International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 5 Issue 2, February - 2021, Pages: 37-40

Power Loss Minimization In Distribution System With Integrating Renewable Energy Resources

Suyarov Anvar

Faculty of Power engineering and Radio electronics
Jizzakh Polytechnic Institute
Jizzakh city, Uzbekistan
anvarsuyarov1989@gmail.com

Abstract*—*This article clearly illustrates the significance of optimal distributed generation allocation and sizing on the power loss minimization in the distribution system.

Keywords— distributed generation; photovoltaic; wind turbines; distribution system

1. INTRODUCTION

Due to the huge growth in electricity demand, the use of traditional energy sources is causing environmental problems. These power units emit huge amounts of greenhouse gases. With a global concern to reduce addiction to fossil fuels and reduce climate change, an alternative paradigm for electricity generation has been adopted. Distribute generation across the distribution system (DS). The DS is the endpoint of the power system. It acts as a link between the power supply area and individual consumers with unidirectional power flow. Research shows that about 70% of the total power loss in a power system is attributed to the DS side. A small source of energy directly connected to the grid or close to the consumer is called "Distributed Energy Resource (DER)" or "Distributed Generation (DG)". DG is an attractive replacement for centralized power generation. DG divisions include both renewable and non-renewable energy sources. DGs have tremendous technical, economic, and environmental benefits. These technical and economic benefits can be achieved by choosing the location, size, and type of DG for installation in an electrical power system (EPS). Optimal placing and sizing of the DG have technical advantages such as reduced overall system losses, improved voltage profile, voltage stability, system safety, reliability, power quality, and economic benefits such as low capital costs, replacement costs, operating costs, and maintenance, fuel cost and reliability increase cost. The integration of a DG based on Renewable Energy Sources (RES) into the DS has environmental benefits such as environmental friendliness (no emissions), free availability, abundance in nature, and so on [1-2].

The most commonly used DG systems in the residential sector are solar photovoltaic (PV) technology, small wind turbines (WT), fuel cells, natural gas-fueled ultrasounds, and emergency standby generators, usually fueled by diesel or gasoline. However, the commercial and industrial sectors use solar photovoltaic panels, hydropower, biomass combustion, biomass or natural gas fuel cell combustion, reciprocating internal combustion engines, and standby generators powered by petroleum-type diesel systems. Integration of DG units does not guarantee the reliability and stability of the system if they are placed in non-optimal places with different sizes. Instead of improving reliability and maintaining system stability, this will affect the voltage profile and increase system losses [2]. The optimal placement of the DG has taken on great importance due to its various advantages. However, integrating DG into an existing system will be an important and challenging task. As DG integration changes the behavior of the network from passive to active. Bidirectional power flow ultimately increases system losses and affects the reliability and stability of operation [3]. Planning to integrate a DG into an existing system requires optimal location, size, type of DG, and network connectivity. This reduces overall power loss, improves the system voltage profile and stability, reliability, safety, power quality, power factor, and overall system efficiency. Incorrect placement of WG units will distract from all of the above advantages [1]. Therefore, it is very important to place the DG unit in an optimal location and with a suitable size. The IEEE 1547 series of standards for connecting DG / DER to a power DS is shown in Table 1 [4]. This collective summary provides a consistent set of requirements, recommended practices, and guidelines for a standardized DER interconnection solution. The main reasons for the widespread use of DG are listed below [5]:

- A small generating unit takes up less space.
- New technologies in DG have a capacity from 10 kW to 100 MW.
- Advanced techniques widely used in the past (gas turbines, internal combustion engines), modern techniques (wind, solar energy), and future experimental techniques (fuel cells, solar panels in buildings).
- This reduces the cost of expansion of transmission and distribution (T&D) since the DG units are located close to consumers.

- Continuous availability of natural gas used in gas generator stations with expected stable prices worldwide.
- DG installation requires a shorter time with moderate investment risk.
- Flexible cost-effectiveness and reliability.

Table 1: Different DG levels and technology [5] header

No.	Type	Size	DG technology
1	Micro DG	~ 1 W < 5 kW	Solar (PV) Technology
2	Small DG	5 kW < 5 MW	Fuel cell, WT, Biomass
3	Medium DG	5 MW < 50 MW	Geothermal
4	Large DG	50 MW < ~ 300 MW	Hydrogen Energy system

2. Main Mathematical Formulation of the Studied Optimization Problem

As mentioned above, the optimal allocation of DG is achieved to minimize system power losses. The power loss calculations can be achieved as follows. If we assume the two buses distribution system as shown in Fig. 1.

The active and reactive power flow can be calculated as follows [6-7]:

$$P_i = P_{i+1} + P_{L,i+1} + R_{i,i+1}\left(\frac{P_i^2 + jQ_i^2}{|V_i|^2}\right) \tag{1}$$

$$Q_i = Q_{i+1} + Q_{L,i+1} + X_{i,i+1}\left(\frac{P_i^2 + jQ_i^2}{|V_i|^2}\right) \tag{2}$$

The voltage at receiving bus can be calculated using (3).

$$V_{i+1}^2 = V_i^2 - 2*(R_{i,i+1}*P_i + X_{i,i+1}*Q_i) + (R_{i,i+1}{}^2 + X_{i,i+1}{}^2)*\left(\frac{P_i^2 + jQ_i^2}{|V_i|^2}\right) \tag{3}$$

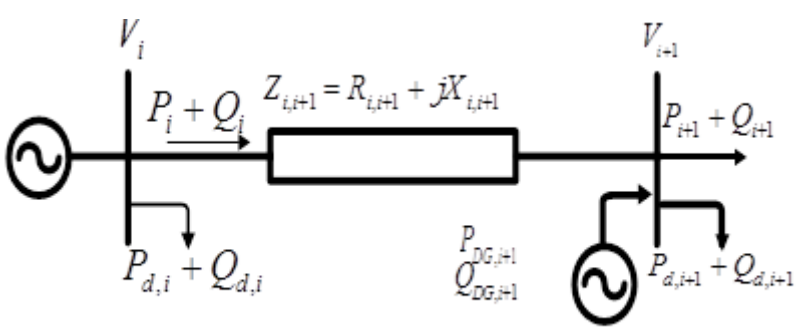

Fig. 1. Equivalent circuit of DS.

The active and reactive power losses between buses *i* and *i+1* can be expressed as follows:

$$P_{loss(i,i+1)} = R_{i,i+1}\left(\frac{P_i^2 + jQ_i^2}{|V_i|^2}\right) \tag{4}$$

$$Q_{loss(i,i+1)} = X_{i,i+1}\left(\frac{P_i^2 + jQ_i^2}{|V_i|^2}\right) \tag{5}$$

The main objective function is the minimizing total active power losses that can be given as follows:

$$F_{obj} = minimize(P_{loss}) \tag{6}$$

where, P_{loss} is the total power loss.

The above objective function is subjected to some constraints such as DG size, bus voltage, and branch current.

2.1 Equality constraints

The generated power must be equal to the demand loads and power losses as [8]:

$$P_{swing} + \sum_{i=1}^{N_{DG}} P_{DG}(i) = \sum_{i=1}^{L} P_{Lineloss}(i) + \sum_{k=1}^{N} P_d(k) \tag{7}$$

$$Q_{swing} + \sum_{i=1}^{N_{DG}} Q_{DG}(i) = \sum_{i=1}^{L} Q_{Lineloss}(i) + \sum_{k=1}^{N} Q_d(k) \tag{8}$$

where, P_{swing} and Q_{swing} are the active and reactive powers of swing bus, N_{DG} is the number of DGs, and L is the number of transmission lines.

2.2 Inequality constraints

- Voltage limitation

The bus voltages must be within the minimum voltage value ($V_{\min}$) and the maximum voltage value ($V_{\max}$)

$$V_{\min} \le |V_i| \le V_{\max} \tag{9}$$

- The limits of power generated from DG

The DG's installation capacity in the network is limited. Therefore, it must not exceed the power provided by the substation [7] to prevent reverse power flow.

$$\sum_{i=1}^{N_{DG}} P_{DG}(i) \le \frac{3}{4} * \left[\sum_{i=1}^{L} P_{Lineloss}(i) + \sum_{k=1}^{N} Pd(k)\right] \tag{10}$$

$$\sum_{i=1}^{N_{DG}} Q_{DG}(i) \le \frac{3}{4} * \left[\sum_{i=1}^{L} Q_{Lineloss}(i) + \sum_{k=1}^{N} Qd(k)\right] \tag{11}$$

$$P_{DG}^{\min} \le P_{DG}(i) \le P_{DG}^{\max} \tag{12}$$

$$Q_{DG}^{\min} \le Q_{DG}(i) \le Q_{DG}^{\max} \tag{13}$$

where, $P_{DG}^{\max}$ and $P_{DG}^{\min}$ are the maximum and minimum active powers generated by DG unit, $Q_{DG}^{\max}$ and $Q_{DG}^{\min}$ are the maximum and minimum reactive outputs of DG unit.

- Transmission line current limitation

The maximum transmission line current must meet the following constants [2].

$$I_k \le I_{\max,k} \tag{14}$$

where $I_{\max}$ is the maximum allowed current through the branch *k*.

3. CONCULISION

The present article clearly illustrates the significance of optimal DG allocation and sizing in a distribution system. Simultaneously the study elucidates DG integration benefits like power loss minimization and voltage profile improvement by integrating RER-based DG units. This study also focuses on parameters that depend on optimal DG allocation and sizing.

REFERENCES

[1] M. Khasanov, S. Kamel, K. Xie, P. Zhou and B. Li, "Allocation of Distributed Generation in Radial Distribution Networks Using an Efficient Hybrid Optimization Algorithm," 2019 IEEE Innovative Smart Grid Technologies - Asia (ISGT Asia), Chengdu, China, 2019, pp. 1300-1305.

[2] M. Khasanov, S. Kamel, M. Tostado-Véliz, and F. Jurado, "Allocation of Photovoltaic and Wind Turbine Based DG Units Using Artificial Ecosystem-based Optimization," in 2020 IEEE International Conference on Environment and Electrical Engineering and 2020 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS Europe), 2020, pp. 1-5: IEEE.

[3] M. Mashhour, M. A. Golkar and S. M. M. Tafreshi, “Optimal sizing and siting of distributed generation in radial distribution network: Comparison of unidirectional and bidirectional power flow scenario”, IEEE Bucharest Power Tech, Bucharest, pp. 1-8, June 28th - July 2nd 2009.

[4] M. M. Aman, G. B. Jasmon, A. H. A. Bakar, H. Mokhlis, “A new approach for optimum simultaneous multi-DG distributed generation Units placement and sizing based on maximization of system loadability using HPSO (hybrid particle swarm optimization) algorithm”, Energy, vol. 66, pp. 202-215, 2014.

[5] M. H. Moradi, M. Abedin, “A combination of genetic algorithm and particle swarm optimization for optimal DG location and sizing in distribution systems”, Electrical Power and Energy Systems, vol. 34, pp. 66–74, 2012.

[6] M. Khasanov, S. Kamel, and H. Abdel-Mawgoud, "Minimizing Power Loss and Improving Voltage Stability in Distribution System Through Optimal Allocation of Distributed Generation Using Electrostatic Discharge Algorithm," in 2019 21st International Middle East Power Systems Conference (MEPCON), 2019, pp. 354-359: IEEE.

[7] M. Khasanov, S. Kamel, H. M. Hasanien, and A. Al-Durra, "Rider Optimization Algorithm for Optimal DG Allocation in Radial Distribution Network," in *2020 2nd International Conference on Smart Power & Internet Energy Systems (SPIES)*, 2020, pp. 138-143: IEEE.

[8] M. Khasanov, K. Xie, S. Kamel, L. Wen and X. Fan, "Combined Tree Growth Algorithm for Optimal Location and Size of Multiple DGs with Different Types in Distribution Systems," 2019 IEEE Innovative Smart Grid Technologies - Asia (ISGT Asia), Chengdu, China, 2019, pp. 1265-1270.