LOAD OPTIMIZATION ALGORITHMS FOR INTEGRATION OF DISTRIBUTED GENERATORS IN MAIN ELECTRICAL NETWORKS

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Abstract— *This paper introduces a hybrid approach to find the optimal location and size of distributed generations (DG) in the radial distribution network (RDN). The proposed approach is based on the whale optimization algorithm (WOA) technique to calculate the optimal allocation of DGs and loss sensitivity index (LSI) to obtain the best buses for DGs installation in RDN. The presented approach is applied to the standard 33-bus RDN to minimize power losses. The results obtained prove that the developed approach can be highly effective in integrating DG into RDN in comparison with other methods in the literature.*

Keywords— whale optimization algorithm distributed generation; photovoltaic; wind turbines; distribution network

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 radial distribution network (RDN) [1-2]. The RDN 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 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). The integration of a DG based on Renewable Energy Sources (RES) into the RDN has environmental benefits such as environmental friendliness (no emissions), free availability, abundance in nature, and so on [3-4].

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.

2.Problem Formulation

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 radial distribution network as shown in Fig. 1.

The active and reactive power flow can be calculated as follows [8-9]:

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

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

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

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

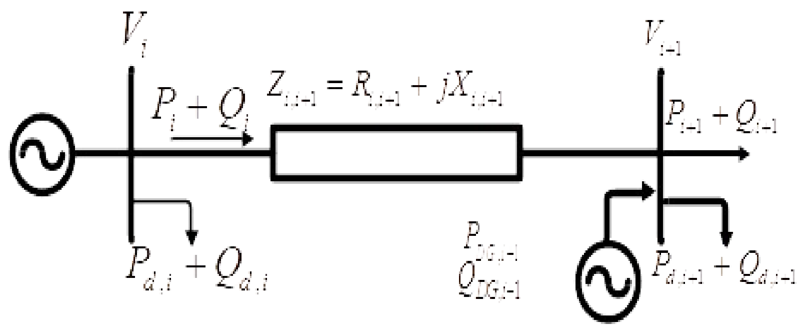

Fig. 1. Equivalent scheme of RDN.

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

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

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

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

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

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 [10]:

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

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

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

2.2Inequality 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 [11] to prevent reverse power flow.

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

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

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

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

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 [12].

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

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

3.CONCULISION

In this paper, whale optimization algorithm (WOA) with a loss sensitivity index (LSI) has been proposed for the solution problem of optimal allocation of DG units in RDN. The main goal of the proposed technique is to minimizing power losses. The proposed approach has been applied to the standard 33-bus system and compared results obtained with existing optimization techniques. The proposed approach is very effective in finding the optimal solution (minimum power loss) compared to other optimizations technique. This study also focuses on parameters that depend on optimal DG allocation and sizing.

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