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THE ROLE OF DISTRIBUTED GENERATION ON THE PERFORMANCE OF ELECTRICAL RADIAL DISTRIBUTION NETWORK

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ABSTRACT
Purpose: This article provides available information on the role of distributed generation (DG) in the performance of a power distribution network.
Design/methodology/approach: The study reviewed articles about available methods for reducing technical losses in electrical distribution networks. The second step involved studying various researchers' views on renewable energy in some developing countries for introducing DG into a distribution network. The influence of DG on the economic performance of a distribution network. Finally, the study scouted for available information on the implementation of a demand response (DR) program on the performance of a distribution network in the presence of DG.
Findings: Available information reveals that the reliability of DG for reducing the technical losses in a distribution network is higher than relying on alternating current controllers. There are indications of renewable energies in developing countries for introducing DG into a distribution network. According to the articles reviewed, the approach for the optimal location of DG did not include the combination of the voltage stability index and power loss reduction index. It is also worth considering using the power system analysis toolbox (PSAT) for DG sitting. The economic influence of DG on a distribution network's performance has not been evaluated based on the technical loss, generation cost, emission cost and reliability. It is also worth considering the benefits of demand response programs in the presence of DG.
Research limitation: The review concentrated mainly on DG's influence in reducing technical loss. Articles relating to the effect of DG on other distribution network technical issues such as voltage stability, harmonics etc. also require attention
Practical implications: Distribution network performance is essential for the operation of electrical gadgets. Therefore, improved distribution network performance will result in the economic development of a country.
Originality/Value: This paper provides the platform that stimulates interest in using DG to improve the distribution network performance.

Keywords: *Demand response. distributed generation. radial networks. renewable energy. technical losses.*

INTRODUCTION

A power distribution network is responsible for transferring electrical power from a transmission substation to the load end. A distribution network layout classification includes radial, ring and mesh networks (Northcote-Green & Wilson, 2017).

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A radial network transfers power from one feeder, with supply at only one end, to end loads. A fault on a radial network deprives consumers (after the faulty point) of power supply since the supply source is from only one point (Efkarpidis, De Rybel & Driesen, 2016). This type of network is easy to construct and relatively cheap in terms of the initial cost. However, the reliability of a radial network is low. The loads on the radial network at distance ends are often affected by a high voltage drop as the distance from the feeder increases. Radial networks can be very long and multi-arterial because of the desire to extend supply to all parts of a country. This phenomenon affects the electricity delivery efficiency to end-users due to the low voltage profile, high technical losses, high distribution cost and frequent faults.

Line losses contribute to low voltage profiles at some load buses on a distribution network. Therefore, an approach to reduce technical losses and improve voltage will increase revenue and enable end-users to enjoy quality power.

Distribution assets are sometimes constrained in the capacity to transfer the peak load demand on the network (Gelazanskas & Gamage, 2014). Sharing less than expected energy to the end consumer reduces the network's reliability. Failure to meet load demand also causes electricity consumers and utility providers revenue loss. Identifying approaches to reducing the stress on the distribution network will improve reliability and reduce the risk of revenue loss.

Apart from peak load demand, the demand load sometimes increases unexpectedly, making it challenging to balance power demand and supply. The implementation of load-shedding programmes sometimes manages this constraint of the power system. However, this approach is entirely based on the decision of the utility provider and does not give consumers the chance to select the loads to turn off. Therefore an alternative method will be one that will motivate consumers to reduce electricity consumption willingly by selecting loads that can stay off (Eid, Koliou, Valles, Reneses, & Hakvoort, 2016). This alternative approach entails implementing a demand response (DR) programme (U.S. Department of Energy, 2006).

Several articles relate to the reduction of technical losses in distribution networks. This article, therefore, seeks to review some papers relating to:

- Approach to reduce technical losses of electrical distribution network.
- The influence of DG on the economic performance of a distribution network
- Implementation of a demand response (DR) programme on the performance of a distribution network in the presence of DG.

TECHNICAL LOSS REDUCTION

The main requirement of a distribution network is to transfer power from one end to the other. However, the impedance of the distribution lines hinders the perfect delivery of the power (active and reactive) to the receiving end, as illustrated in Figure 1 (Benysek, 2007). Therefore, the expected sending end bus active power (Psr) and reactive power (Qsr) transferred to the receiving end bus are expressed in equations (1) and (2).

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$$P_{sr} = \frac{V_s V_r}{R_{sr}} \quad (1)$$

$$Q_{sr} = \frac{V_s^2 - V_s V_r}{X_{sr}} \cos \delta \quad (2)$$

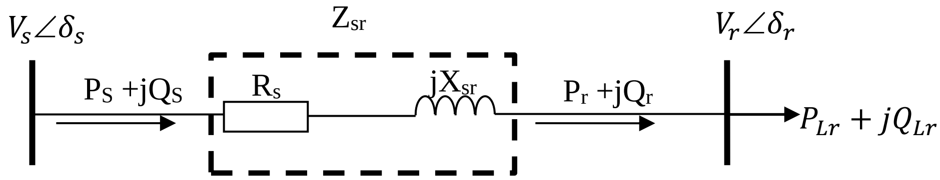

Figure 1: Representation of a simple electrical power network

where:

- 'V_s' is the sending end voltage.
- 'V_r' is the receiving end voltage
- 'δ' is the phase angle between V_s and V_r
- 'X_{sr}' is the line reactance
- 'R_{sr}' is the line resistance
- 'P_{Lr}' and 'Q_{Lr}' are loads of active and reactive power, respectively
- 'P_r' and 'Q_r' are the receiving ends of active and reactive power, respectively
- 'P_s' and 'Q_s' are the sending ends of active and reactive power, respectively.

Equations (1) and (2) indicate that the main factors influencing power (active and reactive) transfer are the voltages at both sending and receiving ends. The angle difference between the voltage and current results from the resistance and reactance of the transmission line. The transmission line resistance and reactance are responsible for active and reactive power losses. Also, the resistance and reactance (combined as impedance) contribute to the voltage drop level across the transmission line.

The impedance of a transmission line is directly proportional to the length of the transmission line. Hence, reducing the line length from the source to the load end reduces line losses and voltage drop. Alternatively, reducing the power flow in the line will mitigate the losses. The receiving end voltage is often lower than the sending end voltage due to the voltage drop across the transmission line. Therefore, an approach to reduce network losses and improve the voltage profile will enhance the quality of electric power delivered at the receiving end.

Compensation techniques for technical loss reduction

Manipulation of electrical network characteristics affects a distribution network's technical losses and voltage profile (Irinjila & Jaya, 2011; Vijaysimha & Kumar , 2013). The main methods for

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controlling a distribution network's characteristics depend on alternating current (AC) controllers (Zhang, Rehtanz, & Pal, 2006). However, the classification of AC controllers includes conventional switches and flexible alternating current transmission system (FACTS) devices.

The use of a conventional method for varying network characteristics involves the manipulation of the capacitance of capacitors (Vijaysimha & Kumar , 2013; Mondal, Chakrabarti, & Sengupta, 2014; Dulhe, 2015; Dinakaran & Venkateswara, 2015; Li, et al., 2015) or the phase angle of a phase transformer (Dobrijević & Milanović, 2010; Molapo, Mbuli, & Ijumba, 2011; Makhathini, Mbuli, Sithole, & Pretorius, 2012; Siddiqui, Khan, Ahsan, Khan, & Annamalai, 2012; Hraïech, Ben-Kilani, & Elleuch, 2014). Variations in capacitance or phase angle during compensation involve mechanical switching. Some losses also occur during the operation of moving switches owing to sparks. Furthermore, mechanical switches are generally suitable for steady-state controlling conditions but not for controlling transient conditions. Therefore, the functions of conventional devices are limited in dealing with dynamic transient disturbances.

Other AC devices are FACTS technology and use static devices to control the power network's characteristics. These devices include a static var compensator (Dinakaran & Venkateswara, 2015; Dulhe, 2015; Jadhao & Vadirajacharya, 2015; Jaswani, Bharti, & Dubey, 2015; Kumar, Suryakalavathi, & Kumar, 2015), a thyristor-controlled series compensator (Bawankar & Rajderkar, 2010; Jamhoria & Srivastava, 2014; Jamhoria & Srivastava, 2014; Shukla, Singl, & Dwivedi, 2016), a thyristor-controlled phase shifter (Bati, 2010; Rafi et al., 2013), static synchronous compensators (Wang & Crow, 2011; Lipu & Karim, 2013; Imanishi, et al., 2014; Lee, Gui, Han, & Chung, 2015; Ling, et al., 2016; Wang, Ye, Xiong, Wang, & Hou, 2016), static synchronous series compensators (Faridi, Maeiiat, Karimi, Farhadi, & Mosleh, 2011; Su & Chen, 2011; Kumar, Easwarlal, & Kumar, 2012; Khan & Bhowmick, 2014; Shankar, Thottungal, & Mythili, 2015) and a unified power flow controller (Fujita, Akagi, & Watanabe, 2006; Liu, Zhu, Kang, & Chen, 2007; Khanchi & Garg, 2013; Rathod, 2016). These devices' control speed enables the control of both steady-state and transient-state conditions (Murali et al., 2010; Beaty & Fink, 2013; Ramakrishna Rao et al., 2014). FACTS technology-based devices, according to various researchers (Bawankar & Rajderkar, 2010; Jamhoria & Srivastava, 2014; Dinakaran & Venkateswara, 2015; Dulhe, 2015; Jadhao & Vadirajacharya, 2015; Kumar, Suryakalavathi, & Kumar, 2015; Shukla, Singl, & Dwivedi, 2016) are capable of reducing power losses and improves voltage profile.

According to research (Pazouki & Kerendian, 2012; Mahari & Mahari, 2014; Elsherif & Shaaban, 2015; Grisales, Grajales, Montoya, Hincapie, & Granada, 2015; Ahmad, 2017), DG in a distribution network helps in reducing power losses. Furthermore, a comparison of the level of reduction in power losses due to the introduction of DG (Pazouki & Kerendian, 2012; Chatterjee, Nath, Biswas, & Das, 2013; Rath, Ghatak, & Goyal, 2016) shows an improvement over what is provided by conventional mechanisms and FACTS technology. Therefore, it is essential to concentrate on the use of DG for the reduction of technical losses.

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COMPENSATION USING DISTRIBUTED GENERATION

DG involves the generation of power close to load centres. The presence of DG in a distribution network potentially reduces the transmission line impedance (since the length of the lines reduces), thus reducing power losses in a power system. Depending on the technology involved, DG can vary active power or reactive power or both of a power system. Also, DG penetration level, according to Ogunjuyigbe et al. (2016), determines the significance of DG in compensating for power losses in a network. Furthermore, various publications (Ahmad, 2017; Elsherif & Shaaban, 2015; Grisales, Grajales, Montoya, Hincapie, & Granada, 2015; Mahari & Mahari, 2014; Pazouki & Kerendian, 2012) have confirmed the reliability of DG in contributing to a reduction in technical losses in a distribution network. DG can therefore enhance the stability of a power network.

Energy Sources for DG

The main classifications of energy sources for electricity generation are non-renewable and renewable. The primary non-renewable energy sources are fossil fuels, while renewable energy sources are naturally occurring energy flux.

The dependence on fossil fuels allows generating any quantity of electricity at a single location. Moreover, the products are easily accessible for efficient electricity generation at a relatively low cost. Nevertheless, burning fossil fuels releases carbon dioxide and contributes to greenhouse effects, which cause global warming. Additionally, sulphur dioxide emitted from coal burning is responsible for acid rain.

Though electricity generation from non-renewable sources enables constant generation, the high emission of substances harmful to the environment (Elbisy & Mlybari, 2017) calls for the consideration of alternative energy sources. On the other hand, electricity generation from renewable sources comes with the emission of almost zero environmentally harmful substances (Maiga, Chen, Wang, & Xu, Renewable energy options for a Sahel country: Mali, 2008; Abanda, Renewable energy sources in Cameroon: Potentials, benefits and enabling environment, 2012). Furthermore, the world is concerned about ensuring an end to the emission of greenhouse gas (GHG). Therefore, renewable energy is an alternative for introducing DG into a distribution network.

Assessment of Renewable Energy Sources

The level of electricity generation at a location depends on the site's energy availability. In effect, the information on electricity generation from the available energy sources dictates the DG technology for power compensation. Among the tools for assessing the potential of energy sources at locations are the Hybrid Optimization Model for Electric Renewable (HOMER) software and RETScreen Clean Energy Management software. These tools assist in the assessment of alternative energy potentials.

Some researchers (Olatomiwa, Saad, Huda, & Kamilu, 2015; Hassan, Jaszczur, & Abdulateef, 2016) depend on HOMER software to estimate the percentage of various energy source combinations suitable for off-grid electricity generation. The factors considered in the assessments

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are location, cross-sectional area, batteries' capacities, and a power converter. Other factors considered were project life, storage capacity, interest rate and fuel price.

An assessment of the potential of various energy sources by Fathoni et al. (2014), Pfeiffer (2014) and Asumadu-Sarkodie and Owusu (2016) concentrated on the ability of RETScreen to assess the potential of various energy sources at a location. The economic viability of generating electricity from various energy sources depends on the site, the project life, and the efficiency of the adopted technology. According to Ramli et al. (2017), HOMER and RETscreen provide the exact economical solutions for off-grid power for domestic purposes.

DG SITING

The location of the suitable capacity of a DG unit in a distribution network plays a significant role in influencing the performance of a power network. For instance, a reduction in power losses and an increase in bus voltages are dependent on the optimal location and capacity of installed DG units in the network (Pisica, Bulac, & Eremia, 2009; Liu, Zhu, Kang, & Chen, 2007; Talaat & Al-Ammar, 2011; Sulaiman, Mustafa, Azmi, Aliman, & Abdul Rahim, 2012; Tan, Hassan, Majid, & Rahman, 2013; Elsherif & Shaaban, 2015; Kaur & Mehta, 2016; Shivarudraswamy, Gaondar, & Jayalakshmi, 2016; Rakesh, VenkataPanana, & Keerthi, 2017). Furthermore, the optimal location of multiple DG systems increases the penetration level of DG in a network to enable the manipulation of power flow in a power system (Talaat & Al-Ammar, 2011; Elsherif & Shaaban, 2015; Ogunjuyigbe, Ayodele, & Alinala, 2016). Therefore, improving power quality with DG systems cannot be achieved without adopting a method that can assist in the optimal siting of DG systems.

Method for Optimal Siting

Various methods are available for determining the optimal siting of DG in a power network. One of the approaches adopted is heuristic techniques, such as genetic algorithm (GA) (Pisica, Bulac, & Eremia, 2009; Talaat & Al-Ammar, 2011), firefly algorithm (FA) (Sulaiman, Mustafa, Azmi, Aliman, & Abdul Rahim, 2012) cuckoo search algorithm (CS) (Tan, Hassan, Majid, & Rahman, 2013) and human opinion dynamics algorithm (Kaur & Mehta, 2016). Other methods include the ant colony optimization (ACO) algorithm (Ogunsina, et al., 2021) and the inherent power system (IPSN) (Somefun, Abdulkareem, Awosope, & Alayande, 2021). On the hand, the conventional search methods, such as the bus injection to branch-current (BIBC) and branch-current to bus-voltage (BCBV) matrix (Elsherif & Shaaban, 2015), are for determining DG locations. Additionally, hybrid algorithms such as the combination of PLI and GA (Rakesh, VenkataPanana, & Keerthi, 2017) and hybrid particle swarm (HPSO) with the Quasi-Newton algorithm (Tolba, Tulsky, & Diab, 2017) are all for identifying DG location.

Research by (Shivarudraswamy, Gaondar, & Jayalakshmi, 2016) recommends using GA in a simulation process for consistency. However, (Pisica, Bulac, & Eremia, 2009; Talaat & Al-Ammar, 2011; Priya & Prakash, 2014) consider GA for determining the voltage variation in a power network.

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The bases for the human opinion dynamics algorithm are the factors influencing a human decision. This algorithm is applicable (Kaur & Mehta, 2016) for determining the position and size of DG in a distribution network. As tested on the IEEE 14 bus and 30 bus, its reliability was higher than the GA. The FA, based on the flashing of fireflies, is an option for determining the optimal location of DG units in a distribution network. The solutions of FA (Sulaiman, Mustafa, Azmi, Aliman, & Abdul Rahim, 2012) are as good as those of GA regarding reducing power loss and improving bus voltage. The particle swarm optimization (PSO) algorithm, based on the principles of birds or fish moving in search of food, also determines the site of DG units (Rajalakshmi & Durairaj, 2016). The basis of the bacteria foraging optimization (BFO) algorithm is the principles of bacteria foraging for food in an environment. The BFO algorithm provides the right solution (Devabalaji & Ravi, 2016) for the optimal placement of DG and distribution static compensator (DSTATCOM) in a radial distribution network.

The competitive swarm optimizer (CSO) algorithm (Kumarappan & Arulraj, 2016) is an alternative method recommended for siting multiple DG units in an electrical power network for lower power losses and an improved voltage profile. This algorithm indicates a higher reduction in power losses as the penetration level increases. According to the CSO simulation result, the distribution of DG units at different buses in a network indicates a reduction in power losses, which is better than increasing DG capacity at one bus in a system.

The biological principles used by ants to locate the shortest route to food are the bases for the ACO algorithm (Ogunsina, et al., 2021). The steps in applying the ACO algorithm include the random generation of variables corresponding to DGs' real and reactive power required at various locations. Each iteration section produces a global best variable value during each step and updates the previous global best variable. Finally, at the maximum iteration index, the global best variable values are selected as the optimal location and capacity of DG required.

A proposed two-port network representation (Somefun, Abdulkareem, Awosope, & Alayande, 2021) involves the presentation of all generators in a power network on one side and all loads on one side, as indicated in figure 2. Then, the network's generated eigenvalue of the Z-impedance matrix for each bus is solved. Finally, the bus with the least eigenvalue represents the optimal location for DG installation.

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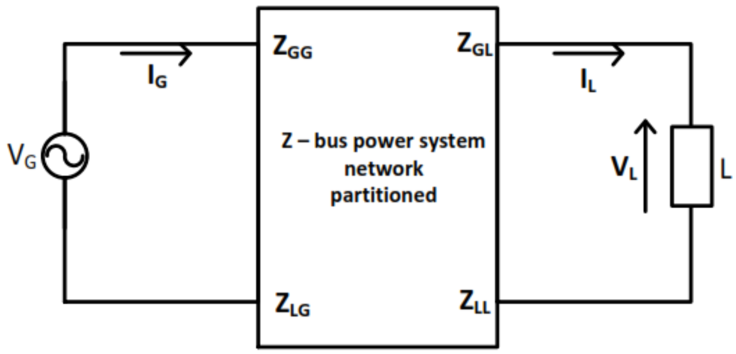

Figure 2: Two-port network representation
(Somefun, Abdulkareem, Awosope, & Alayande, 2021)

Hybrid Methods
Research (Rakesh, VenkataPanana, & Keerthi, 2017) has demonstrated that a combination of GA with PLI provides more reliable results than with GA only. Combining the PSO algorithm with the Chu-Beasly genetic algorithm (CBGA) (Grisales, Grajales, Montoya, Hincapie, & Granada, 2015) for locating and sizing DG can decrease the technical losses in a power network by about 50% of the base value. The CBGA was used to identify the potential nodes for DG installation and the PSO for the required DG capacity. PSOGSA, a combination of PSO and the gravitational search algorithm (GSA) on a MATLAB platform (Tolba, Tulsky, & Diab, 2017), also helps determine the site for DG in a power network. An HPSO algorithm (Tolba, Tulsky, & Diab, 2017) is also helpful in the siting of DG.

FACTORS THAT INFLUENCE THE ECONOMIC PERFORMANCE OF A DISTRIBUTION NETWORK

Power losses experienced in a distribution network and the reliability of the energy supply to end consumers influence the economic performance of a network. Hence, DG plays a significant role in the financial performance of a distribution network.

The main economic factors that influence the consideration of the type of energy source to deploy for DG include initial capital, operational cost and maintenance cost (Fathoni, Utama, & Kristianto, 2014; Olatomiwa, Saad, Huda, & Kamilu, 2015; Asumadu-Sarkodie & Owusu , 2016; Hassan, Jaszczur, & Abdulateef, 2016; Adefarati & Bansal, 2017; Adefarati & Bansal, 2019). The capital consists of the cost of components and the plant installation, which is dependent on (Pfeiffer, 2014; Devabalaji & Ravi, 2016; Ramli, Wahid, & Hassan, 2017) the DG technology deployed at a geographical location. The operating and maintenance cost involves generating power from the plant and keeping the plant in a condition that ensures efficient generation. Researchers have shown that the location of DG in a distribution network influences the network's level of technical losses. Additionally, the accuracy of the solution to determine the site for the

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Installation of DG affects the operational cost of the network (Liu, Zhu, Kang, & Chen, 2007; Grisales, Grajales, Montoya, Hincapie, & Granada, 2015; Tolba, Tulsky, & Diab, 2017).

The base for the economic evaluation by Liu et al. (2011) is the cost of line losses. On the other hand, the basis for the economic assessment by Grisales et al. (2015), Mohamed et al. (2015), Olatomiwa et al. (2015) and Adefarati and Bansal (2017) was the cost of generation from various energy sources. Assessment by Mohamed et al. (2015) and Adefarati and Bansal (2017), however, included the cost of energy in the economic influence analysis. Furthermore, another cost component that may affect a distribution network's operation is the GHG emission penalty depending on the energy source deployed (Zia & Shaikh, 2017; Adefarati & Bansal, 2019).

The quantity of electricity generated from alternative sources influences the possibility of introducing DG into a power network. Furthermore, the Installation of DG in a power network affects the network's reliability (Adefarati & Bansal, 2017; Adefarati & Bansal, 2019). However, national policies play a role in economic performance since the type of available energy resource influences the introduction of DG into a network, which affects the network's reliability.

Method for economic assessment
Economic influence can be determined according to Tolba et al. (2017) and Santos et al. (2018) based on the net present cost (NPC), using either HOMER simulation or PSOGSA analysis on a MATLAB platform. Other researchers also determined the economic influence of DG in a power network by considering the net present value (NPV) in HOMER (Zia & Shaikh, 2017) or by using sequential quadratic programming (SQP) analysis (Hatziargyriou, Gastasiadis, & Tsi, 2011). Considering the lifecycle cost, the annual cost of load losses and the cost of emitted gas (Adefarati & Bansal, 2019), solved using MATLAB software, is an alternative approach to assessing DG's economic impact.

Method for GHG emission assessment
HOMER simulation helps determine the level of CO_2 reduction due to introducing renewable energy into the microgrid (Zia & Shaikh, 2017; Santos, Zheng, Olsen, & Jorgensen, 2018). SQP can also assess the level of reduction in GHG emissions (Hatziargyriou, Gastasiadis, & Tsi, 2011). Another method used to determine the emission level associated with a microgrid is modelling using MATLAB software (Adefarati & Bansal, 2019).

EFFECT OF DEMAND RESPONSE ON DISTRIBUTION NETWORK
The implementation of a DR program in distribution can contribute to reducing the peak demand load. However, the benefits of DR implementation depend on the contract between the consumers and the power suppliers. This section presents researchers' assessments of the benefits of implementing DR.

The measurement of benefits derived from DR, according to Albadi and El-Saadany (2007), Aalami et al. (2011), Mohagheghi and Falahati (2011), Nikzad and Mozafari (2014), Nwulu and Xia (2017), Zhao et al. (2019) and Contey et al. (2020), is based on the energy saved and financial

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gain to utility providers and consumers. The basis for evaluating the benefits of DR (Aalami, Khodaei, & Fard , 2011; Nikzad & Mozafari, 2014) is the incentive paid and the penalty paid by consumers for not being part of the DR program.

Research by Nikzad and Mozafari (2014) included reliability on both the supply and the consumer sides in the assessment. This assessment was carried out through modelling and solving with the help of GAMS software. The basis for other research assessments is the effect of DR on the reliability of a distribution network (Mohagheghi & Falahati, 2011; Syrri & Mancarella, 2016; Nejad, et al., 2019). Syrri and Mancarella's (2016) research also assessed the risk involved in implementing DR and compared the outcome with inter-trip systems. The basis for reliability evaluation by Nejad et al. (2019) was the introduction of DG at an optimal location and the implementation of DR. The improved placement index helped determine the optimal location of the DG, while PSO is for assessing the reliability of the distribution network under DR.

The research work by Nwulu and Xia (2017), Vu et al. (2018) and Contey et al. (2020) determined the influence of renewable energy sources on benefits derived from the implementation of DR. The benefits of implementing DR measured by Nwulu and Xia (2017) and Contey et al. (2020) refer to the modification of the load profile and the incentive disbursed. Contey et al. (2020) also assessed the influence of the DR programme and renewable energy, cited in the distribution network based on GA, on the emission of GHG.

Research by Vu et al. (2018) evaluated the influence of the implementation of DR based on the line losses in a distribution system due to the introduction of DG. Simulation in MATLAB is for the assessment. The time of use was the basis for further research (Zhao et al., 2019) on the influence of DR in a network with multi-energy consumers. The benefit of DR, in this case, is also based on cost reduction, the load profile and the cost of energy purchased.

CONCLUSION

This article discusses various issues related to the introduction of DG into distribution networks. The main topics presented are the sitting of DG, the economic and environmental effect of DG and the implementation of DR in the presence of DG.

The studied methods for siting DG units include GA, the human opinion dynamics algorithm, FA, BFO, particle swarm optimization (CSO) and CS algorithm. Other available methods include GA and PLI, PSO and CBGA, particle swarm optimizer, and a hybrid particle swarm algorithm for sitting DG.

This article has shown that NPC or PSOGSA analysis techniques on a MATLAB platform, the NPV in HOMER simulation and SQP analysis are available procedures for assessing economic impact. Other approaches for determining economic effect include examining the lifecycle cost, the annual cost of load losses and gas emission cost (GEC) analysis on a MATLAB platform. Available information indicates that HOMER simulation software and SQP analysis modelling in

MATLAB is alternatives for determining gas emission levels of various energy sources. The mentioned assessment methods are sound. However, it is also essential to consider the assessment of the economic effect of DG on the performance of a distribution network based on the combination of line losses, generation cost, emission cost and reliability.

The factors considered in assessing DR benefits include incentives or penalties for either being part of the programme or not participating. Also available is information on factors such as reliability, location of DG, risk, line losses, load profile, the cost of energy purchased and gas emission. Additionally, information on the assessments based on the combination of operating cost of generation, line losses, incentive paid, energy curtailed, GHG and reliability are available.

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