UNIVERSITY OF TURKISH AERONAUTICAL ASSOCIATION
INSTITUE OF SCIENCE AND TECHNOLOGY

OPTIMAL LOCATION OF DISTRIBUTED GENERATION IN IRAQI NETWORK

MASTER THESIS

Husham Sulaiman SAJIR

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

OCTOBER 2017

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Supervisor: Assist. Prof. Dr. JAVAD RAHEBI

HUSHAM SAJIR, having student number 1406030009 and enrolled in the Master Program at the Institute of Science and Technology at the University of Turkish Aeronautical Association, after meeting all of the required conditions contained in the related regulations, has successfully accomplished, in front of the jury, the presentation of the thesis prepared with the title of: "OPTIMAL LOCATION OF DISTRIBUTED GENERATION IN IRAQI NETWORK".

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THE UNIVERSITY OF TURKISH AERONAUTICAL ASSOCIATION
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I hereby declare that all the information in this study I presented as my Master's Thesis, called "Optimal Location of Distributed Generation in Iraqi Network" has been presented in accordance with the academic rules and ethical conduct. I also declare and certify on my honor that I have fully cited and referenced all the sources I made use of in this present study.

HUSHAM SULAIMAN SAJIR

25. 10. 201

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October 2017 Husham SAJIR

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LIST OF ABBRIVIATION

AC	Alternative Current
BE	Biomass Energy
BFS	Backward Forward Sweep
CHP	Combined Heat and Power CHP
COPQP	Causes of Power Quality Problems
CPD	Custom Power Devices
CSO	Competitive Swarm Optimizer
DG	Distributed Generation
EPS	Electrical Power Systems
FA	Firefly Algorithm
GA	Genetic Algorithm
GE	Geothermal Energy
GS	Gauss-Seidel
HE	Hydrogen Energy
HP	Hydroelectric Power
KV	Kilo Volte
Mv	Medium Voltage
MVA	Mega Volte Ampere
MW	Mega Watt
NP	Nuclear Power
NR	Newton Raphson
OLTC	On Load Tape Changer
OV	Overvoltage
PCE	Power Conditioning Equipment
PMU	Phasor Measurement Unit
PQ	Power Quality
PQPs	Power Quality Problems
PS	Power System
PSO	Particle Swarm Optimization
Pv	Photovoltaic
SFLA	Shuffled Frog Leaping Algorithm
SFLA	Shuffled Frog Leaping Algorithm
TE	Tidal Energy
UV	Undervoltage
WE	Waves Energy
WT	Wind Turbines

ABSTRACT

OPTIMAL LOCATION OF DISTRIBUTED GENERATION IN IRAQI NETWORK

SAJIR, Husham Sulaiman

Master, Department of Electrical & Electronic Engineering

Thesis Supervisor: Assist. Prof. Dr. Javad RAHEBI

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In recent years, the distribution generator has become very important and common. The distributed generation (DG) can have positive effects on distribution networks by improving the level of voltages at the consumer end and on the transmission lines by reducing losses in lines that are working at overload. Therefore, to compensate for the leakage of the central plant due to the fixed increase in the load demand recently, the proposed method in this thesis minimizes active power loss in a practical power system and determines the optimal positioning of a brand new installed distribution generator. Iraqi 30 bus-33 KV distribution systems can be applied to determine the performance of a distributed generator. They contribute to the control of the voltage fluctuation to have a positive role in the work of the on load tap changer (OLTC) which is sometimes unable to compensate for the lack of value of the voltages supplied from the source. The main contribution of this work is the introduction particle swarm optimization (PSO) algorithm to simulate a power system using the MATPOWER 6.0 as a tool box and one distributed generation to support the voltage profile. The results were positive as the system was simulated before the generator was entered into the network and the voltage measurement results were Low and after the input of the generator to the distribution network recorded a clear improvement in the voltage profile. The results indicate the efficiency of the particle swarm optimization (PSO) algorithm, which proposes the optimal location of the generator in a part of the Iraqi distribution network. In this thesis, the PSO algorithm and the MATPOWER 6.0

toolbox are applied as a solution to the reactive power dispatch problem. PSO is an optimization strategy that is equipped with an excellent search power.

Keywords: Distributed Generation (DG), Particle Swarm Optimization (PSO), On Load Tap Changer (OLTC)

ÖZET

IRAK NETWORK'TA DAĞITIMI KUŞAK'IN OPTİMAL YERİ

SAJIR, Husham Sulaiman
Yüksek Lisans, Elektrik ve Elektronik Mühendisliği Bölümü
Tez Danışmanı: Yrd. Doç. Dr. Javad RAHEBI
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Son yıllarda, dağıtım jeneratörünün önemi arttı ve yaygınlaştı. Dağıtım jeneratörü (DG); aşırı yüklenme durumunda çalışan hatlardaki kayıpları azaltarak, tüketici tarafındaki gerilimin seviyesini ve iletim hatlarını iyileştirerek dağıtım ağları üzerinde olumlu etkiler yapabilir. Bu nedenle yakın zamanda yük talebindeki sabit artış nedeniyle, merkezi tesisin sızıntısını telafi etmek için, bu tezde önerilen yöntem, pratik bir güç sisteminde aktif güç kaybını en aza indirgemekte ve yepyeni kurulmuş bir dağıtım jeneratörünün en uygun konumunu belirlemektedir. Dağıtılan bir jeneratörün performansını belirlemek için Irak'taki 30 bus-33 KV dağıtım sistemi uygulanabilir. Voltaj dalgalanmasının kontrolünde kaynaktan gelen gerilim değerinin eksikliğini bazen telafi edemeyen yük kademe değiştiricisinin (OLTC) çalışmasında olumlu bir role sahip olmalarına katkıda bulunurlar. Bu çalışmanın ana katkısı, bir alet kutusu olarak MATPOWER 6.0'ı ve gerilim profilini destekleyen bir dağıtık nesne kullanarak bir güç sistemini simüle etmek için parçacık sürü optimizasyonuna (PSO) giriş algoritmasıdır. Sistemin, jeneratörün şebekeye girmesinden önce simüle edilmesi, gerilim ölçüm sonuçlarının düşük olması ve jeneratörün dağıtım şebekesine girmesinden sonra gerilim profilinde belirgin bir iyileşme kaydedildiğinden sonuçlar olumluydı. Sonuçlar, Irak dağıtım ağının bir bölümünde jeneratörün en uygun yerini öneren parçacık yığın optimizasyonu (PSO) algoritmasının verimliliğini göstermektedir. Bu tezde, PSO algoritması ve MATPOWER 6.0 alet kutusu, reaktif güç dağıtım problemine bir çözüm olarak uygulanmaktadır. PSO mükemmel bir arama gücü ile donatılmış bir optimizasyon stratejisidir.

Anahtar Kelimeler: Dağıtılmış Üretim (DG), Parçacık Sürüsü Optimizasyonu (PSO), Yük Kademe Değiştirici (OLTC)

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Distributed generation (DG) in power networks has become increasingly justified. This increase in justification is due to a number of factors such as network load, the development of small-scale power generation technologies, the distribution of energy sources, a reduction of power transmission losses, increased network reliability and increased service quality [1]. Recently, the load demand grows up, this increasing load is resulting in increased burden and reduced voltage [2]. DGs units have been introduced to solve the network problems discussed in the distribution networks. In fact, cases of system distribution are uncontrolled or have no effect on the location and size of the generator to a certain extent. The introduction of distribution generators, Renewable energy, which helps reduce greenhouse gases that are harmful to the environment, is one of the advantages of modern distribution systems [3]. When the generating units are distributed in the distribution networks, they must be protected from overcurrent. In the radial electric lines is usually used recloser at the beginning of the distribution Line and uses the fuse in the sub-lines. Used for distribution lines with DGs (an efficient communication-based over current protection scheme) [4]. The medium and low voltage distribution networks have become overcrowded with the connection of distributed energy sources and sometimes there is an increase in the voltage level above the permissible limit which affects the network equipment such as the on-load tap changer in the power transformers and the remote-control switches. This process is represented by the representation of the distribution network on the Internet as an additional scheme for the management of active networks of distribution networks to minimize the impact of distributed generation and the transformation of distribution networks from negative networks to positive networks [5].

1.2 Impacts of Distributed Generation on Distributed System

1.2.1 Network Voltage Changes

All distribution centers have consumer commitments on power quality or voltage quality and to ensure the level of voltage within the limits allowed at the consumer ±10%. If a DG is connected to the end of the network, the flows in the network will change and the voltage level will change at the consumer. The voltages must be maintained within certain limits [6].

1.2.2 Increase in Network Fault Levels

When a large production unit or several small units are connected to a medium voltage network, the fault stream seen by the relay can be reduced to protect the feeder, which can prevent the operation of the overcurrent relays. This is also called the protection of overload. Theoretically, the problem can be explained as follows. A situation, where a production unit is connected to a medium voltage (mv) feeder close to a primary substation is studied. When a fault occurs at the end of the feeder the fault current consists of contributions both from the grid (I_1) and from the generator (I_2) as shown in figure 1.1 [7].

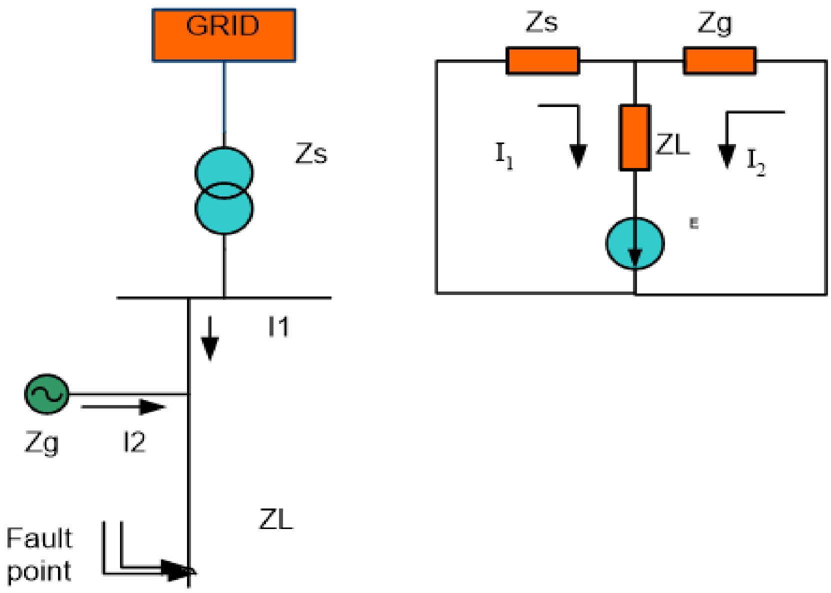

Figure 1.1: Current fault for network.

Where the parameter is shown in table 1.1

Table 1.1: Parameter of network fault.

Zs	impedance of the grid and primary transformer
Zg	impedance of the generator
ZL	impedance of the feeder (line)
I_1	Current from the grid
I_2	Current from generator

1.2.3 Protection

Distributed generation flows can reduce the effectiveness of protective equipment. Customers wanting to operate in 'islanding' mode during an outage must take into account important technical (for instance the capability to provide their own, ancillary services) and safety considerations, such that no power is supplied to the grid during the time of the outage. Once the distribution grid is back into operation, the distributed generation unit must be resynchronized with the grid voltage. Distributed generation flows can reduce the effectiveness of protective equipment. Customers wanting to operate in 'islanding' mode during an outage must take into account important technical (for instance the capability to provide their own, ancillary services) and safety considerations, such that no power is supplied to the grid during the time of the outage. Once the distribution grid is back into operation, the distributed generation unit must be resynchronized with the grid voltage [8].

1.2.4 Stability

The penetration of the DGs units into the distribution system can increase or decrease the voltage margin depending on its operation in the unit, lead or delayed power factors. Currently, most of the DGs installed are usually related to the work in the power factor unit to avoid interfering with voltage regulation devices connected to the system. For this reason, assume that all power plants units are operated by the unit capacity factor. In addition, some facilities allow the DG units to work in the static power factor mode ranging from 0.95 lagging to 0.95 leading, a case study representing this condition is also considered. Protection is necessary to ensure selectivity. Ding units that are capable of providing a large short circuit current may prevent the operation of feeder relays. On the other hand, the overcurrent relays can be applied with the big units based on the inverter that does not feed any short circuit large current [1].

1.2.5 Economic Impact of DG

Because of economies of scale, large-scale centralized power plants are usually more economical than those of the DG, requiring capital expenditures and higher operating expenses. Capital and operating expenses of a different central generation. It should be noted that the increase in the operating expenses of DGs system partly contributes to limited access to remote areas that serve fuel transportation, storage, security and maintenance services that are not affordable and expensive. Moreover, these technologies are often associated with uncertainties in internal return rate, and the financial returns from the export of electricity to the electricity grid are insufficient to support the required funding scheme. DG technologies associated with renewable energy, solar photovoltaic, wind energy, the combined biomass cycle and geothermal energy systems, are particularly competitive with central generation technologies. Thus, the deployment of these technologies involves a long recovery period (typically more than a decade), which makes their investment less attractive. In another technical and technical assessment in the United Kingdom, the solar photovoltaic solar system (PV) has a repayment period of 9 to 11 years [9].

1.2.6 Impact of DG on Transmission System

The effect of DG on the transmission lines is positive in terms of reducing the load on the transmission line and at the same time reducing the losses resulting from the transfer of power from power plants to the consumer [10].

1.3 Motivations

In this thesis, the focus is placed on finding the optimal place for the distribution generator in the distribution system with the power of a part of the Iraqi network using the practical swarm optimization algorithm, since the optimal identification of the generator of the distribution is a recurrent problem and this problem is technically and economically complex. On the other hand, the solution of this problem will return on the network power and transmission lines several factors. First, increase the reliability of the network and the system; secondly, to utilize available capacities such as wind and solar energy as clean energy added to the grid; thirdly reduce the loss of electricity transmission because the generation will be free for the consumer; fourth, reduce the costs of laying new transmission lines and take advantage of existing lines to feed other areas.

Other additional targets, including diversification of power sources, are also to find clean energy sources that can reduce the footprint of carbon dioxide and its negative impact on the climate.

1.4 The Iraqi Network Case Study

The Iraqi high voltage network consists of 423 buses, including 400 buses for 132 KV and 23 buses of 400 KV. And the level of voltage distribution system for the Iraqi networks of 11 KV and 33 KV and because of the recent load loads, a large part of the Iraqi system has become working under the influence of increasing load, especially transmission lines and stations and solve this problem is the distribution of generation. As the Iraqi Ministry of Electricity is an initiative to add to the electrical network small generating units in several cities in order to reduce transport losses and reduce the increase in load on stations. The mechanism of operation of these units depends on diesel fuel and voltage of output 11 KV these units can be inserted through secondary switching stations to a voltage of 11 KV directly or to a voltage of 33 KV by connecting the transfer voltage lever. This contributes to increasing the reliability of the network, reducing the loss of transmission capacity and improving the level of voltages at the consumer. The aim of this study is to analyze a section of the network and find the optimal place for generators, which contributes to reducing the impact of adding to the power system.

1.5 Objective

The objective of this thesis is to analyze the part of the Iraqi network and study the behavior of the distribution network in Anbar city and how to introduce the distributed generation and its impact on the level of voltages and control of inefficient capacity in the network. The main objective of this thesis is to find the optimal place for the distribution generator. So that we get the highest efficiency of the distribution system, reduce the power loss and improve the response of the equipment responsible for controlling the inefficient capacity (capacitor bank) and improve the level of voltages.

1.6 Scope

The scope of this thesis is the study and analysis of part of the distribution system in the city of Anbar, Iraq, which includes the level of voltages and inefficient power and loss of power transmission as well as the introduction of the distributed generator based on the appropriate place using the PSO algorithm and impact on the distribution system. Issues related to generator protection or energy systems were not considered. The main idea of this research, which differs from the rest of the studies, is the use of a part of the Iraqi network and its analysis using MATPOWER 6.0

1.7 Organization of the Thesis

This thesis contains five main chapters. Where the chapter one contains the introduction of the thesis, which showed the effects and the importance of research in addition to the thesis objective.

Chapter two: In this chapter, the introduction of the electrical system, DG definition, and benefit, energy resources which are used for power generation and reviewed the previous studies in the field of use of distributed generation in a distributed system.

Chapter three: This chapter provides an overview of the methodology used in this thesis, and energy quality, problems, and solutions.

Chapter four: This chapter, including charts, tables, and discussion of all results.

Chapter five: Conclusions and Future work.

CHAPTER TWO

BACKGROUND

2.1 INTRODUCTION

The electrical power system generates electricity and deliver it to customers in a three-stage process of generation, transmission, and distribution. Each stage has its own characteristics, as illustrated in figure 2.1 [11].

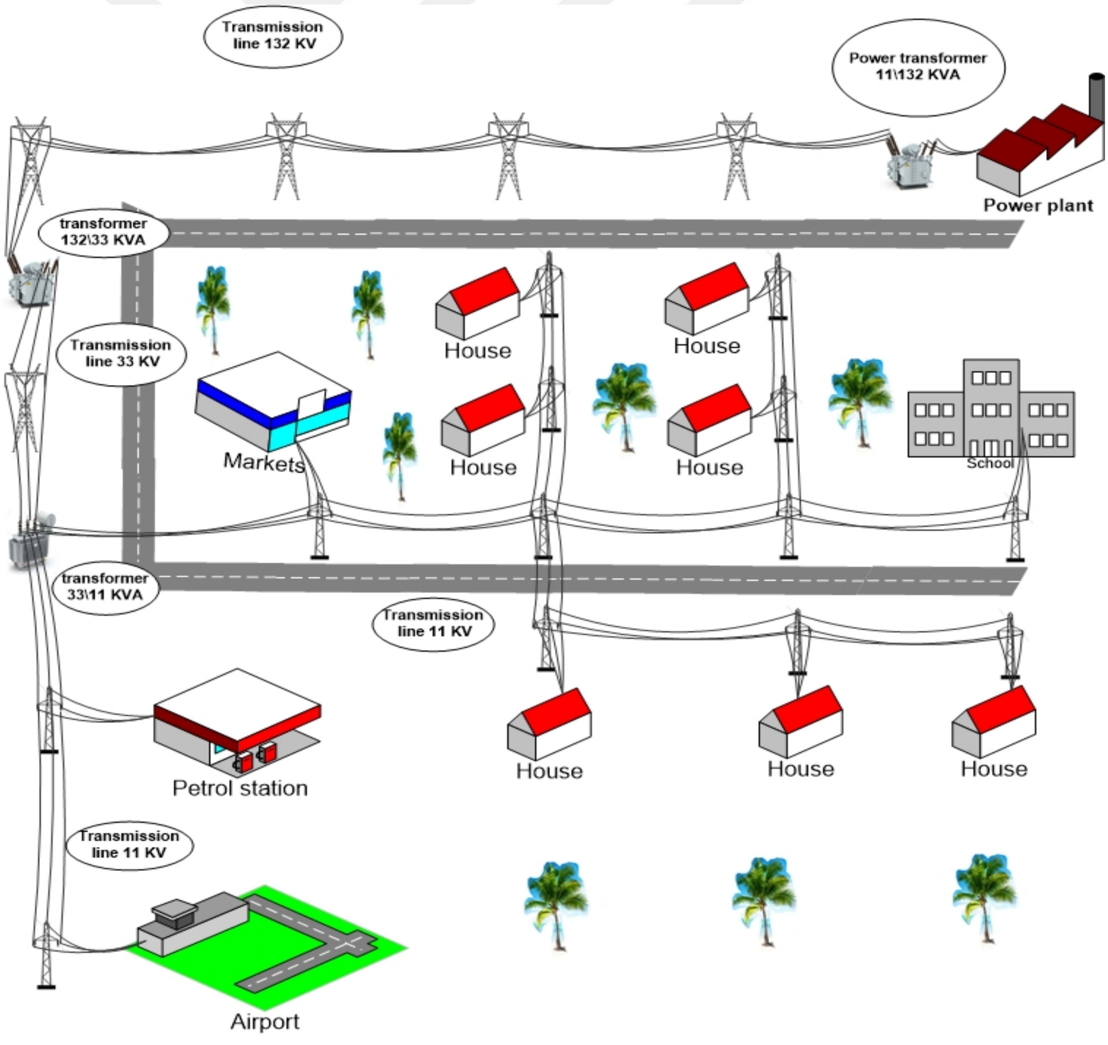

Figure 2.1: Representation of electrical power system.

2.1.1 Generation

To produce electricity must be there mechanical energy, by converted it into electrical energy. The mechanical energy mover, such that steam turbine, wind turbine, hydroelectric, photovoltaic, etc. and the source of mechanical energy depend on a variety factors including time, weather, geography, and economics [12].

2.1.2 Transmission

The transmission types are split into two parts: transmission and sub transmission system. The transmit systems moves energy from generator station to a sub-transmission system through substations at voltage levels of 132 kV or higher [13].

2.1.3 Distribution

Distribution is the last step of providing electricity to customers. However, some of distribution engineers prefer to define the DS as the part of the electric utility system between the distribution substation and the consumers [14].

2.2 Distributed Generator Definitions

Distributed generation is a modern offer in the power industry. In fact, it is new, neither a standard description nor a standard name for doing it have been arranged upon. The various descriptions and names have recently been used in the books. Some researchers define the DG by the capacity of DG products, the authors define DG in the conditions of the technology used. DG also appears under different brands, depending on country. As an example, in some parts of North America, the word Dispersed Technology is used, while in South of America, Embedded generator has been coined [15].

DG can be category according upon capacity.

a. Micro distributed generation the rating between (1 W < 5 kW).
b. Small distributed generation the rating between (5 kW < 5 MW)
c. Medium distributed generation the rating between (5 MW < 50 MW)
d. Large distributed generation the rating between (50 MW < 300MW)

And DG can be category according to technology

a. Modular DG
b. Combined temperature and electrical power
c. Combined Heat and Power (CHP) DG

Usually, the diesel generators were considering distributed generator due to their high reliability and low cost. Diesel generators use as DG However environmental problem and high cost of fuel used. The DG technologies can be broadly divided to renewable energy, non -renewable energy and energy storage. The DG technologies are portrayed in Figure 2.2.

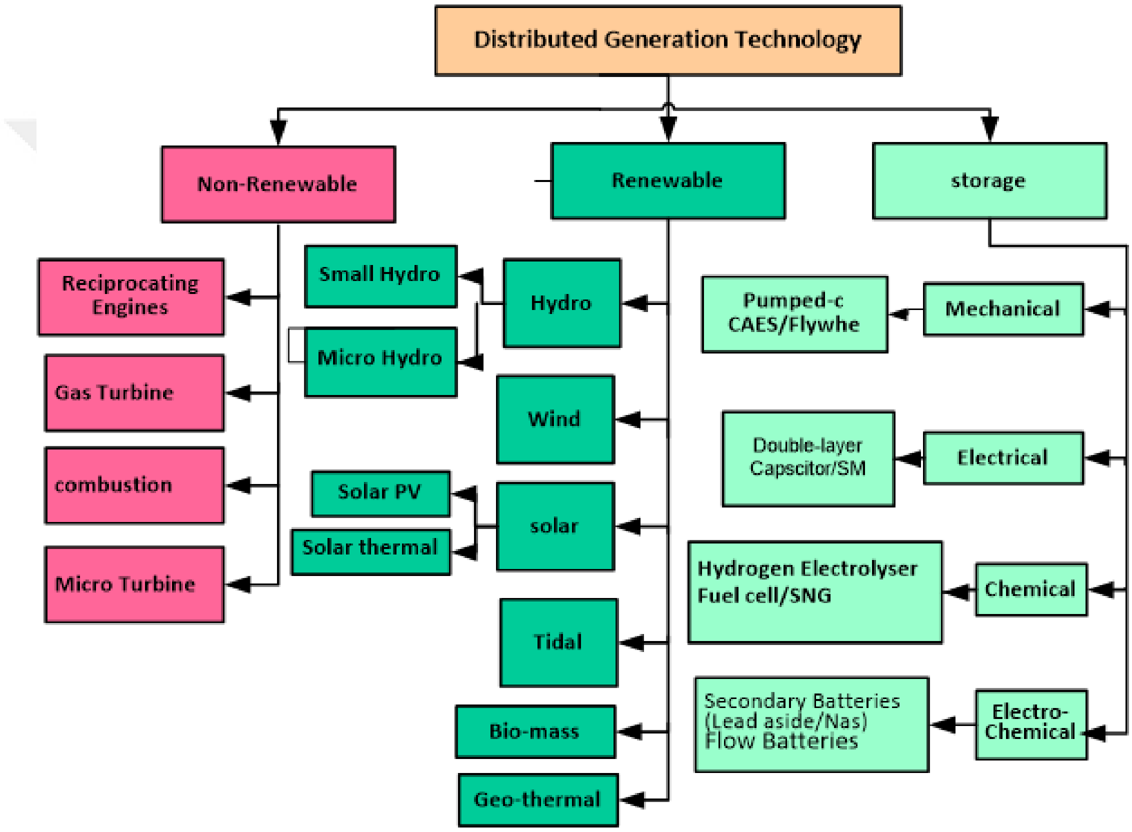

Figure 2.2: Distributed Generation Technologies

2.3 Benefit of Distributed Generation

The major benefits associated with the integrations of DG to electric power networks are as follows [15, 16, 17, 18].

a. Causing a decrease in transmission losses.
b. Enhancing networks voltage profile, expanding substations capacities the load factor due to Injecting real and non-active power by DG models.

c. without requiring increasing existing generation capacity, increases in power needs because of load progress can be developing by DG units
d. DG technology is available in a wide capacity range, providing it overall flexibility for sizes and siting.
e. DG requires a small-time frame to installation.
f. More environment friendly when compared with traditional electrical power plants.
g. DG help the system service in continuity and reliability.

Reactive power plays a prominent role in minimizing the actual electric power loss of the ability networks. The reactive power mail approach can significantly reduce the power factor viewpoint of each bus, thus cutting the overall energy losses. Each year, a value of power is lost on the transmitting line.

The estimations of the USA Energy Details Administration, the yearly losses power in the US in distribution system can reach as much more as 6% [19]. Moreover, almost all this damage occurs at the syndication level. This real force loss not only triggers energy waste and produces extra carbon emission, but also boosts the generation cost.

This thesis summarizes the status of reactive electricity dispatch and present global PSO method. A modified MATPOWER code utilizing PSO algorithm is developed to resolve the non-active power dispatch issue in the power systems.

The expected contribution of this thesis mainly includes the following aspects

1. Applying particle swarm search engine optimization algorithm to adapt the values of control parameters (voltage magnitudes, tap positions, and shunt capacitance) in the power networks to minimize the true power reduction.
2. Identifying the optimum placement of a new installed distributed generator in an existing power system.
3. Introducing MATPOWER6.0 toolbox to compute the power flow and manage the equality restrictions in the reactive electrical power dispatch problems.

2.4 Energy Resources

In this section, we will discuss the available energy sources that are used to produce electricity

2.4.1 Solar Energy

The solar panel uses semiconductors (wafers) that produce photocurrent when exposed to sunlight and are therefore referred to as photovoltaic (pv) cells. The equivalent circuit shown in the figure (2.3) shows the mechanism of the cell's work since the optical diode near the cell surface produces photocurrent as a result of light [20].

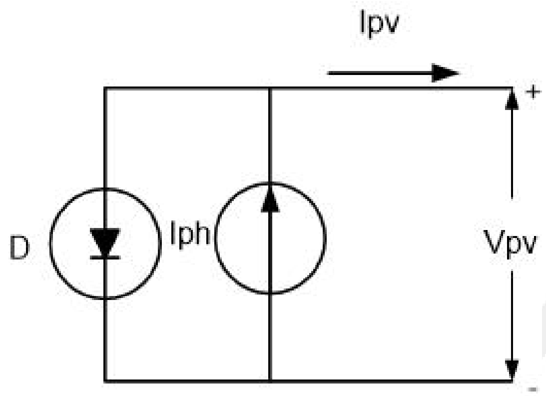

Figure 2.3: The equivalent circuit of a photovoltaic cell [20].

2.4.2 Wind Energy

The first country in the world that used wind energy to produce electric power was Denmark and was in 1890s. The wind turbines (wt) were connected to a mini-generating unit ranging from 5 to 25 kW. After that, the technology moved to America with small capabilities. After 1970s, the cost of producing electric power increased, and the search for sources that produced at lower cost began to pay attention to this source of energy and built large wind turbines around the world to equip the electric power of the consumer [21].

2.4.3 Geothermal Energy (GE)

Geothermal energy is a source of renewable energy and is available in the form of thermal tanks inside the earth's crust. This energy is extracted by injecting water into the tank. Heat exchange is carried out through pipes, water is converted into steam and used in geothermal power plants to produce electricity. This force is used by several countries, including Iceland. The problem of this type of energy is that the continuous use of thermal energy in the tank is reduced by exchange because the plant needs more heat than the heat gained from the ground [22].

2.4.4 Hydrogen Energy (HE)

The world is today finding an alternative to fossil fuels and finding clean sources of energy, such as the use of hydrogen to produce electricity, where there are environmental benefits of using hydrogen as a fuel, including reducing carbon emissions in the atmosphere from the use of fossil fuels in the world. Hydrogen is a widely available element in the universe but it is not freely available but is combined with other gases such as water containing hydrogen and oxygen [23].

2.4.5 Tidal Energy (TE)

The technique of producing electric energy is derived from the tidal energy generated within the oceans and the farms are created from turbines of tidal stream at certain depths within the sea. There is little information available about the accuracy of tidal stream turbines [24].

2.4.6 Waves Energy (WE)

Researchers in 1970 began to study different concepts of the energy of the sea waves and how to benefit from this source of energy and already used this energy to produce electricity. A previous study published that in 2013 there were more than 100 projects to produce electricity around the world. Sea wave energy is one of the clean energy sources [25].

2.4.7 Hydroelectric Power (HP)

Hydroelectric power is used to produce electricity from hydroelectric plants. When water levels vary from side to side, the flow of water leads to the production of large energy used to produce electricity. The visible form of this energy is either dams, large reservoirs or rising upstream or downstream and usually hydroelectric plants are far from the consumer and the need to extend long distance transmission lines. The capacity of these stations varies depending on the flow of water, which is different throughout the year [26].

2.4.8 Biomass Energy (BE)

Biomass energy based on fuel wood and animal manure some countries that do not own local oil and natural gas resources such as Turkey support the growing demand for energy. Countries also have abundant reserves of renewable energy, which can be part of the overall energy supply process [27].

2.4.9 Nuclear Power (NP)

Nuclear power is an important and currently important energy source for power generation. And that the countries bordering on the trend towards the establishment of nuclear power plants. Nuclear power is cleaner and more efficient than coal, which tops Australia's electric power production and has a negative impact on climate [28].

2.4.10 Fossil Fuels (Coal, Oil And Natural Gas)

Coal, natural gas and crude oil are among the main sources of energy supply around the world despite the availability of large coal reserves and low prices compared to idle oil and natural gas, which make coal one of their alternatives to energy production [29].

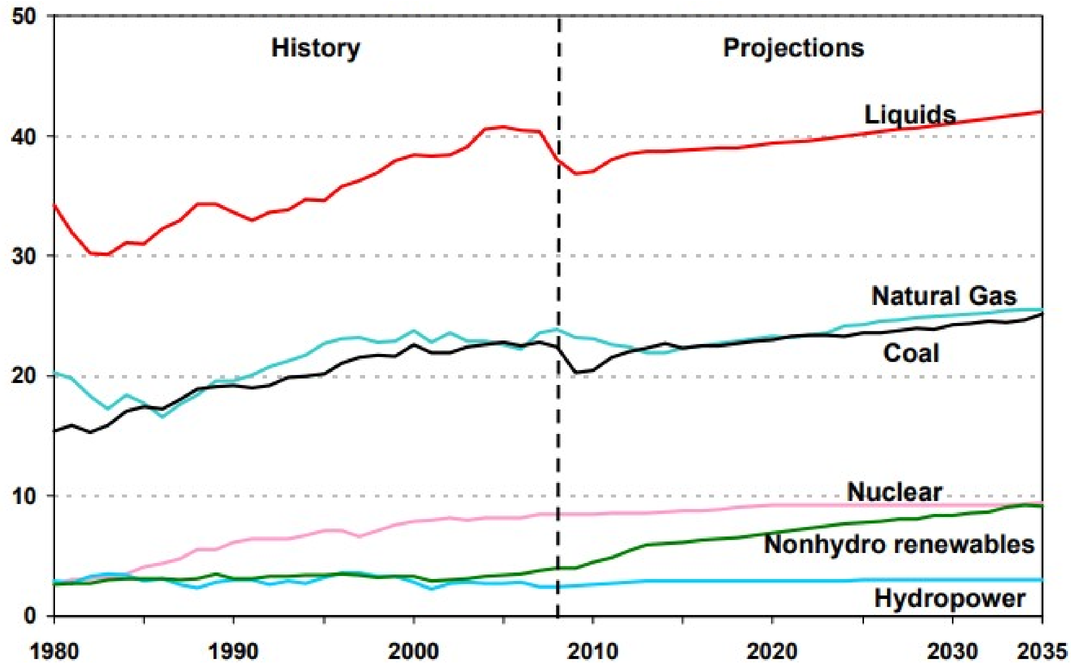

Figure 2.4: The energy sources to produces electricity [30].

2.5 Reactive Electricity Compensation Techniques

a. Single power factor correction.
b. Group power factor static correction.
c. Bulk electricity factor correction

The loads in the electric power system varying all the time, to keep up the power system operating at the regular optimum condition, the reactive power optimization want be consistently conducted theoretically. Nevertheless, frequent switching functions are not feasible in the sensible application. These businesses are not going to bring extra workload to the operator of the network, but also accelerate the old age of the equipment in the power systems. Sometimes the frequent moving over businesses could even threaten the safety procedure of the network. Therefore, the quantity of turning businesses and tap positions changing businesses are strictly limited.

Most of the existing models convert the active model into the stationary model [31, 32]. Suggest dividing a whole day into several intervals and then further divide each interval into several periods. Within each of these periods, the discrete control variables stay constant. Only the ongoing control variables keep changing to reduce the energy reduction. The minimum real electrical power loss during a day is set as the optimization object.

The good thing about this process is that it can decrease the total electric power loss of the device while significantly decrease the quantity of switching operations.

Relying on force forecasting and wind flow speed prediction information, main grid operators can obtain the solutions of the reactive power dispatch at different wind conditions in enhance, and then match these solutions with the true situations to minimize the real power loss.

2.6 Literature Review

Arulraj R and N Kumarappan used (Competitive Swarm Optimizer (cso) Algorithm) to find the optimal location by using several generators in a radial network in addition to get the optimal location it reduction of Ploss and Qloss also improve in network voltage profile also he compared with number of algorithms like (GA IP PSO CSO) with the same data and show that the CSO algorithm was the pest algorithm to find optimal location and optimal size in radial network [33].

In [34], Mohamed Shekeew, Mostafa Elshahed and Magdy Elmarsafawy used different types of DGs units to reduce the loss in distribution network. This method applied to get optimal size of DGs for different types and location. In this method, also did not address the optimal number of generators in distribution network. However, they used genetic and backward forward sweep (BFS) algorithms to solve this problem. The purpose of this paper to study effected of increasing number of two types of DGs units on distributed system considering the voltage limits and the lines capacities. By applied these methods on IEEE 69 buses radial distribution system the researcher proved that the best way of using DGs units were using DGs units of type-2 which supply reactive and active power.

By using exponential PSO algorithm in [35], Sripana Roy Ghatak and Parimal Acharjee used this algorithm to employed recognize the distributed network for two parts weak buses area and healthy buses area. They also focused on the weaker part of network to improve the voltage level and losses redaction. Which is the optimal allocation to put the distributed generation in the network. By restrict the search place of the algorithm just to weaker zone of the system instead of all zone of network. However, they were comparing with other methods such as simple (pso) and adoptive (pso) stay the exponential (pso) is the best method in this paper.

In [36], Prabhjot Kaur , Sandeep Kaur and Rintu Khanna the first focus was on the place of the distributed generators and the second think was the size of the DGs. First steep they run the basic load flow of 33 bus systems was carried out for a radical system network and calculated the line current and bus voltage by using appropriate method was used to carry out load flow analysis.

Ahmed M. A. Haidar discussed in [37], examination the effects of distribution sources and their installation at the voltage levels in the electrical network and the extent of the change in network transactions such as improving the voltage level and reducing network losses. An (PSO) algorithm was used to find the most suitable place for the generator in the network by minimizing losses and improving the voltage level in the system. Although finding the right place for the distribution generator site, the selection of the size of the session remains very important, as the size of the generator can increase the loss of the network if properly selected. Newton Raphson method was also used for the purpose of solving the problem of power flow in the network and for the purpose of finding optimal location by measuring the level of voltages and flow capacity in the node. On the other hand, attention was not paid to financial cost and other benefits.

In [38], C.Nayanatara and J .Baskaran were used genetic algorithm (GA) to find the optimal location and size for the generator of the distribution and to maximize the use of the network analysis to find the weaknesses and to take advantage of the input of the generator at that point and at the same time improve the network parameters such as the level of voltage and reduce the losses of the network to pour full benefit to consumers and reduce congestion. Also, in this study, the selection of the optimal size of the generator is important. If the volume exceeds the required, this leads to a non-linear increase in losses, as the appropriate size plays an important role in determining the losses and increasing the benefit of the consumer. On the other hand, the adoption of this algorithm reduces the size of the problem by providing optimal solutions. Three types of generators were selected: wind turbines, gas turbines and photovoltaic with 30 buses distributed. The result was a significant reduction in losses, the results of this simulation indicate that the solutions obtained were of high quality compared to the traditional solutions. This algorithm used is easy and practical results and is used in large power systems.

Amaresh Gantayet and Sudipta Mohanty used clean renewable energy such as solar, wind, biomass, and hydro energy, which are naturally spread throughout the world. According to the studies, the addition of these types of energy through the distribution networks is the best proportion to the level of transport for a number of reasons, including that the voltage level is converted to the voltage of the distribution network power source voltage, the addition or introduction of the generator near the load is better by reducing the losses resulting from the transfer of energy Long-distance improvement of the level of consumer voltages. One of the benefits of the distribution generator is to reduce a load on the central generator, increase the efficiency of transport lines and reduce losses, increase distribution network capacity, increase system reliability and improve capacity. Also in this study was based on improving the level of the system through the redistribution of energy sources and approved the mechanism of distribution to choose the location of generator distribution in the node. Which were most likely to collapse and thus reduce the burden of the system [39].

In [40], Ketfi Nadhir, Djabali chabane and Bouktir Tarek study and discuss the behavior of the electrical grid at the level of energy distribution and three phases system, which were the first stage without adding generators, And the second by adding one generator for the electrical network, which consists of 33 buses where the losses were reduced to a certain extent, and the third phase, which included two distribution generators and the characteristics of the network was studied using the Firefly algorithm, which was developed in 2007 by the Dr. Xin-She Yang at the University of Cambridge It has the same principles of working with the Swarm algorithm, and also the Firefly algorithm has several similarities with the rest of the algorithms. This algorithm is used in the distribution network to determine the location and size of the generator optimizations and appear more influential than the rest of the algorithms as it is optimal for several subjects. One of the problems facing here is that the distribution system is different from the transportation system which is more radiant and the radial system is a high line obstruction. In this study, the network was analyzed using the first two methods using Firefly algorithm (FA) and it was the best in terms of reducing the total losses and improving the level of the voltages and the second using the Shuffled Frog Leaping Algorithm (SFLA) and was less efficient than (FA)**.**

M. H. Sulaiman, M. W. Mustafa, A. Azmi, O. Aliman and S. R. Abdul Rahim were using in [41], the Firefly to provide solutions for the optimal location and size of the DG. The results showed that the distribution system could be treated by reducing the main line losses and improving the system's voltages profile. In comparison with GA, also to see how much FA can solve the problem it turns out, also to find out the feasibility of solving the problem. It was found that it was good to find the optimal solution where the FA was applied. A distribution network of 69 buses was analyzed for three stages. The results were the first stage without the distribution generator. And then inter one of a distribution generator was inserted and the results were reduced to approximately 60% of the losses compared to the first case. Also has been improved the level of voltages, the introduction of the second generator has reached a loss ratio to 67% of the total loss values, improve the level of voltages and considered the algorithm of FA of the algorithms developed. Which have the potential to solve multiple problems and find optimal solutions.

The main objective in [5], Nikolaos C. Koutsoukis, Dimitris O. Siagkas, Pavlos S. Georgilakis, and Nikos D. Hatziargyriou is to identify the introduction of distributed generators on the network and to include them within the restructuring of the network and whether to bear the introduction of more or not. Because the distribution networks become overcrowded and sometimes suffer from the high level of voltages and thus the network becomes negative and not positive. This study suggests re-representing the distribution network on the Internet as an additional scheme for the performance of active networks of distribution networks to minimize the impact of distributed generation and switching from negative networks to positive networks. Active distribution networks enable control of distribution and load generators, energy storage systems and maintenance of network components such as load voltages and remote-control switches, as well as control of voltages at permissible limits and treatment of the reverse flow of power and overload of distribution generator. The solutions presented in this study are to reduce congestion on the network and reduce the high voltages. This study is dedicated to controlling renewable energy such as photovoltaic and wind turbines.

In [42], Mohammadhafez Bazrafshan, Student Member and Nikolaos Gatsis, the emphasis was placed on the study distributed generation of the that draws energy from the solar PV systems in the radiographic distribution system. Which is a modern energy system. The advantage of these systems is that they are close to the consumer, which prevents the congestion of the distribution system and reduce the loss of transport. But there are some problems in this energy, including weak radiation, which leads to insufficient energy production to satisfy the consumer and also affect the quality of energy. The decentralization algorithm was used to analyze the random program of calculating the flow of power in each node of the radial system studied in this paper.

In [43], Antonio Camacho, Miguel Castilla, Jaume Miret, Juan C. Vasquez, and Eduardo Alarcón-Gallo focus on the addition of renewable sources of energy, namely wind turbines, and photovoltaic, through a three-phase DG inverters and a control test under the influence of the grid fault. On the other hand, renewable energy sources are a good example to be added to distributed generation. The inclusion of such sources leads to a change in the energy production model, which is receiving increasing international attention due to its distinct advantages from traditional central generation systems. One of these advantages is that energy production is near the consumer. Also in this study, a flexible control algorithm is used to cope with different types of voltage fluctuation because the high performance of the control schemes is the basis for the proper operation of the DG systems, especially in light of the network fault. The proposed voltage support control scheme has the following advantages: 1) Flexible support the grid voltage; 2) Increase positive or decrease negative voltage sequence, and 3) Clear the phase jump, which is a powerful tool for voltage support. A detailed analysis has been developed in order to theoretically describe the behavior of the proposed voltage support control.

Juntao Chen, Student and Quanyan Zhu presented a PMU-enabled distributed algorithm was proposed for the purpose of determining quantitative strategies for renewable energy generation in micro grid networks. The objectives of this algorithm were realized by applying them to the IEEE 14 bus system. Three systems have been selected for generating electricity wind energy, solar energy, and geothermal power. They were connected to a micro grid. If an open circuit fault occurs on a transmission line connecting the network buses, this does not affect the supply of the load power because the energy flow is moving from one bus to another and will be activated by applying this algorithm, the generation will increase in that Bus to achieve balance and stability in the smart grid. Using renewable energy technology such as solar, wind and geothermal power, it has an important role in reducing greenhouse gas emissions and is there before able to mitigate the climate [44].

In [1], R. S. Al Abri, Ehab F. El-Saadany, Senior and Yasser M. Atwa present potential for all renewable energy resources and demand for pregnancy as vital factors to be considered to support the stability of network voltage. On the other hand, this paper proposes the method of the average voltage indicator to determine the size and location of the distribution generator taking into consideration the voltage stability margin with all the operating conditions of the system in order not to exceed the voltage of the approved voltage bus and to stay within the voltages level. This is the first part of the study. Section II deals with the effect of DG on voltage stability. Section III Implement a method of selecting the appropriate bus to connect the DG. The following figure shows how well the voltages are improved with the increase in load demand.

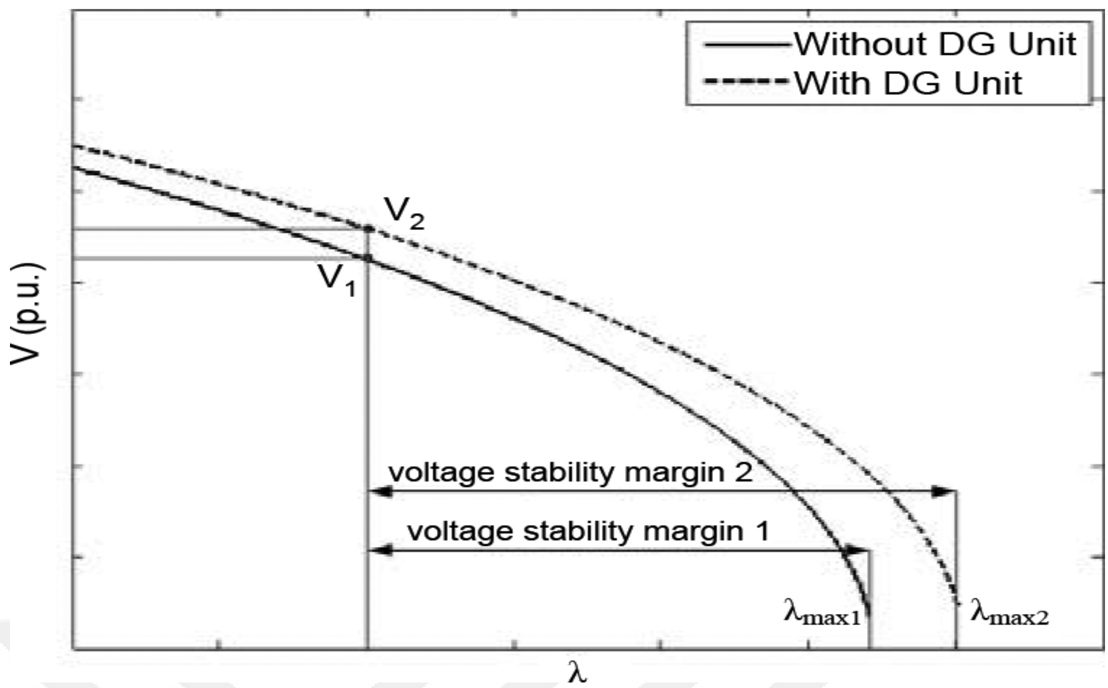

Figure 2.5: Impact of a DG Unit on maximum loadability and voltage stability level.

The x-axis represents λ, which is the scaling factor of the load demand at the certain operation point. Where λ Variables from zero to maximum scale (λmax).

λmax is the real power injection from DG unit. the normal operating point of the voltage increases from V1 toV2 and at the same time the maximum loadability increases from λmax1 to λmax2[1].

$$P_i = \lambda P_{o,i}$$
$$Q_i = \lambda Q_{o,i} \tag{2.1}$$

2.7 Summary

From previous studies, it is found that many solutions and optimization algorithms have been employed in order to solve the problems of losses and voltage level in the network. Some of them have been developed the algorithms to give a more efficient solution. Many constraints have been used in the various studies such as generator location, loading effect, transmission line losses and the voltage level. From these studies, we found that many optimizations algorithms gave global solutions and have proved that.

CHAPTER THREE

METHODOLOGY

3.1 Global Optimization Methods

In most cases, the objective functions in nonlinear optimization problems are not convex. Traditional optimization methods (such as gradient-based approaches) can only find local optimal values. Moreover, the results from traditional optimization methods often have strong connections with the initial guess. To overcome these problems, global optimization methods are suggested in this thesis.

Global optimization methods can only guarantee to achieve acceptable solutions. Usually, finding the global optimal results will take plenty of time and resources. Sometimes it is not profitable to do so. If the improvement is insignificant, then it is

Probably a bad deal to take the time to find the globally optimal solution. Therefore, if the result is very close to the global optimal solution, it can be viewed as an acceptable solution.

Global optimization methods, some concessions have to be made (for instance, increasing their objective function values in some iterations) to allow potential solutions to escape from the local optimum. Most of the time, there is no way to determine if a global optimal value is already achieved or not, so global optimization methods usually need to take plenty of iterations without bias. This requirement will in turn force the scheme of the global optimization methods to be as simple as possible.

3.2 Power Quality Definition

Power quality (PQ), voltage quality is the ability of the equipment or the system to operate satisfactorily in an electromagnetic environment without the introduction of electromagnetic interference to any extent in that environment [45].

The principle of electrical power quality can be explained in a number of ways, but here it is generally understood that the consumer obtains high-quality electrical energy and without any distortions. This means that the voltages are constant in value and frequency.

Depending on whether electricity is consumed or supplied, term power quality can be again being viewed in two different perspectives. From the supply point of view, it can be referred as the ability of the generator to generate electricity at 60 or 50 hertz (Hz) with the Little or no variation, while of the transmission and distribution point of view, it refers to the ability of the voltage staying Within an acceptable range with an increase or decrease of (10%).

$$V_{min} \leq V \leq V_{max} \tag{3.1}$$

V_{min} =0.95 pu

V_{max} = 1.05 pu

V= Voltages at the consumer

Researchers like Roger Dugan, Wayne Beaty and Mark McGranaghan, they define power quality as any deviation in frequency, current and voltage that would result in malfunction or failure of end user or utility equipment.

In general, the concept of electrical power quality means an assessment of electrical energy as a product based on specific indicators. These indicators are methods or Basic means which we can assess the efficiency of electrical power networks starting from transport networks and ending for distribution networks for end consumers.

Electrical power quality is very important for optimal performance of electrical equipment and appliances for consumers. electrical power quality is related to the shape of the wave, which is determined by the following factors (amplitude, frequency, harmonics, symmetry of 3- phases system, voltage regularity) [46].

Technically, the power quality is the rate of output of the output voltage and current. As the current is difficult to control and determine the quantity, the controlled capacity can be controlled by controlling the voltage level. Therefore, the standards in maintaining the energy quality are dedicated to maintaining voltage supply within certain limits and problems They are faced with two kinds [47].

3.2.1 Overvoltage

The overvoltage (OV) is an increase in the average square root of the AC voltage more than 110% of the power frequency for longer than one minute and usually the voltage increase is due to [47].

1- Switching load (take out a large load of the system or the operation of bank condensers).
2- Disruption of system voltage regulation or voltage controls are insufficient.
3- The voltage changer settings in the transformer (OLTC) are incorrect resulting in increased voltage.

3.2.2 Undervoltage

Undervoltage (UV) represents a decrease in the square root value of AC to less than 90% of the power frequency value for longer than one minute and the result is [47]:

1- Load switch (insert a large load of the system)
2- Low source voltage so that the equipment is not capable of bringing the voltage back into the load.
3- Increasing the rolling load of the design capabilities level.

3.3 Need to Energy quality

There are many factors that triggered the need to prevent and to solve power quality problems. These include the deregulation of the power industry, Increased use of hardware that generates problems in the quality of electrical power, increased use of sensitive equipment and the increased in power system(PS) interconnectedness. All of the factors listed have an impact on the ability of utility companies to compete with each other, to keep existing customers and get new ones at the same time.

It is also a well-known experience that poor power quality has a negative effect on system and equipment. Therefore, to some extent, the success of the consumers or the end user in his or her business depends on the utility company, because the utility company can cause the end user disruption in his day to day productions. Therefore, the need to continuously assess a supreme quality of power is of utmost important in order to avoid such effects [45].

3.4 Power Quality Problems Types

In order to resolve all the problems and fluctuations of the electric power, it is necessary to understand and identify the types of fluctuations that occur in the electrical grid. For describe and understand the different types of power quality problems, effects and cause. Power quality problems are easy to determine by varying the nature of the basic components of the sine wave, sine wave for the voltage, current and frequency [48].

3.5 Causes Of Power Quality Problems (COPQP)

Some typical actions or disturbances on the electrical power systems (EPS) which cause power quality problems (PQPs) are listed below:

a. Operation of non-linear loads.
b. Malfunction or damage in cables and transformers electrical.
c. Lightning and natural phenomena.
d. Start-up or switching of large loads e.g. motors.
e. Energization of transformer and capacitor bank.
f. Wrong maneuvers (Connection) in distribution substations.

Although all the disturbance mentioned above are concern in the context of power quality, but still there is no doubt that the most problematic issue is the occurrence of faults, which is the main concern of this work. In the occurrence of fault, there will be a voltage variation at different points of the system which differs in both magnitude and duration, depending on how far is the point from the fault location, the procedure of fault clearing and the system impedances [49].

$$P = \sqrt{3}VI\cos(\theta) \tag{3.2}$$

3.6 Solutions to Power Quality Problems

Various methods of preventing and solving power quality problems had been reported in many literatures such as [46]. The solutions in the literature include:

a. Reducing the effects of PQ problems on sensitive equipment.
b. Use of custom power devices (CPD) and power conditioning equipment (PCE).

c. By analyzing the symptoms of the problem and determining its cause, after that must solve this problem.

In this section only the first two approach of solving and preventing PQ problems would be discussed. Nevertheless. In the following sections of this chapter, 0ne of the most representative heuristic global optimization methods (particle swarm optimization) is introduced. This global optimization method can be easily programmed and is well suited for solving reactive power dispatch problems [50].

3.7 Particle Swarm Optimization

Scientists have created a number of computer computations based on the interpretation of the movement of organisms such as the school of fish and the herd of birds where scientists had an idea of the dynamics of the table group such as those developed by the cellular mechanism[51]. The PSO algorithm is one of the simulation models inspired by the behavior of organisms developed by R. Eberhart and J. Kennedy in 1995[52]. Both models relied on distance manipulation between the herding group these are birds' efforts to keep the distance between themselves and their neighbors. But it does not seem like a big leap because it is logical to assume that some of the rules themselves are behind the behavior of the social animal, including the school of fish and the herd of birds. Theoretically, members of the school or herd can benefit from the previous experiences of the school members during the search for food. Through the above, the algorithm began to emulate social circles such as the herd of birds or the school of fish, which protects themselves from colliding with each other when you are looking for food On the other hand, the simulators introduced a dynamic force as the herds of birds heading towards food in case The food is placed on the ground, the herds of birds are heading towards the edge without prior knowledge of its location [53].

Now we have a conception of the possibility of finding solutions by the BSU algorithm, which is whether there is a group of birds looking for food within a specific area with specific dimensions that the birds do not know where the food is together, they know that local birds have a greater chance of finding food within their regions. The representation of each particle within the PSO algorithm as one of the birds of that group. Each particle is represented as the $x_i = (x_{i1}, x_{i2},..., x_{in})$. Where the first solutions in this algorithm are selected randomly and the search for optimal solutions is maintained by modifying the solutions until they reach the final value of the solutions. Food is. However, they know which bird is local to the closest bird to the food.

The fitness value of the particle is related to the aim function. The velocity of the particles $v_i = (v_{i1}, v_{i2},..., v_{in})$ pertains to its previous acceleration, the global best-known position, and the local most extensively known position. The acceleration indicates the directions of all the particles over the following iteration. The local best-known position is the best solution that is achieved by each particle so far [10]. A global best-known position is the best solution among all the achieved solutions. The basic principle of the PSO criteria is quite straightforward.

$$V_n + 1 = w(v_n + c_1 r_1 (pbest_n - x_n) - c_2 r_2 (gbest_n - x_n)) \tag{3.3}$$

$$x_{n+1} = x_n + v_{n+1} \tag{3.4}$$

where v_n is the current velocity, $V_n + 1$ is the updated velocity

x_n is the best location.

c_1 and c_2 the acceleration factors,

r_1 and r_2 Randomly generated numbers with a range of [0,1] to stop the swarm converging too quickly.

w Inertia weight, which enhance the exploration ability of particles.

pbest Personal best position particle i achieved based on its own experience.

gbest Global best particle position based on overall swarm's experience.

k Iteration index.

The acceleration factors handle the step sizes of the particles in the next iteration.

In case the acceleration factors are too small and the particles might not exactly have sufficient velocity to reach the target regions and if the acceleration factors are very large, the debris may exceed the optimal value. An appropriate selection of acceleration factors may avoid trapping into a local minimum and reduce the computation time.

V_{max} limits the maximum velocity of each particle. If the velocity of a compound is greater than the maximum allowable velocity, then the velocity of this particle will be restricted to V_{max}. Otherwise, the particle may also exceed the optimal solution. The maximum velocity is specified by users depending on different problems. The features of the PSO are summarized thus [54]:

1. The PSO algorithm selects the directions of the next step by cohesiveness and competition.

2. Fewer parameters need to be set in comparison to the simulated annealing method and genetic formula method.
3. The calculation speed of the PSO is less sensitive to the complexity of the goal functions.
4. The PSO protocol applies to many areas.

The flow chart of the PSO algorithm is shown in Figure 3.1.

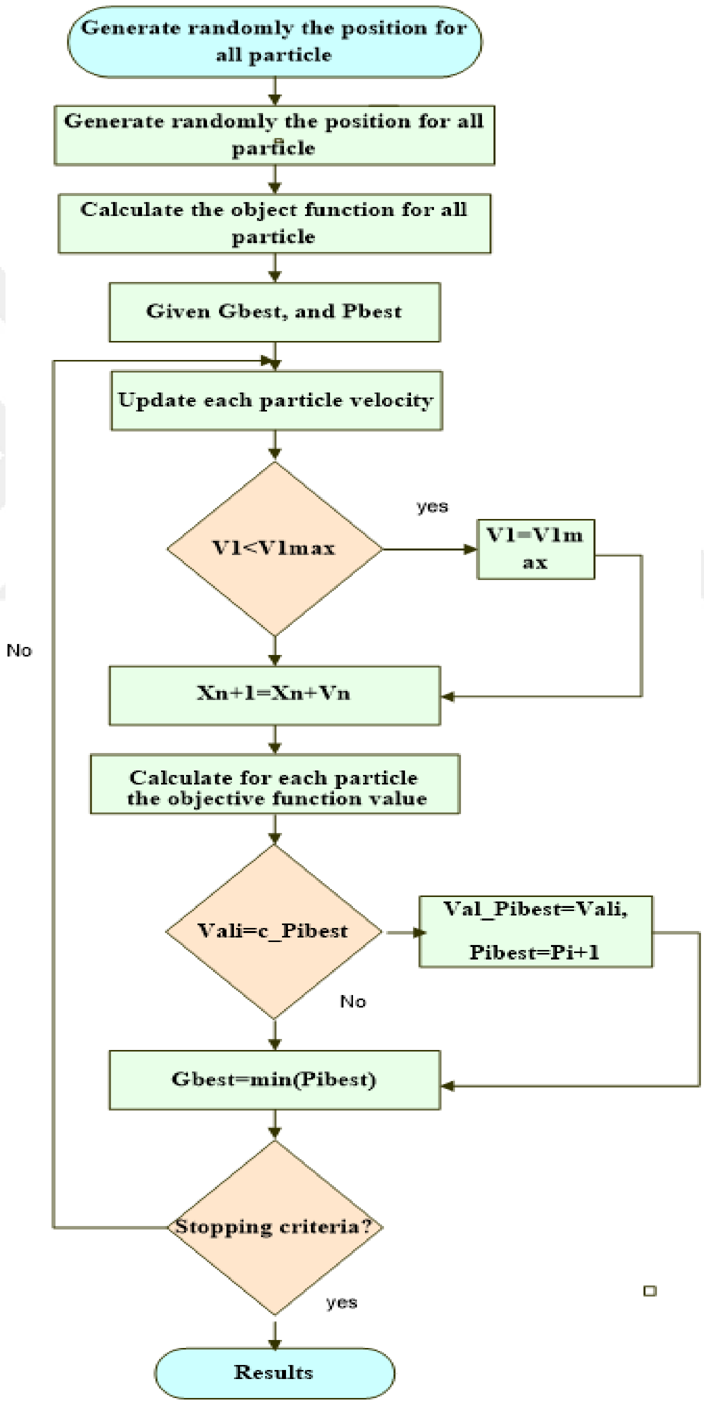

Figure 3.1: Flow Chart of the PSO algorithm

3.8 PSO Parameters Selection

The selection of the PSO parameters for general problems is listed in Table 2.3. Programmers may change some of these parameters based on different problems.

Table 3.1: Parameters Selection of PSO.

Particles size	When the dimensions increase, the numbers of the particles should also increase, from 20 to 40 works well for most of the optimization problems.
particles Domains	count on the lower and upper bound constraints
particles Dimensions	Equals the number of control variables.
Factor of Acceleration	$2 \leq \phi 1 = \phi 2 \leq 4$
Stopping criteria	Iteration number
	No improvement after a certain iterations number
	Difference between the current best solution and the previous best solution

3.9 MATPOWER 6.0

Matpower (matlab power system simulation package) is widely used in research and education for simulations, for finding and determining the ability of programs and calculating the optimal power flow of systems. It also contains operating tools and many examples of power flow, starting from 4 buses to represent a truly global network of thousands of buses for network representation cases [55]. MATPOWER consists of them file (MATLAB file) group designed to provide the best performance with ease of implementation and understanding.

Additionally, it contains the libraries of strong mathematics and it is an integrated development environment with excellent capabilities that is developed by an active community of developers and users as a high-level scientific language. It is also suitable for numerical calculations and issues to represent stable energy systems. It has been the market leader in Internet-based testing of power markets, power transfer calculations, line break factors and the efficiency of the derivatives calculation from energy flow equations [56].

In this section, several useful input and output MATPOWER 6.0 functions regarding this research are given.

-The Generator case Information: The generator information's in MATPOWER 6.0 is:

[bus Pg Qg Qmax Qmin Vg mBase status Pmax Pmin Pc1 Pc2 Qc1min Qc1max Qc2min Qc2max ramp_agc ramp_10 ramp_30 ramp_q apf].

The most important generator function columns and their corresponding meanings are listed in Table 3.1. The parameters settings of the generator data in 30 bus radial distribution system.

Table 3.2: Generator Name Columns Explanation.

The Function	The Meaning
Gen_bus	The generator Busbar No.
Pg	Generation active power
Qg	Generation reactive power
Qmax	output max. reactive power
Qmin	output min. reactive power
Vg	busbar Voltage magnitude
Pmax	output max. active power
Pmin	output min. real power

```
%genrator data
%    bus Pg  Qg   Qmax    Qmin    Vg  mBase   status  Pmax    Pmin    Pc1 Pc2 Qc1min  Qc1max  Qc2min
%    Qc2max  ramp_agc    ramp_10 ramp_30 ramp_q  apf
mpc.gen = [
    1   120 0   150 -20 1   100 1   80  0   0   0   0   0   0   0   0   0   0   0   0;
    2   10  0   60  -20 1   100 1   80  0   0   0   0   0   0   0   0   0   0   0   0;
    3   0   0   62.5    -15 1   100 1   50  0   0   0   0   0   0   0   0   0   0   0   0;
    4   0   0   48.7    -15 1   100 1   55  0   0   0   0   0   0   0   0   0   0   0   0;
    5   0   0   40  -10 1   100 1   30  0   0   0   0   0   0   0   0   0   0   0   0;
    6   0   0   44.7    -15 1   100 1   40  0   0   0   0   0   0   0   0   0   0   0   0;
];
```

Figure 3.2: Generator data.

- The branch information's in MATPOWER 6.0 is:

[fbus tbus r x b rateA rateB rateC ratio angle status angmin angmax].

Some of the most important branch name columns and their corresponding meanings are listed in Table 3.2.

Table 3.3: Explanation of the Branch Name Columns

Function	Meaning
f_bus	number of Start point busbar
t_bus	number of End point busbar
br_r	branch Resistance value
br_x	branch Reactance value
rate_a	branch Long-term rating
rate_b	branch Short-term rating
rate_c	branch Emergency rating
Ratio	transformer Tap ratio
Angle	transformer Phase shift angle
Pf	"from" bus side active power injection
Qf	"from" bus side Reactive power injection
Pt	"to" bus side active power injected
Qt	"to" bus side Reactive power injected

```
%   fbus    tbus    r   x   b   rateA   rateB   rateC   ratio   angle   status  angmin  angmax
mpc.branch = [
    1   2   0.02    0.06    0.03    130 130 130 0   0   1   -360    360;
    1   3   0.05    0.19    0.02    130 130 130 0   0   1   -360    360;
    1   4   0.06    0.17    0.02    65  65  65  0   0   1   -360    360;
    2   5   0.05    0.2 0.02    130 130 130     0   0   1   -360    360;
    2   6   0.06    0.18    0.02    65  65  65  0   0   1   -360    360;
    2   7   0.01    0.04    0   90  90  90  0.987   0   1   -360    360;
    2   8   0.05    0.12    0.01    70  70  70  0.95    0   1   -360    360;
    2   9   0.03    0.08    0.01    130 130 130 0.943   0   1   -360    360;
    2   10  0.01    0.04    0   32  32  32      0   0   1   -360    360;
    2   11  0   0.21    0   65  65  65          0   0   1   -360    360;
    2   12  0   0.56    0   32  32  32          0   0   1   -360    360;
    2   13  0   0.21    0   65  65  65          0   0   1   -360    360;
    3   14  0   0.11    0   65  65  65  0   0   1   -360    360;
    4   15  0   0.26    0   65  65  65  0   0   1   -360    360;
    4   16  0   0.14    0   65  65  65  0   0   1   -360    360;
    4   17  0.12    0.26    0   32  32  32  0   0   1   -360    360;
    4   18  0.07    0.13    0   32  32  32  0   0   1   -360    360;
    4   19  0.09    0.2 0   32  32  32  0   0   1   -360    360;
    4   20  0.22    0.2 0   16  16  16  0   0   1   -360    360;
    4   21  0.08    0.19    0   16  16  16  0   0   1   -360    360;
    4   22  0.11    0.22    0   16  16  16  0   0   1   -360    360;
    3   23  0.06    0.13    0   16  16  16  0   0   1   -360    360;
    3   24  0.03    0.07    0   32  32  32  0   0   1   -360    360;
    3   25  0.09    0.21    0   32  32  32  0   0   1   -360    360;
    3   26  0.03    0.08    0   32  32  32  0   0   1   -360    360;
    3   27  0.03    0.07    0   32  32  32  0   0   1   -360    360;
    3   28  0.07    0.15    0   32  32  32  0   0   1   -360    360;
    3   29  0.01    0.02    0   32  32  32  0   0   1   -360    360;
    3   30  0.1 0.2 0   16  16  16  0   0   1   -360    360;
```

Figure 3.3: Branch data.

- The Busbars Information: The busbars information in MATPOWER 6.0 is:

[bus_i type Pd Qd Gs Bs area Vm Va baseKV zone Vmax Vmin].

The most important bus name columns and their corresponding meanings are listed in Table 3.3 Figure 3.4 The parameters settings of the bus data in the 30-bus distribution system.

Table 3.4: Explanation of the Bus Name Columns.

The Function	The Meaning
Bus i	Bus bar No.
Bus-type	Types of bus bar ,1 ≡Load bus, 2 ≡ voltage generator, and 3 ≡reference bus
Pd	Demand active power
Qd	Demand Reactive power
Gs	Conductance
Bs	susceptance
Area	bus bar area
Vm	The value of voltage magnitude
Va	The voltage angle phase
Zone	Zone No.

```
%% bus data
%	bus_i	type	Pd	Qd	Gs	Bs	area	Vm	Va	baseKV	zone	Vmax	Vmin
mpc.bus = [
	1	3	0	0	0	0	1	1	0	132	1	1.05	0.95;
	2	1	51.6	20.7	0	0	1	1	0	33	1	1.05	0.95;
	4	1	50	26.3	0	0	1	1	0	33	1	1.05	0.95;
	5	1	6	2.7	0	0.19	1	1	0	33	1	1.05	0.95;
	6	2	5.8	4.3	0	0	1	1	0	33	1	1.05	0.95;
	7	1	7	7	0	0	1	1	0	33	1	1.05	0.95;
	8	1	5.2	3	0	0	1	1	0	33	1	1.05	0.95;
	9	1	0	0	0	0	1	1	0	33	1	1.05	0.95;
	10	1	4	2	0	0	3	1	0	33	1	1.05	0.95;
	11	1	10	0	0	0	1	1	0	33	1	1.05	0.95;
	12	1	22	12.5	0	0	2	1	0	33	1	1.05	0.95;
	13	1	0	0	0	0	2	1	0	33	1	1.1	0.95;
	14	1	6.2	1.6	0	0	2	1	0	33	1	1.05	0.95;
	15	1	8.2	2.5	0	0	2	1	0	33	1	1.05	0.95;
	16	1	3.5	1.8	0	0	2	1	0	33	1	1.05	0.95;
	17	1	9	5.8	0	0	2	1	0	33	1	1.05	0.95;
	18	1	3.2	0.9	0	0	2	1	0	33	1	1.05	0.95;
	19	1	9.5	3.4	0	0	2	1	0	33	1	1.05	0.95;
	20	1	2.2	0.7	0	0	2	1	0	33	1	1.05	0.95;
	21	1	17.5	11.2	0	0	3	1	0	33	1	1.05	0.95;
	22	1	0	0	0	0	3	1	0	33	1	1.1	0.95;
	23	1	3.2	1.6	0	0	2	1	0	33	1	1.1	0.95;
	24	1	8.7	6.7	0	0.04	3	1	0	33	1	1.05	0.95;
	25	1	0	0	0	0	3	1	0	33	1	1.05	0.95;
	26	1	3.5	2.3	0	0	3	1	0	33	1	1.05	0.95;
	27	1	0	0	0	0	3	1	0	33	1	1.1	0.95;
	28	1	0	0	0	0	1	1	0	33	1	1.05	0.95;
	29	1	2.4	0.9	0	0	3	1	0	33	1	1.05	0.95;
	30	1	10.6	1.9	0	0	3	1	0	33	1	1.05	0.95;
```

Figure 3.4: Bus data.

To conclude, the main optimization steps of the PSO based reactive power dispatch are as follows:

1- Loading case information: in MATPOWER 6.0, a 30 bus distribution system data is saved in case30.m file. The case including following the format information’s of the generators, buses, and branches.

2- Set the particle numbers, total iteration numbers, and start value velocity, each particle in the design chosen randomly assign the position.

3- Determine the particle fitness and save the local and the global best-known position of each particle.

4- Update the velocities and positions: Then check whether the solution within the limit or not.

5- Calculate each particle: by substitute the position of each particle into the objective function to find the assessment value.

6- Update best known position of global and local best-known position: if the fitness value is smaller than the historical better fitness value, update the global and local best-known position.

7- Decide stopping criterion: Evaluate when the iteration has reached to the max. Iteration numbers. If yes, stop the optimization process and print the result; if no, the iteration advanced one as $i_{ter}=i_{ter}+1$, and return to step 3.

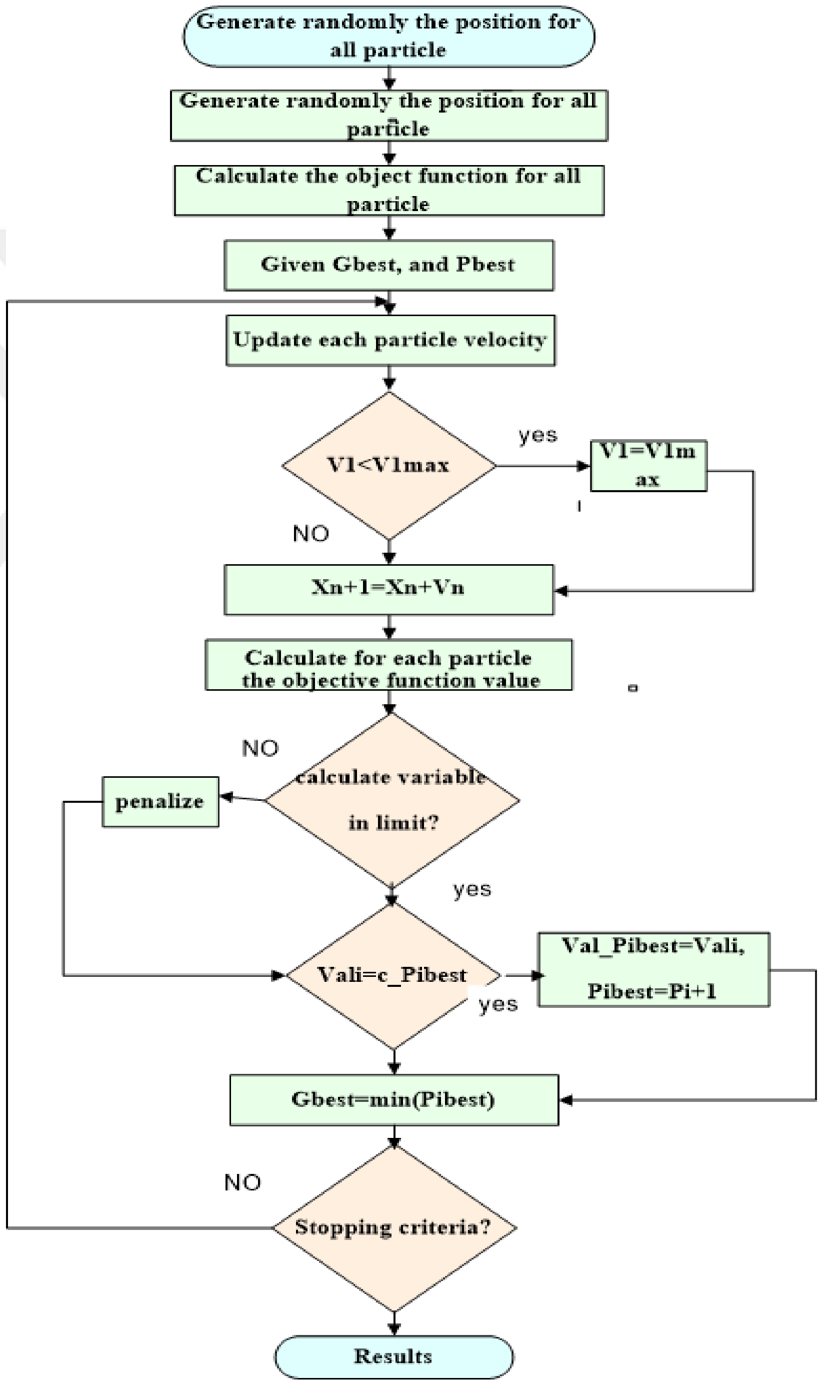

Figure 3.5: Flow chat of PSO

The flow chat of the PSO based reactive power dispatch is illustrated in the Fig.3.5

Several useful input and output MATPOWER 6.0 functions regarding this research are given.

i- The load case Functions:

The function (load case) can load the data information from the struct of m.file. The information is brought-in and then salvaged in a struct. Users can alter the structure the network by changing the imported data when needed.

The conventional format of using the load case is mpc=loadcase (casefile).

ii- The save case Function

The (save case) function conserves the data of the network to the m.file. This kind of file can even be over-written when needed. Found in MATLAB 8.5 environments, if the case data file needs to be overwritten more than once in a single run, users need to choose conserving the case information in the MAT-format. Otherwise, a problem message would appear, and the case information would remain unchanged. The format of using save case is: - save case (mpc).

iii- The run pf Function

The function (run pf) can calculate the power circulation of the power network. When evaluating the power, the run pf function has many different options:

1- 'AC' determines the AC power move of the program.

2- 'DC' calculates the power flow of the system.

3- 'GS' means using the Gauss-Seidel iterative method.

4- 'NR' relates to use the iterative Newton Raphson method.

5- 'FDLF' is the fast-decoupled iterative method.

run pf works in the AC power flow mode and uses the Newton Raphson iterative method solution to compute the power circulation by default.

The run pf conventional format using is: results sama dengan runpf (casedata).

v- The get losses Function

The (get losses) function can estimate the non-active power shot and power loss in all branches by using the following formulas:

The conventional format using get losses function is loss dengan get losses (results).

$$Ploss = I^2 R \tag{3.5}$$

$$S = IV \tag{3.6}$$

$$S = P + jQ \tag{3.7}$$

$$I = \frac{S}{V} \tag{3.8}$$

$$\text{Losses redaction} = \sum_{i=1}^{i=n} r_i \left(\frac{P + jQ}{V} \right)^2 \tag{3.9}$$

Where: r_i = Resistance of the branch i P_i = Real power flowing through the branch Qi = Reactive power flowing through the branch Vi = Voltage at the receiving end of the branch

3.10 Incorporation Of DG Into Load Flow

Assume that a single-source, radial distribution networks with *NL* branches and a DG is to be placed at node *I* and α be a set of branches connected between the source and node *I*. It is known that, the DG supplies active power (PGi^{DG}) to the systems, but in case of depending sower (QGi) it is supplied to the source of DG, either it is supplies to the systems or consume from the systems. Due to this active and reactive power an active current (I^{r}_{DGi}) and reactive current (I^{i}_{DGi}) flows through the system, and it changes the active and reactive component of current of branch set α. The current of other branches (∉=α) are unaffected by the DG.

Total Apparent Power at i^{th} node:

$$S = S_{D\_i} = \sum P_{D\_i} + jQ_{D\_i} \tag{3.10}$$

Current at i^{th} node:

$$I_D = I_{D\_i}^{without\_DG} = \left(\frac{S_{D\_i}}{V} \right) \tag{3.11}$$

To incorporate the DG model, the active and reactive power demand at i^{th} node at which a DG unit is placed, is modified by:

$$P_{D\_i}^{without\_DG} = P_{Di}^{without\_DG} - P_{Gi}^{DG} \tag{3.12}$$

$$Q_{D\_i}^{without\_DG} = Q_{Di}^{without\_DG} \pm Q_{Gi}^{DG} \tag{3.13}$$

DG power at i^{th} node:

$$S_{DG-i} = \sum P_{G\_i}^{DG} \pm jQ_{G\_i}^{DG} \tag{3.14}$$

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Case studies

Through analysis of the data in this thesis using the program PSO algorithm and MATPOWER 6.0 as a toolbox to determine the optimal location of the distributed generation using a data bank of an Iraqi network consisting of 30 buses with a level of distribution voltage 33 KV and the main source of feeding with a voltage of 132-kV and through the power transformer capacity of 189 MVA and load The total number of replicates, up to 200 iteration, the size of a squadron of up to 50, the max inertia weight is 0.9 and the min inertia weight is 0.4. The Analysis shows that the level of voltage on the bus bar is less than the permissible level and after analyzing the network once others using the PSO algorithm Improve the level of voltages, after the DG is inserted into the distribution system on each bus bar separately, record the results and note the marked improvement of voltages level on bus bar and also reduce the proportion of losses in the network after the completion of the system analysis of each bus turned out to be the perfect place for the generator distribution is the bus number 6.

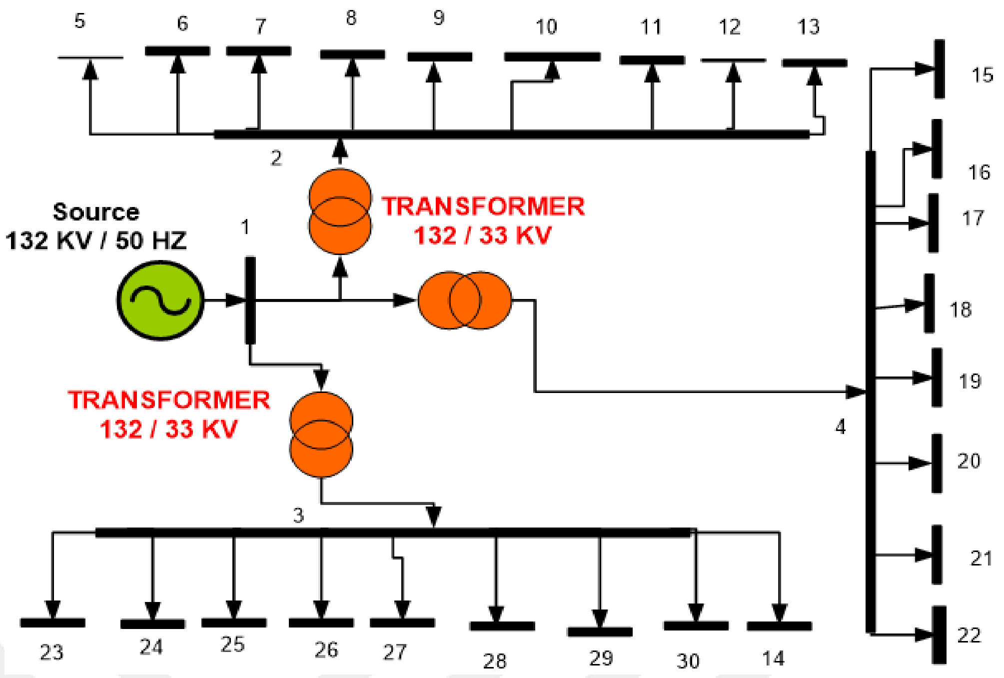

Figure 4.1: The 30 buses of the Iraqi distribution system

Table 4.1: Branch data.

Branch number	From bus to bus	R(p.u)	X(p.u)	B(p.u)
1	1 - 2	0.02	0.06	0.03
2	1 - 3	0.05	0.19	0.02
3	1 - 4	0.06	0.17	0.02
4	2 - 5	0.05	0.2	0.02
5	2 -10	0	0.56	0
6	2 - 11	0	.11	0
7	2 - 12	0	0.26	0
8	2 - 13	0	0.14	0
9	3 - 14	0.12	0.26	0
10	2 - 7	0.09	0.2	0
11	4 - 15	0.22	.2	0
12	4 - 17	0.08	0.19	0
13	4 -18	0.11	0.22	0
14	4 - 9	0.06	0.13	0
15	4 - 20	0.03	0.07	0
16	4 - 17	0.03	0.08	0
17	4 - 21	0.03	0.07	0
18	2 - 6	0.07	0.15	0
19	4 - 22	0.01	0.02	0
20	2 - 9	0.12	0.18	0
21	3 -24	0.13	0.27	0
22	3 -25	0.19	0.33	0
23	3 - 26	0.25	0.38	0
24	3 - 27	0.11	0.21 0	0
26	3 - 29	0.22	0.42	0
27	3 - 30	0.24	0.45	0

Table 4.2: Bus data Power.

Bus no.	type	Pd(MW)	Qd(MVAr)	baseKV	Vmax(p.u)	Vmin(p.u)
1	slack	0	0	132	1.05	0.95
2	PQ	60	31,5	33	1.05	0.95
3	PQ	51.6	20.7	33	1.05	0.95
4	PQ	50	26.3	33	1.05	0.95
5	PQ	6	2.7	33	1.05	0.95
6	PQ	5.8	4.3	33	1.05	0.95
7	PQ	7	7	33	1.05	0.95
8	PQ	5.2	3	33	1.05	0.95
9	PQ	0	0	33	1.05	0.95
10	PQ	4	2	33	1.05	0.95
11	PQ	10	0	33	1.05	0.95
12	PQ	22	12.5	33	1.05	0.95
13	PQ	0	0	33	1.05	0.95
14	PQ	6.2	1.6	33	1.05	0.95
15	PQ	8.2	2.5	33	1.05	0.95
16	PQ	3.5	1.8	33	1.05	0.95
17	PQ	9	5.8	33	1.05	0.95
18	PQ	3.2	0.9	33	1.05	0.95
19	PQ	9.5	3.4	33	1.05	0.95
20	PQ	2.2	0.7	33	1.05	0.95
21	PQ	14.5	11.2	33	1.05	0.95
22	PQ	0	0	33	1.05	0.95
23	PQ	3.2	1.6	33	1.05	0.95
24	PQ	6.7	6.7	33	1.05	0.95
25	PQ	0	0	33	1.05	0.95
26	PQ	3.5	2.3	33	1.05	0.95
27	PQ	0	0	33	1.05	0.95
28	PQ	0	0	33	1.05	0.95
29	PQ	2.4	0.9	33	1.05	0.95
30	PQ	10.6	7.6	33	1.05	0.95

4.2 Distributed generation data

If the DG is installed on a bus (bus 2), with active power capacity of the generator 10MW. In Figure 4.6, note that the active power losses decrease in each branch and overall system

```
%genrator data
%    bus Pg   Qg   Qmax    Qmin    Vg  mBase   status  Pmax    Pmin    Pc1 Pc2 Qc1min  Qc1max  Qc2min
%    Qc2max  ramp_agc    ramp_10 ramp_30 ramp_q  apf
mpc.gen = [
    1   120 0   150 -20 1   100 1   80  0   0   0   0   0   0   0   0   0   0   0   0;
    2   10  0   60  -20 1   100 1   80  0   0   0   0   0   0   0   0   0   0   0   0;
```

Figure 4.2: Generator sitting.

```
%% bus data
%   bus_i   type   Pd   Qd   Gs   Bs   area   Vm   Va   baseKV   zone   Vmax   Vmin
mpc.bus = [
    1   3   0   0   0   0   1   1   0   132   1   1.05   0.95;
    2   2   51.6   20.7   0   0   1   1   0   33   1   1.05   0.95;
    4   1   50   26.3   0   0   1   1   0   33   1   1.05   0.95;
    5   1   6   2.7   0   0.19   1   1   0   33   1   1.05   0.95;
    6   1   5.8   4.3   0   0   1   1   0   33   1   1.05   0.95;
    7   1   7   7   0   0   1   1   0   33   1   1.05   0.95;
    8   1   5.2   3   0   0   1   1   0   33   1   1.05   0.95;
    9   1   0   0   0   0   1   1   0   33   1   1.05   0.95;
    10   1   4   2   0   0   3   1   0   33   1   1.05   0.95;
    11   1   10   0   0   0   1   1   0   33   1   1.05   0.95;
```

Figure 4.3: Enter the generator for the network.

This figure 4.3 shows how to inter the DG in to the system on bus number 2. Similar changes will also be performed in other cases, and by repeating the position of the generator with another bus we find that the least losses are when the generator on the sixth bus.

```
%   bus_i   type   Pd   Qd   Gs   Bs   area   Vm   Va   baseKV   zone   Vmax   Vmin
mpc.bus = [
    1   3   0   0   0   0   1   1   0   132   1   1.05   0.95;
    2   1   51.6   20.7   0   0   1   1   0   33   1   1.05   0.95;
    4   1   50   26.3   0   0   1   1   0   33   1   1.05   0.95;
    5   1   6   2.7   0   0.19   1   1   0   33   1   1.05   0.95;
    6   2   5.8   4.3   0   0   1   1   0   33   1   1.05   0.95;
    7   1   7   7   0   0   1   1   0   33   1   1.05   0.95;
    8   1   5.2   3   0   0   1   1   0   33   1   1.05   0.95;
    9   1   0   0   0   0   1   1   0   33   1   1.05   0.95;
    10   1   4   2   0   0   3   1   0   33   1   1.05   0.95;
    11   1   10   0   0   0   1   1   0   33   1   1.05   0.95;
    12   1   22   12.5   0   0   2   1   0   33   1   1.05   0.95;
    13   1   0   0   0   0   2   1   0   33   1   1.1   0.95;
    14   1   6.2   1.6   0   0   2   1   0   33   1   1.05   0.95;
    15   1   8.2   2.5   0   0   2   1   0   33   1   1.05   0.95;
    16   1   3.5   1.8   0   0   2   1   0   33   1   1.05   0.95;
    17   1   9   5.8   0   0   2   1   0   33   1   1.05   0.95;
    18   1   3.2   0.9   0   0   2   1   0   33   1   1.05   0.95;
    19   1   9.5   3.4   0   0   2   1   0   33   1   1.05   0.95;
    20   1   2.2   0.7   0   0   2   1   0   33   1   1.05   0.95;
    21   1   17.5   11.2   0   0   3   1   0   33   1   1.05   0.95;
    22   1   0   0   0   0   3   1   0   33   1   1.1   0.95;
    23   1   3.2   1.6   0   0   2   1   0   33   1   1.1   0.95;
    24   1   8.7   6.7   0   0.04   3   1   0   33   1   1.05   0.95;
    25   1   0   0   0   0   3   1   0   33   1   1.05   0.95;
```

Figure 4.4: Enter the generator at the sixth bus.

4.3 Discussion

In Figure 4.6 represents the voltage magnitudes at the slack bus or PV bus, T is the tap position of the transformer, and S9 is the reactive power injection at bus 9. When the optimization process starts, the position of each particle will be continuously updated until reaching the stopping criteria.

V_1	V_6	T_1	T_2	T_3	S_9

Figure 4.6: Coordinates of the Particle

Figures 4.3 and 4.4 show the optimization process of the reactive power dispatch when installing a new DG at the optimum location at bus 6. At the beginning of the optimization process, the positions of the particles are randomly selected. The global optimal real power loss is approximately 125 MW at that time. As the particles continually update their positions towards the best solution, the real power loss continues to decrease. After 100 iterations, no obvious improvement can be observed. Finally, the active power loss converges to 9.969 MW.

Table 4.5 shows the real power loss on each branch before and after the particle swarm optimization. Even though the active power loss in some branches are slightly increased, (for instance, branch 19-20, 10-17, 8-28and 22-23), the overall real power loss of the 30 buses system is significantly reduced.

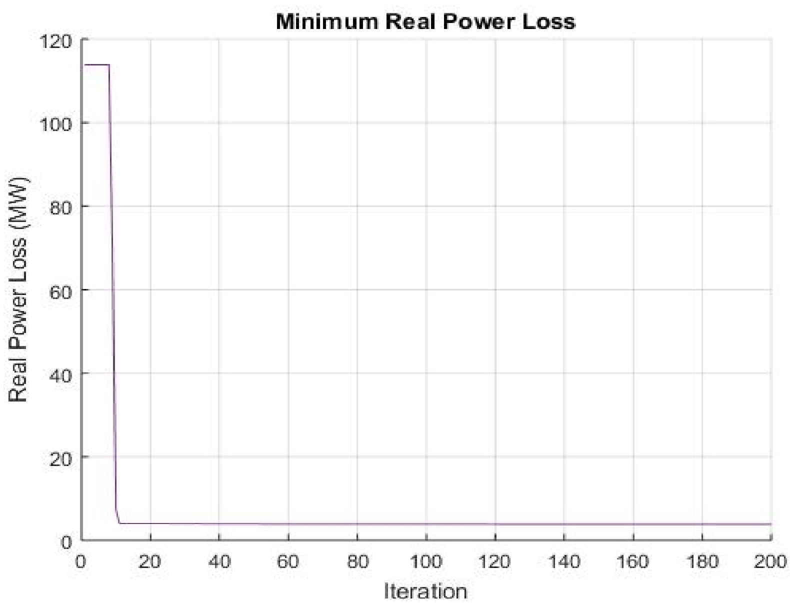

Figure 4.7: Loss Reduction Process

Table 4.3 show the comparison values of the real power loss on each branch of the original network, optimization without a new DG, and optimization with a new DG. The real power loss in all the branches is decreased; therefore, the overall real power loss of the 30-bus system is significantly reduced.

Table 4.3: Comparison of real power loss at each branch.

Branch number	From bus to bus	Before optimization(MW)	After optimization(MW)	Optimization with DG(MW)
1	1 - 2	7.520	4.248	2.667
2	1 - 3	4.605	2.786	1.872
3	1 - 4	2.016	1.317	0.959
4	2 - 5	0.617	0.066	0.285
5	2 -10	0.742	0.587	0.285
6	2 - 11	0.774	0.596	0.178
7	2 - 12	0.000	0.000	0.000
8	2 - 13	0.000	0.000	0.000
9	3 - 14	0.000	0.000	0.000
10	2 - 7	0.000	0.000	0.000
11	4 - 15	0.00	0.000	0.000
12	4 - 17	0.153	0.070	0.062
13	4 -18	0.011	0.002	0.001
14	4 - 9	0.074	0.011	0.010
15	4 - 20	0.006	0.000	0.000
16	4 - 17	0.042	0.043	0.034
17	4 - 21	0.040	0.059	0.035
18	2 - 6	0.013	0.005	0.002
19	4 - 22	0.225	0.161	0.123
20	2 - 9	0.001	0.000	0.000
21	3 -24	0.098	0.145	0.083
22	3 -25	0.008	0.004	0.001
23	3- 26	0.203	0.099	0.096
24	3 -27	0.001	0.003	0.001
25	3 - 29	0.000	0.000	0.000
26	3 - 30	0.192	0.111	0.091

Figure 4.8 shows the voltage profile showing the modification of this profile after optimization and after connecting a DG at the optimum location on bus 6. This figure shows improved voltages in the case of connecting the distribution generator.

Figure 4.9 shows the power loss in the distribution system before and after optimization and after optimization with a DG at bus 6. The figure also shows a decrease in power loss in the distributors and the largest decrease in power in distributors 1-2 where its value is less than 7.520 MW.

In the pre-ideal state of 4.248 MW after the implementation of the PSO method, but without the distribution generator and when connecting the distribution generator, the losses in this distributor will be reduced to 2.667 MW.

Figure 4.10 shows the power loss in the distribution system when the DG is in a different location of the bus and it shows the minimum.

This form represents the loss in the distribution system and its comparison with each case of the location the generator distribution installed and when linked to the different busbar. It is clear from the figure that the least loss in the distribution system when the distributed generator on the bus number 6 where the value 9.198 MW, while the highest value of the loss of power to the system occurs when the generator power to bus number 13 is where the value is 14.087 MW, power loss occurs when the DG is at bus 6. Therefore, the largest reduction of loss will be on this bus. This is clear in Figure 4.11, where the loss reduction is 60.55% at bus 6, and the minimum loss reduction occurs at bus 13, where the value is 39.582%.

From figure 4.9, the real power loss can be reduced by 39.71% by simply applying the PSO algorithm. After adding a new DG to the system and using the PSO algorithm to further adjust the values of control variables, the real power loss can be reduced by as much as 60.55%. A comparison of the loss reduction, when a DG is installed on different buses, is presented in this figure.

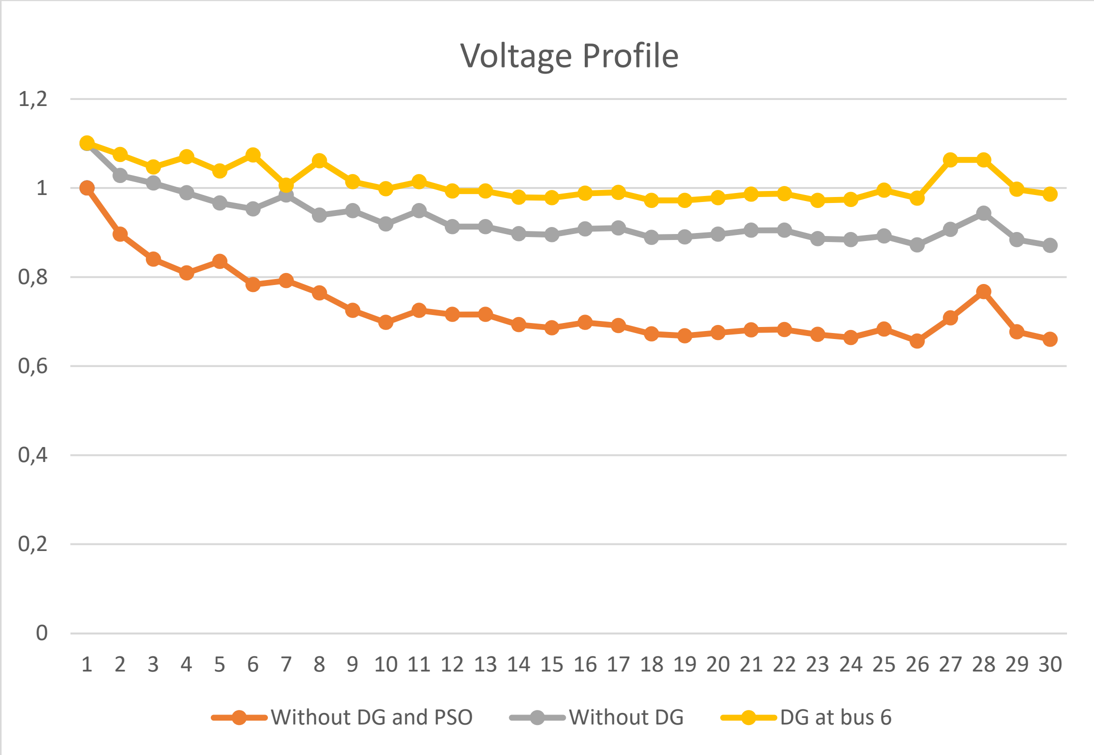

Figure 4.8: Voltage profile.

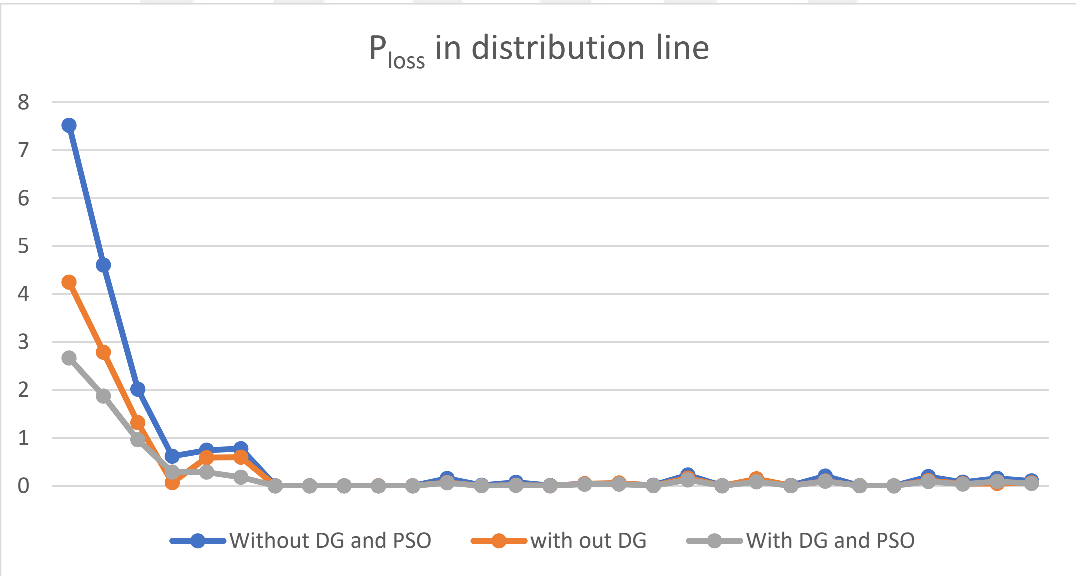

Figure 4.9: Modification Power loss in distribution line.

Table 4.4: Voltage profile.

Variables	Voltage at bus1	Voltage at bus2	Voltage at bus3	Voltage at bus4	Voltage at bus5	Voltage at bus6	Voltage at bus7
Without DG and PSO	1.000	0.896	0.840	0.809	0.835	0.783	0.792
Without DG	1.102	1.028	1.011	0.989	0.966	0.953	0.984
DG at bus 2	1.095	1.086	1.024	1.011	1.029	1.004	1.075
DG at bus 3	1.101	1.060	1.092	1.054	1.025	1.008	1.030
DG at bus 4	1.067	1.035	1.049	1.047	1.003	0.991	1.020
DG at bus 5	1.101	1.063	1.022	1.007	1.089	1.016	1.006
DG at bus 6	**1.101**	**1.075**	**1.047**	**1.070**	**1.038**	**1.074**	**1020**
DG at bus 7	1.102	1.028	0.988	0.966	0.976	0.935	0.967
DG at bus 8	1.102	1.028	0.989	0.966	0.971	0.953	0.951
DG at bus 9	1.102	1.028	0.989	0.966	0.971	0.953	0.984
DG at bus 10	1.102	1.028	0.989	0.966	0.971	0.954	0.970
DG at bus 11	1.102	1.028	0.989	0.966	0.971	0.953	0.984
DG at bus 12	1.102	1.028	0.989	0.966	0.976	0.950	0.972
DG at bus 13	1.101	1.028	1.022	1.007	1.088	1.015	0.988
DG at bus 14	1.102	1.028	0.989	0.966	0.971	0.954	0.964
DG at bus 15	1.102	1.028	0.989	0.966	0.971	0.953	0.955
DG at bus 16	1.102	1.028	0.989	0.967	0.971	0.954	0.946
DG at bus 17	1.102	1.028	0.989	0.966	0.971	0.953	0.960
DG at bus 18	1.102	1.028	0.989	0.966	0.971	0.953	0.945
DG at bus 19	1.102	1.028	0.989	0.966	0.971	0.952	0.966
DG at bus 20	1.102	1.028	0.989	0.966	0.971	0.953	0.954
DG at bus 21	1.102	1.028	0.989	0.966	0.971	0.953	0.950
DG at bus 22	1.102	1.028	0.989	0.966	0.971	0.954	0.958
DG at bus 23	1.102	1.028	0.989	0.966	0.971	0.953	0.968
DG at bus 24	1.102	1.028	0.989	0.966	0.971	0.953	0.966
DG at bus 25	1.102	1.028	0.989	0.966	0.971	0.953	0.984
DG at bus 26	1.102	1.028	0.989	0.966	0.971	0.954	0.970
DG at bus 27	1.102	1.028	0.989	0.966	0.971	0.953	0.984
DG at bus 28	1.102	1.028	0.989	0.966	0.971	0.953	0.951
DG at bus 29	1.102	1.028	0.988	0.966	0.976	0.950	0.967
DG at bus 30	1.102	1.028	0.989	0.966	0.971	0.954	0.985

Table 4.4 (Continued): Voltage profile.

Variables	Voltage at bus8	Voltage at bus9	Voltage at bus10	Voltage at bus11	Voltage at bus12	Voltage at bus13	Voltage at bus14	Voltage at bus15
Without DG and PSO	0.764	0.725	0.698	0.725	0.716	0.716	0.693	0.686
Without DG	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 2	0.990	0.986	0.962	0.986	0.958	0.958	0.943	0.941
DG at bus 3	0.995	1.029	0.999	1.029	0.998	0.998	0.983	0.980
DG at bus 4	0.977	1.023	0.991	1.023	0.990	0.990	0.975	0.972
DG at bus 5	1.002	0.987	0.964	0.987	0.958	0.958	0.944	0.942
DG at bus 6	**1.061**	**1.014**	**0.998**	**1.014**	**0.939**	**0.939**	**0.979**	**0.978**
DG at bus 7	0.935	0.946	0.916	0.946	0.911	0.911	0.983	0.895
DG at bus 8	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 9	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 10	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 11	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 12	0.935	0.987	0.916	0.946	0.911	0.911	0.895	0.893
DG at bus 13	1.001	0.949	0.964	0.987	0.958	0.958	0.943	0.941
DG at bus 14	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 15	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 16	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 17	0.939	0.948	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 18	0.938	0.947	0.919	0.948	0.912	0.912	0.897	0.895
DG at bus 19	0.937	0.949	0.918	0.947	0.912	0.912	0.896	0.895
DG at bus 20	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 21	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 22	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 23	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 24	0.939	0.948	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 25	0.939	0.949	0.919	0.948	0.913	0.913	0.897	0.895
DG at bus 26	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 27	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 28	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895
DG at bus 29	0.935	0.946	0.916	0.946	0.911	0.911	0.895	0.893
DG at bus 30	0.939	0.949	0.919	0.949	0.913	0.913	0.897	0.895

Table 4.4 (Continued): Voltage profile.

Variables	Voltage at bus16	Voltage at bus17	Voltage at bus18	Voltage at bus19	Voltage at us20	Voltage at bus21	Voltage at bus22	Voltage at bus23
Without DG and PSO	0.698	0.691	0.692	0.668	0.675	0.681	0.682	0.671
Without DG	0.908	0.910	0.889	0.890	0.896	0.905	0.905	0.886
DG at bus 2	0.953	0.954	0.935	0.935	0.941	0.948	0.949	0.933
DG at bus 3	0.991	0.991	0.947	0.947	0.979	0.980	0.985	0.985
DG at bus 4	0.983	0.983	0.966	0.966	0.971	0.977	0.977	0.961
DG at bus 5	0.953	0.956	0.936	0.937	0.943	0.951	0.951	0.935
DG at bus 6	**0.988**	**0.990**	**0.972**	**0.972**	**0.978**	**0.986**	**0.987**	**0.972**
DG at bus 7	0.905	0.904	0.887	0.887	0.902	0.902	0.902	0.884
DG at bus 8	0.908	0.910	0.889	0.890	0.896	0.905	0.905	0.886
DG at bus 9	0.908	0.910	0.889	0.890	0.896	0.905	0.905	0.886
DG at bus 10	0.908	0.910	0.889	0.890	0.896	0.905	0.905	0.886
DG at bus 11	0.908	0.910	0.889	0.890	0.896	0.905	0.905	0.886
DG at bus 12	0.906	0.907	0.887	0.888	0.894	0.902	0.902	0.884
DG at bus 13	0.953	0.955	0.936	0.937	0.942	0.951	0.951	0.934
DG at bus 14	0.908	0.910	0.889	0.890	0.896	0.905	0.905	0.886
DG at bus 15	0.908	0.910	0.889	0.890	0.896	0.904	0.905	0.886
DG at bus 16	0.908	0.910	0.889	0.890	0.896	0.905	0.905	0.886
DG at bus 17	0.908	0.910	0.889	0.890	0.896	0.905	0.905	0.886
DG at bus 18	0.907	0.910	0.889	0.890	0.896	0.904	0.904	0.886
DG at bus 19	0.907	0.909	0.889	0.890	0.895	0.903	0.903	0.885
DG at bus 20	0.908	0.910	0.889	0.889	0.896	0.905	0.905	0.886
DG at bus 21	0.908	0.910	0.889	0.890	0.896	0.904	0.905	0.886
DG at bus 22	0.908	0.910	0.890	0.890	0.896	0.905	0.905	0.886
DG at bus 23	0.908	0.910	0.889	0.890	0.896	0.905	0.905	0.886
DG at bus 24	0.908	0.910	0.889	0.890	0.896	0.905	0.905	0.886
DG at bus 25	0.908	0.910	0.889	0.890	0.896	0.904	0.904	0.886
DG at bus 26	0.908	0.910	0.889	0.890	0.896	0.905	0.905	0.886
DG at bus 27	0.908	0.910	0.889	0.890	0.896	0.905	0.905	0.886
DG at bus 28	0.908	0.910	0.889	0.890	0.896	0.905	0.905	0.886
DG at bus 29	0.905	0.907	0.887	0.887	0.893	0.902	0.902	0.884
DG at bus 30	0.908	0.910	0.889	0.890	0.896	0.905	0.905	0.886

Table 4.4 (Continued): Voltage profile.

Variables	**Voltage at bus24**	**Voltage at bus25**	**Voltage at bus26**	**Voltage at bus27**	**Voltage at bus28**	**Voltage at bus29**	**Voltage at bus30**
Without DG and PSO	0.664	0.683	0.656	0.708	0.767	0.677	0.660
Without DG	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 2	0.931	0.943	0.922	0.957	0.994	0.936	0.924
DG at bus 3	0.970	0.965	0.965	0.946	0.974	1.000	0.953
DG at bus 4	0.955	0.952	0.933	0.960	0.983	0.938	0.926
DG at bus 5	0.934	0.948	0.925	0.966	1.005	0.944	0.932
DG at bus 6	**0.974**	**0.995**	**0.977**	**1.063**	**1.063**	**0.997**	**0.986**
DG at bus 7	0.881	0.889	0.869	0.903	0.940	0.881	0.867
DG at bus 8	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 9	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 10	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 11	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 12	0.882	0.889	0.869	0.904	0.940	0.881	0.889
DG at bus 13	0.934	0.948	0.929	0.965	1.005	0.944	0.932
DG at bus 14	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 15	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 16	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 17	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 18	0.884	0.892	0.872	0.906	0.943	0.884	0.871
DG at bus 19	0.883	0.891	0.871	0.906	0.942	0.883	0.870
DG at bus 20	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 21	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 22	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 23	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 24	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 25	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 26	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 27	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 28	0.884	0.892	0.872	0.907	0.943	0.884	0.871
DG at bus 29	0.881	0.889	0.869	0.903	0.940	0.881	0.867
DG at bus 30	0.884	0.892	0.872	0.907	0.943	0.884	0.871

In Table 4.4 shows us by recording voltmeter readings for each bus of the 30 buses. We note that the voltage level was low before the distributed generation of the network entered from the level allowed for customer processing (0.95 to 1.05). Also note the readings of the voltages after connecting the generator to the thirty buses for each bus separately. The degree of improvement is evident at the voltage level as well as the optimum location of the generator is when it is connected to the bus number 6 which is the voltage level in the best condition.

Table 4.5: Power loss and loss reduction.

Variables	P_{losses} (MW)	Loss Reduction %
Without DG and PSO	23.316	0
Without DG with PSO	14.0561	39.71
DG at bus 2	11.423	51
DG at bus 3	10.718	54.03
DG at bus 4	10.606	54.511
DG at bus 5	11.587	50.3
DG at bus 6	**9.198**	**60.55**
DG at bus 7	14.069	39.66
DG at bus 8	14.062	39.67
DG at bus 9	14.056	39.71
DG at bus 10	14.058	39.7
DG at bus 11	14.056	39.71
DG at bus 12	14.067	39.66
DG at bus 13	14.056	39.715
DG at bus 14	14.059	39.70
DG at bus 15	14.062	39.69
DG at bus 16	14.061	39.93
DG at bus 17	14.061	39.93
DG at bus 18	14.063	39.68
DG at bus 19	14.060	39.69
DG at bus 20	14.062	39.69
DG at bus 21	14.063	39.68
DG at bus 22	14.061	39.93
DG at bus 23	14.059	39.70
DG at bus 24	14.060	39.69
DG at bus 25	14.057	39.711
DG at bus 26	14.058	39.796
DG at bus 27	14.056	39.715
DG at bus 28	14.062	39.689
DG at bus 29	14.069	39.659
DG at bus 30	14.055	39.719

Table 4.5, shows comparison the loss of real power in each branch and how the losses were reduced to acceptable values for the system.

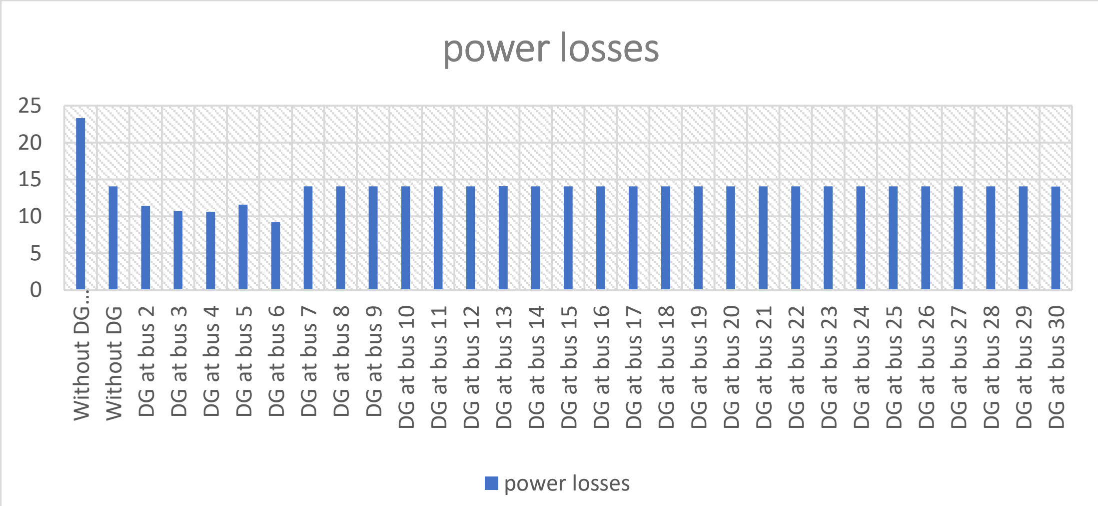

Figure 4.10: Power loss.

The figure 4.10, shows the extent of variation in total system losses when DG rotates on 30 buses. It is clear that the bus No. 6 is the ideal bus where recorded the proportion of the least losses can be a total loss 9.198 MW, which is required either the highest losses recorded at the bus No. 13 and had recorded losses up to 14.067 MW.

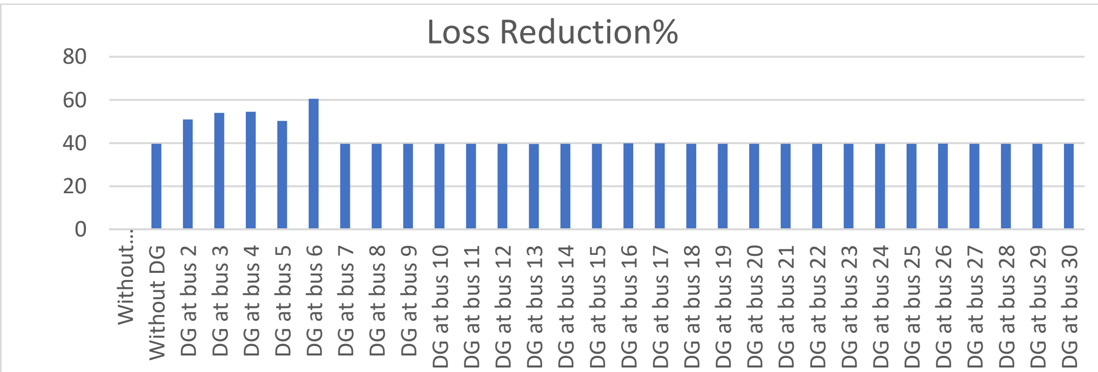

Figure 4.11: Power loss reduction in percent.

This is evident in figure 4.11 which represents the reduction of losses when a DG is tied to 30 buses. The highest percentage of losses on bus No. 6 was recorded at 60.55 and the lowest percentage in bus number 13 was 39.67.

$$\text{Losses reduction at b.6} = \frac{23.316 - 9.198}{23.316} = 60.55\%$$

$$\text{Losses reduction at b.13} = \frac{23.316 - 14.067}{23.316} = 39.67\%$$

By analyzing the results of the three case studies, the following conclusions can be obtained:

1. Before the reactive power optimization, the non-active power in the 30-bus system is unreasonably distributed. The reactive power dispatch can significantly reduce the loss of active power for the system and improve the power quality.
2. Satisfying results can be achieved after conducting approximately 90 iterations, which reflects the excellent searching ability of the PSO algorithm to solve nonlinear problems.
3. When a small capacity DG is added into the system, the real power loss is further reduced. As the output of the DG increases, the real power loss of the system decreases.

Table 4.6: Total Generation and Main Losses of the Iraqi Network.

Total Generation	15250 MW
Total load demand for the city of Baghdad	3700 MW
Total load demand for the city of Ninawa	435 MW
Total load demand for the city of Kirkuk	662 MW
Total load demand for the city of Salah Al-Dien	378 MW
Total load demand for the city of Al-Anbar	370 MW
Total load demand for the city of Diyala	560 MW
Total load demand for the city of Babylon	690 MW
Total load demand for the city of Karbala	670 MW
Total load demand for the city of Najaf	690 MW
Total load demand for the city of Qadisiyah	520 MW
Total load demand for the city of Wasit	640 MW
Total load demand for the city of Muthanna	340 MW
Total load demand for the city of Dhi Qar	630 MW
Total load demand for the city of Basra	3010 MW
Total losses in Iraqi network	915 MW

This table shows the total generation volume of Iraqi stations for the eighth month with the load required for each city with the total losses and we can see the size of the high losses in the network, which amounted to 6% of the total generation value.

CHAPTER FIVE

CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

5.1 Conclusions

In this research, the theoretical study and simulation based on the introduction of the generator distribution on the distribution system and find the optimal place for the generator by simulating the system using the PSO algorithm and IEEE MATPOWER 6.0.

The integration of the distributed generator with the distribution system is based on a system of energy production. The integration of the distribution generator into the electrical system is due, inter alia, to compensate for the shortage of production of the central generating plants, reducing transport losses, increasing the reliability of the system and keeping the voltage within permissible limits.

And to determine the optimal location of the generator within part of an Iraqi network of 30 buses. The data are displayed through MATPOWER 6.0 which supports the power flow system using the PSO algorithm the system analysis and identification of buses for the purpose of connecting the distributed generation on the basis of improving the margin of voltage and reduce system losses. The simulation results indicate that the optimal generator position has a positive effect on the voltage margin level. First, the network simulation and representation without the use of the PSO algorithm or the introduction of the distributed generator of the system and through the results show the level of voltage regression and recording losses in the system is high and the system needs to provide quick solutions. Second, simulating and representing the network using the PSO algorithm and not using the distribution generator and the results recorded a high level of voltage spread but the system remains outside the permissible frame of voltage. Third, the network is monitored and represented using the PSO algorithm and the distribution generator is connected to the

30 buses separately and the voltage level is measured with the reduction of the losses within the system. The monitoring and analysis of the results show that bus number 6 is the ideal base for the generator site through a clear improvement in voltages In the 30 buses which must be within the permissible range of the system is between 0.95 to 1.05 per unit and reduce system losses by 60.55%.

5.2 Suggestions for future work

This work is done by simulating a stable electrical network for the purpose of network analysis and integrating the distribution generator to the electrical grid to increase stability.

Distribution generators can be introduced using multiple sources of operation, especially those with renewable energy that limit greenhouse gas emissions.

We can upgrade existing distribution systems using distributed generators controlled by intelligent measuring instruments to control generator operation mechanism to reduce energy loss.

REFERENCES

1. Al Abri, R., E.F. El-Saadany, and Y.M. Atwa, Optimal placement and sizing method to improve the voltage stability margin in a distribution system using distributed generation. IEEE transactions on power systems, 2013. **28**(1): p. 326-334.

2. Brown, R.E., Electric power distribution reliability. 2008: CRC press.

3. Georgilakis, P.S. and N.D. Hatziargyriou, Optimal distributed generation placement in power distribution networks: models, methods, and future research. IEEE Transactions on Power Systems, 2013. **28**(3): p. 3420-3428.

4. Nikolaidis, V.C., E. Papanikolaou, and A.S. Safigianni, A communication-assisted overcurrent protection scheme for radial distribution systems with distributed generation. IEEE transactions on smart grid, 2016. **7**(1): p. 114-123.

5. Koutsoukis, N.C., et al., Online Reconfiguration of Active Distribution Networks for Maximum Integration of Distributed Generation. IEEE Transactions on Automation Science and Engineering, 2017. **14**(2): p. 437-448.

6. Lakervi, E. and E.J. Holmes, Electricity distribution network design. 1995: IET.

7. Kauhaniemi, K. and L. Kumpulainen, Impact of distributed generation on the protection of distribution networks. 2004.

8. Pepermans, G., et al., Distributed generation: definition, benefits and issues. Energy policy, 2005. **33**(6): p. 787-798.

9. Theo, W.L., et al., Review of distributed generation (DG) system planning and optimisation techniques: Comparison of numerical and mathematical modelling methods. Renewable and Sustainable Energy Reviews, 2017. **67**: p. 531-573.

10. Rani, P., et al. Loss reduction of Rajasthan power system with Distributed Generation in transmission network. in Power Electronics, Intelligent Control and Energy Systems (ICPEICES), IEEE International Conference on. 2016. IEEE.

11. Chebbo, A., M. Irving, and M. Sterling. Reactive power dispatch incorporating voltage stability. in IEE Proceedings C-Generation, Transmission and Distribution. 1992. IET.

12. Masters, G.M., Renewable and efficient electric power systems. 2013: John Wiley & Sons.

13. Maruvada, P.S., Corona performance of high-voltage transmission lines. 2000: Research Studies Press Baldock, UK.

14. Short, T.A., Electric power distribution handbook. 2014: CRC press.

15. Stalin, A.S., et al. Design and implementation of accurate reactive power compensator for renewable grid connected transmission system. in Industrial Instrumentation and Control (ICIC), 2015 International Conference on. 2015. IEEE.

16. Abdul-Rahman, K., S. Shahidehpour, and M. Daneshdoost, AI approach to optimal VAR control with fuzzy reactive loads. IEEE Transactions on Power Systems, 1995. **10**(1): p. 88-97.

17. Chen, C.-R., H.-S. Lee, and W. Tsai. On-line Optimal Shunt Capacitors Dispatch of Peak Power Systems. in Transmission and Distribution Conference and Exhibition: Asia and Pacific, 2005 IEEE/PES. 2005. IEEE.

18. Kou, X., Particle Swarm Optimization Based Reactive Power Dispatch for Power Networks with Distributed Generation. 2015.

19. Tang, Y., et al. Impact of PV inverter penetration on voltage profile and power loss in medium voltage distribution systems. in Control and Modeling for Power Electronics (COMPEL), 2016 IEEE 17th Workshop on. 2016. IEEE.

20. Bollen, M.H. and F. Hassan, Integration of distributed generation in the power system. Vol. 80. 2011: John wiley & sons.

21. Johnson, G.L., Wind energy systems. 2006: Gary L. Johnson.

22. Cassedy, E.S., Prospects for sustainable energy: a critical assessment. 2000: Cambridge University Press.

23. Momirlan, M. and T.N. Veziroglu, The properties of hydrogen as fuel tomorrow in sustainable energy system for a cleaner planet. International journal of hydrogen energy, 2005. **30**(7): p. 795-802.

24. Harrison, M., et al., Comparison between CFD simulations and experiments for predicting the far wake of horizontal axis tidal turbines. IET Renewable Power Generation, 2010. **4**(6): p. 613-627.

25. Drew, B., A.R. Plummer, and M.N. Sahinkaya, A review of wave energy converter technology. 2009, Sage Publications Sage UK: London, England.

26. Edenhofer, O., et al., Renewable energy sources and climate change mitigation: Special report of the intergovernmental panel on climate change. 2011: Cambridge University Press.

27. Kabak, M. and M. Dağdeviren, Prioritization of renewable energy sources for Turkey by using a hybrid MCDM methodology. Energy Conversion and Management, 2014. **79**: p. 25-33.

28. Bird, D.K., et al., Nuclear power in Australia: A comparative analysis of public opinion regarding climate change and the Fukushima disaster. Energy Policy, 2014. **65**: p. 644-653.

29. Shafiee, S. and E. Topal, When will fossil fuel reserves be diminished? Energy policy, 2009. **37**(1): p. 181-189.

30. Outlook, A.E., Energy information administration. Department of Energy, 2010. **92010**(9): p. 1-15.

31. Sharif, S.S. and J.H. Taylor. Dynamic optimal reactive power flow. in American Control Conference, 1998. Proceedings of the 1998. 1998. IEEE.

32. Mirzaei, F., F. Ashkaboosi, and S. Mahdavi, Economic Based Neural Control Switching of TCR and TSC for Optimal Reactive Power Flow and Harmonic Minimization with Fuzzy-Genetic. 2016.

33. Kumarappan, N. and R. Arulraj. Optimal installation of multiple DG units using competitive swarm optimizer (CSO) algorithm. in Evolutionary Computation (CEC), 2016 IEEE Congress on. 2016. IEEE.

34. Shekeew, M., M. Elshahed, and M. Elmarsafawy. Impact of optimal location, size and number of distributed generation units on the performance of radial distribution systems. in Environment and Electrical Engineering (EEEIC), 2016 IEEE 16th International Conference on. 2016. IEEE.

35. Ghatak, S.R. and P. Acharjee. Optimal Allocation of DG Using Exponentential PSO with Reduced Search Space. in Computational Intelligence &

Communication Technology (CICT), 2016 Second International Conference on. 2016. IEEE.

36. Kaur, P., S. Kaur, and R. Khanna. Optimal placement and sizing of DG comparison of different techniques of DG placement. in Power Electronics, Intelligent Control and Energy Systems (ICPEICES), IEEE International Conference on. 2016. IEEE.

37. Haidar, A.M.A. Optimal Location of Distributed Generation Using Intelligent Optimization. in 2011 IEEE 23rd International Conference on Tools with Artificial Intelligence. 2011.

38. Nayanatara, C., J. Baskaran, and D. Kothari. Optimal location of Distributed Generation using micro-genetic algorithm. in Computation of Power, Energy, Information and Communication (ICCPEIC), 2014 International Conference on. 2014. IEEE.

39. Gantayet, A. and S. Mohanty. An analytical approach for optimal placement and sizing of Distributed Generation based on a combined voltage stability index. in Power, Communication and Information Technology Conference (PCITC), 2015 IEEE. 2015. IEEE.

40. Nadhir, K., D. Chabane, and B. Tarek. Firefly algorithm based energy loss minimization approach for optimal sizing & placement of distributed generation. in Modeling, Simulation and Applied Optimization (ICMSAO), 2013 5th International Conference on. 2013. IEEE.

41. Sulaiman, M.H., et al. Optimal allocation and sizing of distributed generation in distribution system via firefly algorithm. in Power Engineering and Optimization Conference (PEDCO) Melaka, Malaysia, 2012 Ieee International. 2012. IEEE.

42. Bazrafshan, M. and N. Gatsis, Decentralized stochastic optimal power flow in radial networks with distributed generation. IEEE Transactions on Smart Grid, 2017. **8**(2): p. 787-801.

43. Camacho, A., et al., Flexible voltage support control for three-phase distributed generation inverters under grid fault. IEEE transactions on industrial electronics, 2013. **60**(4): p. 1429-1441.

44. Chen, J. and Q. Zhu, A game-theoretic framework for resilient and distributed generation control of renewable energies in microgrids. IEEE Transactions on Smart Grid, 2017. **8**(1): p. 285-295.

45. Bollen, M.H., Understanding power quality problems. Piscataway, NJ, USA: IEEE, 2000. **1**: p. 1-35.

46. Kennedy, B., Power quality characteristics. Power Quality Primer, 2000: p. 34.

47. Dugan, R.C., M.F. McGranaghan, and H.W. Beaty, Electrical power systems quality. New York, NY: McGraw-Hill,| c1996, 1996.

48. Gil-de-Castro, A., et al., Harmonic phase angles for a domestic customer with different types of lighting. International Transactions on Electrical Energy Systems, 2015. **25**(7): p. 1281-1296.

49. Seymour, J. and T. Horsley, The seven types of power problems. White paper, 2005. **18**.

50. De Almeida, A., L. Moreira, and J. Delgado. Power quality problems and new solutions. in International conference on renewable energies and power quality. 2003.

51. Heppner, F. and U. Grenander, A stochastic nonlinear model for coordinated bird flocks. The ubiquity of chaos, 1990: p. 233-238.

52. Eberhart, R. and J. Kennedy, Particle swarm optimization, proceeding of IEEE International Conference on Neural Network. Perth, Australia, 1995: p. 1942-1948.

53. Kennedy, J., Particle swarm optimization, in Encyclopedia of machine learning. 2011, Springer. p. 760-766.

54. AlRashidi, M.R. and M.E. El-Hawary, A survey of particle swarm optimization applications in electric power systems. IEEE Transactions on Evolutionary Computation, 2009. **13**(4): p. 913-918.

55. Zimmerman, R.D., C.E. Murillo-Sánchez, and R.J. Thomas, MATPOWER: Steady-state operations, planning, and analysis tools for power systems research and education. IEEE Transactions on power systems, 2011. **26**(1): p. 12-19.

56. Milano, F., An open source power system analysis toolbox. IEEE Transactions on Power systems, 2005. **20**(3): p. 1199-1206.

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