losses improvement is too great, it will make the solution unreliable. Therefore, we need distributed generation installed in distribution network as to improve the distribution system.Besides that, distribution network consists of several feeders with many switches. The feeder lines are often cut accidentally by heavy equipments, natural disaster or intentional attacks which causes blackouts along affected feeders [6]. So, the need to restore as many load as possible by transferring loads in blackout area to other distribution feeder is the real concern.

1.3 Objectives of research

The main objective of this project are:

1. To restore blackout area via service restoration for distribution network reconfiguration by changing the appropriate switches state on the distribution feeders.
2. To determine the suitable size of DG.
3. To reduce power losses by employing IABC algorithm in distribution network reconfiguration with considering the DG.

1.4 Scope

The scope for this research are to restore blackout area via service restoration for distribution network reconfiguration by changing the appropriate switches state on distribution feeders. Next, is to reduce power losses by employing ABC algorithm in distribution network reconfiguration and also to determine the suitable size of DGs. This scope are carry out on IEEE 33 bus radial distribution network system. Data of the research will be simulated by using MATLAB software.

1.5 Outline of the report

This project which is Distribution Network Reconfiguration with Service Restoration by using improved ABC algorithm is aimed to restore blackout area via service restoration for distribution network reconfiguration with considering proper size of DG while minimize power losses by using an optimization method which called Improve Artifial Bee Colony (IABC) algorithm in distribution network reconfiguration. Basically, this thesis is divided into five chapters which are:

Chapter 1	:	Introduction
Chapter 2	:	Literature Review
Chapter 3	:	Research Methodology
Chapter4	:	Results
Chapter 5	:	Analysis & Discussion
Chapter 6	:	Conclusion & Recommendation

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

The literature review will include the theory and basic principle of the project, review of previous related works general artificial bee colony(ABC) algorithm. In theory and basic principle will divided into three sections which are distribution network reconfiguration, service restoration and also distributed generation (DG). As for the research on network recofiguration by applying DG and service restoration in order to restore blackout area and to minimize power losses will be explained in review of previous related works.

2.2 Theory and Basic Principles

The literature review is mainly to focus on the project title which is Distribution Network Reconfiguration via Service Restoration by using improved ABC algorithm considering DG. This chapter 2 will be divided into three main sections and the section number one are also divided into three sub-section which are Distribution Network Reconfiguration (DNR), Service Restoration, and lastly, Distributed Generation.

2.2.1 Distribution network reconfiguration

Energy distribution utilities are facing problem where there is a demand for more efficient network and that is why network management is needed. One task to involve in this development is by configuring network on distribution feeders [1]. However, it is very challenging process as to face its optimization problem [2]. Most distribution network operates radialy, eventhough there are several interconnecting tie lines available to increase system reliability [3]. Radial network have some advantages than other network because it has lower short circuit currents and simpler switching and protecting equipments [4]. In general, finding a network reconfiguration with minimum losses is a mixed integer non-linear programming problem. The pioneer to propose this problem is Merlin and Back's [5], multiple algorithms have been suggested for reaching optimum or near-optimum of a corresponding objective function.

2.2.2 Service Restoration

The main objective for service restoration is to restore as many loads as possible by transferring loads in out of service areas to other distribution feeders via changing the switches. Distribution feeders consist of several feeders with many switches. Sometimes, the feeder lines are often cut accidentally by heavy equipments, natural disaster or intentional attacks. This will cause blackout along the affected areas. In order to overcome it, the attempt to restore the network, providing power downstream of the affected areas is by network reconfiguration [6]. Lastly, radial system structure must be maintained and zero components overloaded [7].

2.2.3 Distributed generation (DG)

Distributed generation is an alternative ways to solve the ever increasing environmental concerns and demand of energy [11]. DG means integrating small generators in a distribution system in order to meet required level of load demand thereby

improving the voltage profile, increasing lifespan of system equipment, provide reliability and economic benefit such as minimum power losses and energy efficiency [12]. Distributed generation provides backup power during system outages [13]. The capacity of DG is ranging from 15kW to 50 MW. It is importance as it make use of renewable energy as well as non renewable energy. Significance impact of installing distributed generations on voltages, load demand, power loss and system reliability make it as the key issue for distribution system planning in power system environment [14]. DG placement is very important for efficiency of the system.

2.3 Review of previous related works

For network reconfiguration, a proposed study is for loss reduction problem has been made in [15]. It provide a new codification as well as exploring efficient way for implementing operator of recombination to guaranty the production of new radial topologies. The contribution of this proposal is on the codification and how to implement recombination process. But this method cannot be compare to other evolutionary algorithm because it does not clearly shows the benefit of the proposal as most evolutionary algorithm uses test system of small complexity, some data used is not applicable and some has different objective and goals to solve the problem.

In propose project in [16] a complex methodology for operational and short-term planning analysis of distribution system is created. The proposed paper has divided into three main parts which are load estimation, an effective determination of power loss and evaluation on cost and benefit. By referring to this paper, a study of network configuration should be held seasonally to overcome smaller error that can be corrected once a month. The benefit of this planning is that it can contribute to a great cost reduction.

In other paper, the authors [17] has presented a heuristic search approach is developed for service restoration. The purpose is to come up with proper restoration plan after fault had been identified and isolated. A heuristic search algorithm is developed for service restoration following a fault in distribution. With a proper installation of service

restoration will help to obtain efficient result. The proposed heuristic search algorithm will give valuable tool for system dispatcher in conducting distribution system restoration.

On the other hand, the authors in [18] has proposed a review on fault location methods for distribution power system. There are many types of fault location method. And the traditional method is based on customer complaint. By this method, we need to consider the geographic location of customer and the connectivity of distribution network to determine the exact place of fault occur. Sometimes, there are breakdown of power during night where it is hard for the operator to locate the fault. Based on this paper, there are several methods that have been used to locate fault which are impedance based method, travelling wave based method and knowledge-based method. Knowledge-based method can be divided into three groups which are:

- Artificial intelligence and statistical based method
- Distributed device based method
- Hybrid methods

In [19], the paper proposed about service restoration by considering customer priority and Distributed Generation (DG). By this paper, it shows that by applying an improved GA algorithm, the apply strategy of coding chromosome with different restoration situation will shortened the length of chromosome and the most optimum solution can be obtained. By this study, they have improved GA algorithm speed and accuracy. With that, it helps the operator to choose the best solution to restore service in distribution system.

The study in [20], presents a reactive tabu search for service restoration in electric power distribution system. Service restoration is important because it helps to restore faulted area as soon as possible when fault occur in distribution system. Hence, we need fast computational time and high quality of solution to meet customer satisfaction. But, the problem with service restoration is it is combinable, non-linear and constrained optimization problem.

As for the ABC algorithm, many previous papers had been made. Firstly, in [21] it said that ABC algorithm is excellent at exploration but poor in exploitation. Therefore, the have been inspired by JADE (adaptive differential evolution with optional external

archive) to proposed and improved ABC algorithm by using external archive. Twelve benchmark functions has been tested in the experiments. A computational result shows that IABC is much better than ABC and GABC algorithm. The solution provides better convergence speed and accuracy than others. This shows that ABC is poor at exploitation phase. The solution strategy in ABC cannot generate good solution with high probability. Therefore, it needs improvement in IABC which external archive is constructed to guide the search of bees. The best solution that has been gathered is added to the archive.

In paper proposed by Mustafa Servet Kiran and Ahmet Babalik in [22], they propose a selection mechanism for neighbourhood solution in the onlooker bee phase. The better fitness value obtain by employed bees is written in the memory board. Then the onlooker will select the neighbor solution on the memory board. The study was applied on five benchmark function and estimation of energy is calculated. The results show that IABC works better than ABC algorithm.

In paper proposed in [23], they use an improved method of IABC called fast mutation artificial bee colony (FMABC). This method will focus on the onlooker bee phase where during choosing a food source, onlooker bee will use pheromone and sensitivity model in Free Search algorithm to replace the traditional roulette wheel selection model. This study has applied seven benchmark functions and resulted with better performance than ABC algorithm.

In proposed study in [24], they have improved ABC algorithm in scout bee phase. The method use Piecewise Logistic to enhance the global convergence. The experiment is conducted with six benchmark optimization function. The results show that, IABC by using Piecewise Logistic provide good performance compared to ABC algorithm. Throughout researched, it shows that there are many ways to improve Artificial Bee Colony algorithm. The difference is only on the method to improve it whether on the onlooker side or scout bee phase. It provides better and good performance compared to the conventional ABC algorithm.

Next, the objective of the study proposes in [25] is to determine the optimal size of DG, power factor and location in order to minimize total power losses by applying ABC algorithm. In order to proof the validity of the algorithm, radial distribution system is

tested with different cases. As the results, different DG has their own constraint. Therefore, the results obtained is not necessary apply to others. By the result also shows that ABC algorithm is easy to implement and are able to handle complex optimization problem.

In the paper at [26] , the method use is EPSO algorithm in order to find optimal network reconfiguration and also the optimal size of DG simultaneously. The main objective of this paper is to gain the lowest result of real power losses in the distribution network while improve the computational time as well as satisfying other operating constraints. The location of DG has been set at 6, 18, 22, and 29.

For paper in [27], the paper proposes the application of Particle Swarm Optimization (PSO) technique to find the optimal size and optimum location for the placement of DG in the radial distribution networks for active power compensation by reduction in real power losses and enhancement in voltage profile. Optimal placement of DG plays an important role for maximizing the total real power loss reduction in the distribution system with active power compensation. But in practice the best location or size may not always be possible due to many constraints i.e. such size may not be available in the market.

Besides, on [28] it is said that Optimal Distributed Generation (DG) output and reconfiguration are among the well accepted approach to reduce power loss in a distribution network. So the paper proposed a simultaneous DG output and reconfiguration analysis is proposed to maximize power loss reduction. The impact of the separated analysis and simultaneous analysis are investigated. The research used ABC algorithm optimization techniques for all the analysis of DNR and DG. The main contribution of this paper is on the employment of simultaneous analysis for reconfiguration and DG output in order to find minimum power loss. The applied Artificial Bee Colony (ABC) algorithm in this work proves its capability to solve the simultaneous analysis.

The authors in [8], presents a paper on hybrid Hooke Jeeves ABC which is known as HJABC algorithm with intensification search based on the Hooke Jeeves pattern search and ABC. The main objective of their paper is to demonstrate how standard ABC can be improved by hybridization strategy. The proposed method were compared in terms of number of function evaluations, success rate and accuracy. As the result, the proposed

method has shown very reliable performances in most cases. However, the lack of this study is that it does not compare the performance in terms of power loss to shows that the proposed method can be apply in power system purposes.

Next, on [9] the paper proposed to minimize power losses in distribution network by satisfying all distribution network costraint by using ABC algorithm. The proposed methodology is this study has been tested with 33 bus system. The results were compared with Refined Generic Algorithm (RGA) and Tabu Search Algorithm (TSA) and it shows that among the other algorithm, ABC algorithm is the best algorithm in minimizing power losses and has been found satisfying the distribution network constraint.

This is also can be prove with paper in [10], where in this paper, ABC algorithm also able to outperformed the other algorithm in terms of minimizing power losses. Different from study tested in [9], the experiment has been tested with 14, 33 and 119 bus system. This shows that ABC algorithm is truly the best algorithm in reducing power losses and at the same time surpass other method in terms of quality of solution and efficiency.

2.4 Summary

Based on the review, distribution network reconfiguration is important to minimize losses and improve voltage and service restoration helps to restore as many loads as possible by transferring loads in the out of service area to other distribution feeder by changing the status of switches. Appropriate size and location of distributed generation is highly important in maintaining network stability and increasing reliability of the system.

Based on the research that have been done, they are none study produced the same title as this study. Therefore, this study is the one and only that consider distribution network reconfiguration via service restoration by using improved ABC algorithm considering distributed generation. For the next chapter, It will explain further on the methodology and results obtain.

CHAPTER 3

METHODOLOGY

3.1 Overview

Basically, in this chapter, the development of ABC and IABC for distribution network reconfiguration will be discussed. It has been divided by three parts which are mathematical model, development of ABC algorithm, and implementation of proposed method to the network reconfiguration via servive restoration.

3.2 Mathematical Model

As stated before, the main objective of this project is to find the ideal size of distributed generation while minimising the power losses in distribution system. The voltage constraints also took into consideration as to validate that the minimum and maximum voltage will not be exceeded.

The connection and also the reconfiguration of DG in distribution network will be taken into consideration as it will overall affect the direction of power flow in the network. Both techniques are combined with each other to get a minimum active power losses in distribution system. Therefore, minimum power losses can be calculated based on the formulation as follow.

$$P_{loss} = \sum_{t=1}^{Nline} |I_t|^2 \; k_t \, R_t \qquad (1)$$

where;

t = line number

I_t = current of line *t*

R_t = Resistance of line *t*

Nline = total line

k_t = variable represents topology status of line t (1=close, 0 = open) .

The general power system constraints that applied in the analysis are:

a) Generator operation constraint:

$$P_k^{min} \leq P_{dg,k} \leq P_k^{max} \qquad (2)$$

The value of active power generation ($P_{dg,k}$) at DG k (k = 1, 2 ..total DG) should be within P_k^{min} and P_k^{max} which represents the lower and upper bound of DG output, and for analysis involving DG units, the DG sizing are within this limit and must not be exceeded.

b) Power injection constraint

$$\sum_{k=1}^{Ndg} P_{dg,k} < P_{load} + P_{losses}$$ where, Ndg= total number of DG (3)

In the effort of avoiding power injection from DG unit for its main grid (substation), the DG output cannot be more than the total load and the total power losses as formulated below.

c) Power balance constraint:

$$\sum_{k=1}^{Ndg} P_{dg,k} + P_{substation} = P_{load} + P_{losses} \qquad (4)$$

The sum amount of power by DG unit ($P_{dg,k}$) and substation ($P_{substation}$) must be equal to the total sum of power load (P_{load}) and power losses (P_{losses}).

d) Voltage bus constraint:

$$V_{min} \leq V_{bus} \leq V_{max} \qquad (5)$$

The amount of voltage for each bus should be operated as in (5) within the range of 1.05 and 0.95 ($\pm$ 5).

e) Radial configuration constraints:

The network configuration must be in radial form to avoid excessive current flow in the system. Several constraints need to take into account to ensure the radial network is maintained. Few rules have been adopted for the selection of switches. Closed switches that do not belong to the loop, connected to the sources and contributed to a meshed network.