ACTA IMEKO
ISSN: 2221-870X
September 2022, Volume 11, Number 3, 1 - 8

Performance enhancement of a low-voltage microgrid by measuring the optimal size and location of distributed generation

Ahmed Jassim Ahmed[1], Mohammed H. Alkhafaji[1], Ali Jafer Mahdi[2]

[1] *Electrical engineering department, University of Technology, Baghdad, Iraq*
[2] *Electrical engineering department, University of Kerbala, Kerbala, Iraq*

ABSTRACT

A power system in which the generation units such as renewable energy sources and other types of generation equipment are located near loads, thereby, reducing operation costs and losses and improving voltage is called a distributed generation (DG), and these generation units are called distributed energy resources. However, DGs must be located optimally to improve the power quality and minimize power loss of the system. The objective of this paper is to propose an approach for measuring the optimal size and location of DGs in a low voltage Microgrid using the Autoadd algorithm. The algorithm is validated by testing it on the IEEE 33-bus standard system and compared with previous studies, the algorithm proved its efficiency and superiority on the other techniques. A significant improvement in voltage and reduction in losses were observed when the DGs are placed at the sites decided by the algorithm. Therefore, Autoadd can be used in finding the optimal sizes and locations of DGs in the distribution system, the possibility of isolating the low voltage Microgrid is discussed by integrating distributed generation units and the results showed the possibility of this scenario during faults time and intermittency of energy time.

Section: RESEARCH PAPER

Keywords: Microgrid; distributed generation integration; autoadd; power losses reduction; voltage profile improvement

Citation: Ahmed Jassim Ahmed, Mohammed H. Alkhafaji, Ali Jafer Mahdi, Performance enhancement of a low-voltage microgrid by measuring the optimal size and location of distributed generation, Acta IMEKO, vol. 11, no. 3, article 21, September 2022, identifier: IMEKO-ACTA-11 (2022)-03-21

Section Editor: Francesco Lamonaca, University of Calabria, Italy

Received March 25, 2022; **In final form** August 30, 2022; **Published** September 2022

Corresponding author: Ahmed Jassim Ahmed, e-mail: ahmedjasem858@gmail.com

1. INTRODUCTION

The Increment in energy demand is an indicator of economic growth, and this demand has been growing rapidly in many sectors, such as in the building, transportation, and manufacturing industries. However, the consumption of energy is linked directly to many environmental issues due to using fuel or coal frequently as the primary sources for electricity generation, as shown in Figure 1, which is the main reason for emitting greenhouse gases (GHG). Those gases are very harmful dangerous for the environment [1]. Because of that, many global actors, such as World Bank, started encouraging countries to use clean energy sources by supporting their projects financially [2]. Therefore even during the pandemic, when the economy got affected by the lockdown, renewable energy sources kept growing fast [3]. Integrating renewable energy sources (RES) in low-voltage networks is creating significant changes in the electric power system's operation. In general, this integration occurs widely in low and medium-voltage networks. This leads to the Microgrid (MG) concept, which can be defined as a complex energy system that needs a specific framework, coordination of information flows and energy resources, as well as protection and the assurance of reliable energy [4]. It is built by the integration of RES, conventional generators, energy storage devices, and loads, as shown in Figure 2.

MGs can work in both the connected mode with the main grid and islanded mode [5]. Distributed Generation (DG) nowadays is gaining its reputation for becoming the main part of operating distribution networks. This is due to the technological improvement of many types of RES, such as photovoltaic systems, fuel cells, combined heat and power sources, and wind energy sources. This integration of DGs has major importance in reducing the emissions of CO_2 and improving the efficiency and the security of distribution networks and achieving a reliable operation of these networks [6]. The uncontrolled allocation of

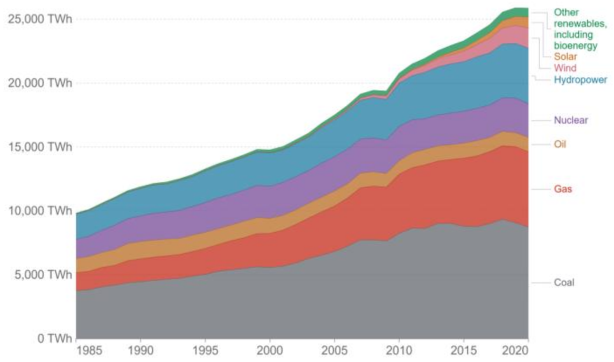

Figure 1. Energy production sources.

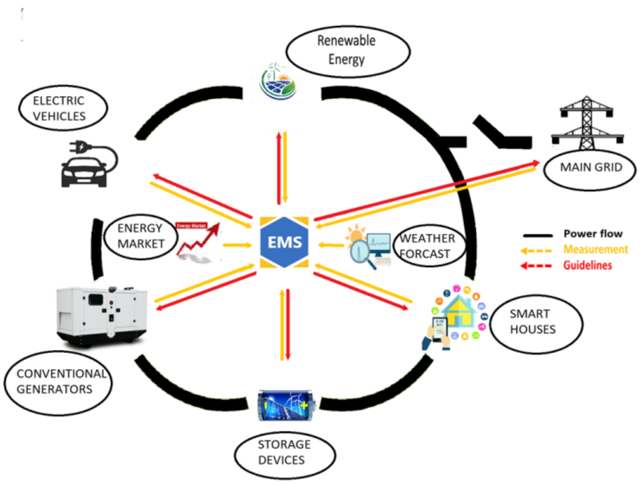

Figure 2. Microgrid architecture.

DGs in distribution networks brought in some serious challenges and problems. Like the bidirectional flow of power in the distribution networks and the problems of power losses and voltage drop [7], [8].

Researchers from the entire world are now focusing on these problems, and they have proposed many methods for selecting the optimal location and size of DGs with the aim to minimize or even eliminate the losses and improve the voltage of distribution networks with DG.

In [7], the Author proposed A new particle swarm optimization (PSO) method to improve the power quality of the network by finding the number of DGs that are going to be connected and the optimal location of these DGs in the system. This method was validated by testing it on the standard 30-bus IEEE system. The results showed a remarkable improvement in the buses' voltage profiles and a reduction in power losses of the system. In [9], integrating the RESs was studied as it gives a significant comfort to Smart Grid technology in terms of cost. In [10], three types of PSO algorithms were used to control the output of DG to find its optimum size. To overcome the issues of variation in RESs, a model of energy optimization was proposed in [11]; it consists of a mathematical tool probability density function to model wind sources and solar. The Author in[12] proposed a methodology for finding the optimal size and placement of many DGs. However, to determine the optimal location, the loss factor is used, and to find the optimal size, they used the algorithm of bacterial foraging. The objectives were to reduce operational costs and losses and to improve the voltage. Their work was validated by testing it on IEEE 119-bus and 33-bus distribution systems. One of the major issues is Intermittency in RESs, RESs integration is studied in [13] by conducting a survey on models from all over the world. The Author found that communication systems, especially two-way communications have an important role in the SG's energy optimization. In [14], combined algorithms inspired by nature were used to optimally find the best place and size of DGs. For DG integration, an optimization technique with two steps got presented. During the first one, particle swarm optimization is used to find the best size of DG, and the results obtained are checked using the approach of negative load for reverse power flow. After that, the optimum location is found by the methods of weak bus and the loss sensitivity factor. During the second one, the optimal size of DGs is found using three algorithms based on nature, i.e., gravitational search algorithm, PSO algorithm, and a combination of those two. By testing them on the 30-bus IEEE system, the effectiveness of the technique has been proved.

In this paper, the Autoadd algorithm is used to find the optimal place and size of a DG in distribution networks. The proposed algorithm is simple, very flexible, easy to use, and supports all types of DG. It differs from the other algorithms by the time that it takes in processing, whereas the other algorithms take a lot of time that could be in some cases hours. This algorithm performs instantly and gives the best place for DGs to achieve the best performance. It is manipulated through the OpenDSS program. The power flow analysis is executed by OpenDSS through the MATLAB com interface. The algorithm and the OpenDSS are validated by testing on the standard IEEE 33-bus system. The results are compared with previous works, which proved that the OpenDSS is reliable, and the Autoadd algorithm gives better results in terms of losses and voltages compared to the earlier studies. After validating the tools, the low voltage Microgrid of Baghdad/Al-Ghazaliya-655 is analyzed, and the DGs are placed optimally to enhance its performance and to assess the capability of the Microgrid to perform in the isolated mode with the objectives of reducing the cost, losses, and minimizing the impact on climate which contribute with the sustainable development goals (SDGs) 7 and 13.

2. IMPACT OF INTEGRATING DISTRIBUTED GENERATION ON LOSSES AND VOLTAGE

2.1. Impact on losses

Integrating DGs proved that they could minimize the losses (real and reactive) due to being placed near the load. Many early studies showed that the size and location of a DG play a significant role in eliminating power losses [15], the location and size of a DG in a distributed network that gives the minimum losses are identified in general as the optimal location and optimal size. The placement procedure of DGs is similar to the placement procedure of capacitors that aims to reduce losses. They differ in that the DG units affect real and reactive powers, whereas capacitors affect just reactive powers. Installing a small DG unit has proven that it may reduce losses for the case of a network with an increment in losses [16].

2.2. Impact on voltage

As known, DG supports and improves the system’s voltage [17], but that is not always accurate, as it has been shown that integrating DGs could cause Undervoltage or overvoltage. Additionally, some DGs change their produced power all the time, like wind generators and photovoltaics. The result of this affects the quality of power badly because of the fluctuation of voltage [8], [18]. In addition to that, Undervoltage and overvoltage are reported in distribution networks integrated with DGs because of the unsuitability of integrated DGs with current methods of regulation. Generally, for regulation, the distribution systems use tap-changing transformers, capacitors, and regulators. Those methods were proved as reliable methods in the past for the unidirectional flow of power. Nevertheless, today, integrating DGs with distribution networks has a significant impact on the performance of methods of voltage regulation because of the power flows in a bidirectional way caused by new DGs on distribution systems. Meanwhile, DGs influence positively on distribution networks due to their contribution to frequency regulation and compensation of reactive power for voltage control. Moreover, in case of faults in the main network, they can work as a spinning reserve [19].

3. AUTOADD ALGORITHM

In this paper, the Autoadd algorithm is used; it is an internal feature of OpenDSS that works automatically to find the optimal location of capacitors and generators. The optimization problem of the analysis of the distribution system in the equation form as in equation (1)

$$\begin{aligned} &\text{Min f}(x,y) = Pl \\ &\text{Subject} - \text{to g}(x,u) \;=\; 0 \qquad\qquad (1) \\ &0.95 \le Vi \le 1.05\,, \end{aligned}$$

where $\text{g}(x,u) = 0$ represents the equation of distribution power flow, PL represents power losses, whereas Vi is the voltage at bus number ith [20]. The equation $\text{Min f}(x,y) = Pl$ calculates the amount of the active and reactive power for every node in order to reduce the losses of the system while keeping voltages within certain limits. In addition to that, OpenDSS uses an iterative algorithm that calculates the unknown voltages and currents. Then, AutoAdd accesses the array of injection currents in the solution directly and takes advantage of it [20]. To move the generators on all the buses, the OpenDSS searches for the available bus that result in the best improvement for capacity and losses on equation (2) below [21]:

$$\text{Minimize } (loss\ weight \cdot losses + UE\ weight \cdot UE) \qquad (2)$$

Loss of weight is losses' Weighting factor in the functions of AutoAdd. UE weight is Unserved Energy's(UE) weighting factor.UE represents load energy that is considered unserved because the power exceeds maximum values

The velocity of convergence of solutions in the autoadd algorithm increases for the reason that the system's admittance matrix is fixed and is not changed. Generally, finding the location of any generator takes about 2-4 iterations for every solution. The improvement factor refers to the next location that is the best to supply power [22]. Figure 3 shows the AutoAdd algorithm.

4. STANDARD IEEE 33-BUS SYSTEM

Figure 4 depicts the standard system of IEEE 33-bus. It has thirty-two branches and thirty-three buses. The voltage level for all the buses is 12.66 kV. The voltage limits for all buses are considered at $\pm 5\,\%$ for maximum and minimum. A synchronous generator feeds the network, the load is 3.715 MW, and 2.3 MVAR is distributed on thirty-two buses with different power factors. The line data and load data of the system are in Table 1 [23].

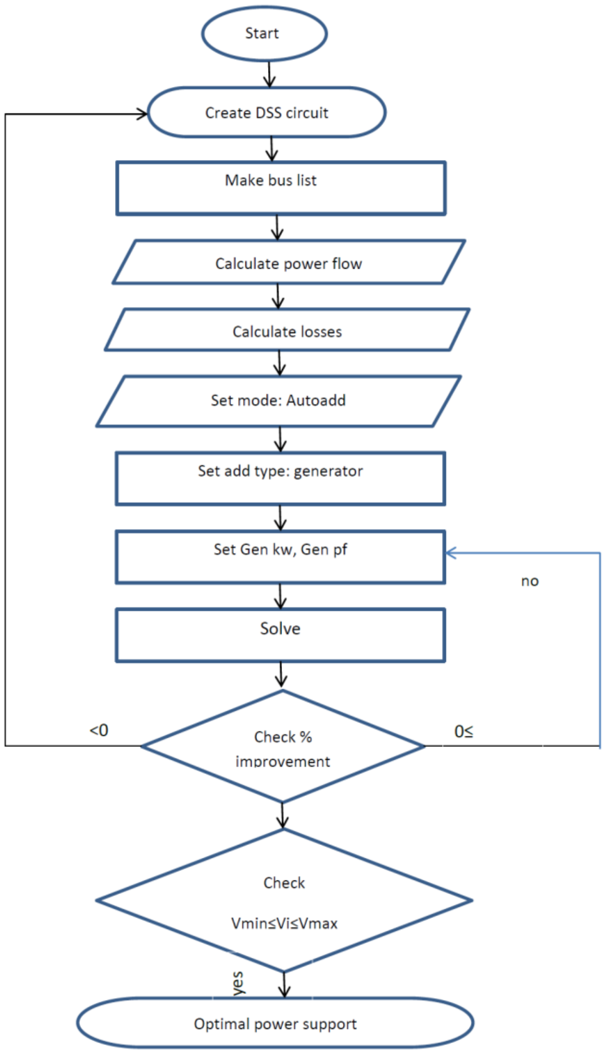

Figure 3. Flow chart of autoadd algorithm.

5. PROPOSED MICROGRID OF BAGHDAD/AL-GHAZALIYA-655

The proposed Microgrid model in Figure 5 represents a distribution system in Iraq Baghdad/Al-Ghazaliya-655. It has fifty-eight buses and fifty-seven branches. The voltages level is 0.4 kV for all the buses.

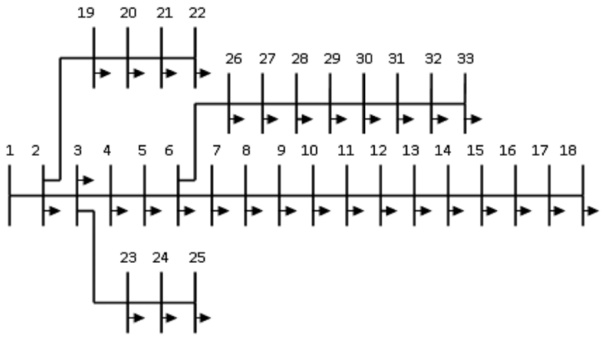

Figure 4. Single line diagram of 33-bus IEEE system.

Table 1. Electrical parameters of 33-bus IEEE system (R_{ij} - resistance, X_{ij} - reactance, P_j - real power, Q_j - reactive power).

Bus 1	Bus 2	R_{ij} in Ω/km	X_{ij} in Ω/km	P_j in kW	Q_j in kVAR	Length in km
1	2	0.0922	0.0477	100	60	1
2	3	0.4930	0.2511	90	40	1
3	4	0.3660	0.1864	120	80	1
4	5	0.3811	0.1941	60	30	1
5	6	0.8190	0.7070	60	20	1
6	7	0.1872	0.6188	200	100	1
7	8	1.7114	1.2351	200	100	1
8	9	1.0300	0.7400	60	20	1
9	10	1.0400	0.7400	60	20	1
10	11	0.1966	0.0650	45	30	1
11	12	0.3744	0.1238	60	35	1
12	13	1.4680	1.1550	60	35	1
13	14	0.5416	0.7129	120	80	1
14	15	0.5910	0.5260	60	10	1
15	16	0.7463	0.5450	60	20	1
16	17	1.2890	1.7210	60	20	1
17	18	0.7320	0.5740	90	40	1
2	19	0.1640	0.1565	90	40	1
19	20	1.5042	1.3554	90	40	1
20	21	0.4095	0.4784	90	40	1
21	22	0.7089	0.9373	90	40	1
3	23	0.4512	0.3083	90	50	1
23	24	0.8980	0.7091	420	200	1
24	25	0.8960	0.7011	420	200	1
6	26	0.2030	0.1034	60	25	1
26	27	0.2842	0.1447	60	25	1
27	28	1.0590	0.9337	60	20	1
28	29	0.8042	0.7006	120	70	1
29	30	0.5075	0.2585	200	600	1
30	31	0.9744	0.9630	150	70	1
31	32	0.3105	0.3619	210	100	1
32	33	0.3410	0.5302	60	40	1

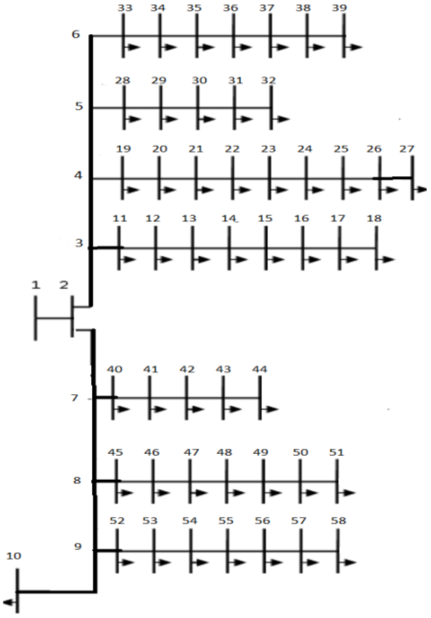

Figure 5. Single line diagram of Baghdad/Al-Ghazalya-655 Microgrid.

Table 2. Electrical parameters of Baghdad/Al-Ghazalya 655 Microgrid.

Bus 1	Bus 2	Resistance in Ω/km	Reactance in Ω/km	Length in km	Active power in kW	Reactive power in kVAR
1	2	0.3416	0.3651	0.001		
2	3	0.3416	0.3651	0.02	15	9.3
3	4	0.3416	0.3651	0.01	20	12.4
4	5	0.3416	0.3651	0.04	30	18.6
5	6	0.3416	0.3651	0.01	20	12.4
2	7	0.3416	0.3651	0.02	20	12.4
7	8	0.3416	0.3651	0.01	15	9.3
8	9	0.3416	0.3651	0.04	15	9.3
3	11	0.3416	0.3651	0.015	10	6.2
11	12	0.3416	0.3651	0.005	10	6.2
12	13	0.3416	0.3651	0.005	10	6.2
13	14	0.3416	0.3651	0.005	15	9.3
14	15	0.3416	0.3651	0.015	15	9.3
15	16	0.3416	0.3651	0.0075	15	9.3
16	17	0.3416	0.3651	0.0075	15	9.3
17	18	0.3416	0.3651	0.015	25	15.5
4	19	0.3416	0.3651	0.015	15	9.3
19	20	0.3416	0.3651	0.005	15	9.3
20	21	0.3416	0.3651	0.005	15	9.3
21	22	0.3416	0.3651	0.005	10	6.2
22	23	0.3416	0.3651	0.005	10	6.2
23	24	0.3416	0.3651	0.005	10	6.2
24	25	0.3416	0.3651	0.005	15	9.3
25	26	0.3416	0.3651	0.015	20	12.4
26	27	0.3416	0.3651	0.015	20	12.4
5	28	0.3416	0.3651	0.015	30	18.6
28	29	0.3416	0.3651	0.015	15	9.3
29	30	0.3416	0.3651	0.015	15	9.3
30	31	0.3416	0.3651	0.015	15	9.3
31	32	0.3416	0.3651	0.015	25	15.5
6	33	0.3416	0.3651	0.015	15	9.3
33	34	0.3416	0.3651	0.015	15	9.3
34	35	0.3416	0.3651	0.005	15	9.3
35	36	0.3416	0.3651	0.005	15	9.3
36	37	0.3416	0.3651	0.005	15	9.3
37	38	0.3416	0.3651	0.015	15	9.3
38	39	0.3416	0.3651	0.015	25	15.5
7	40	0.3416	0.3651	0.015	15	9.3
40	41	0.3416	0.3651	0.015	15	9.3
41	42	0.3416	0.3651	0.015	20	12.4
42	43	0.3416	0.3651	0.015	15	9.3
43	44	0.3416	0.3651	0.015	20	12.4
8	45	0.3416	0.3651	0.015	15	9.3
45	46	0.3416	0.3651	0.015	15	9.3
46	47	0.3416	0.3651	0.015	15	9.3
47	48	0.3416	0.3651	0.015	10	6.2
48	49	0.3416	0.3651	0.005	10	6.2
49	50	0.3416	0.3651	0.005	10	6.2
50	51	0.3416	0.3651	0.005	15	9.3
9	10	0.3416	0.3651	0.03	100	62
9	52	0.3416	0.3651	0.005	10	6.2
52	53	0.3416	0.3651	0.005	10	6.2
53	54	0.3416	0.3651	0.005	15	9.3
54	55	0.3416	0.3651	0.015	15	9.3
55	56	0.3416	0.3651	0.015	20	12.4
56	57	0.3416	0.3651	0.015	20	12.4
57	58	0.3416	0.3651	0.015	40	24.8

Table 3. Comparison of results of Autoadd with other algorithms.

Algorithm	Losses in kW	Minimum voltage	DG location	Size of DG in MW
Proposed method	71.4 kW	0.96839	(14, 24, 30)	(0.76, 1.07, 1.02)
ACSA **[27]**	74.26 kW	0.9778	(14, 24, 30)	(0.7798, 1.125, 1.349)
FWA **[28]**	88.68 kW	0.9680	(14, 18, 32)	(0.5897, 0.1895, 1.0146)
ACO–ABC **[29]**	71.4 kW	0.9685	(14, 24, 30)	(0.7547, 1.0999, 1.0714)
PSO **[30]**	72.8 kW	0.96868	(13, 24, 30)	(0.8, 1.09, 1.053)

The limits of voltages are within ± 5 % for maximum and minimum. The load is 1 MW and 0.62 MVAR distributed on fifty-five buses, as presented in Table 2.

6.ANALYSIS AND RESULTS

6.1. Analysis of test system

The 33-bus IEEE system was modeled in the OpenDSS program. Voltages and losses were calculated using the newton method. A summary is given in Figure 6 and Table 3. The comparison shows that the results were the same as the results obtained by the methods in [24]-[26].

Table 4 shows a list of solutions by researchers in [27]-[30] that find the optimal size and location of three distributed generators that improve losses on the 33-bus IEEE system. In this table, when comparing the algorithm based on the minimum voltage, it can be seen that all the algorithms provide voltages within ± 5 %. For the losses, the proposed algorithm achieved the minimum losses compared to the others. In terms of construction and coding, all the other algorithms require previous knowledge in programming and forming codes to construct them, which is very complex, whereas the Autoadd algorithm is built-in in the OpenDSS program and does not need any coding in formatting it. As for the time of operation, the other algorithms need a high number of iterations to converge, especially the PSO algorithm, and with that number, the computer used for this operation needs to be of high specification, whereas the Autoadd could work with any computer and gives the results instantly.

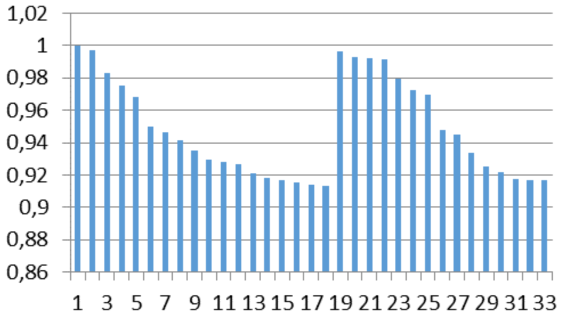

Figure 6. PU bus voltages of 33-bus IEEE system.

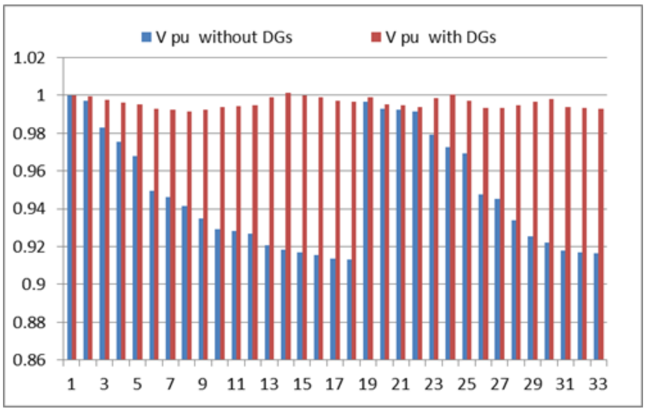

Figure 7. PU voltages before and after adding DGs with Autoadd.

After adding 3 DGs with PF=0.85 the results of network analysis in Figure 7 and Table 5 show the improvement of voltages and reduction of losses

6.2. Analysis of practical network

6.2.1. Grid-connected mode

The load flow is done on the presented network by the fixed-point method for different loads 100 %, 90 %, 80 %, 70 %, 60 %, 50 %, and 40 %, at hours (12 pm, 7 pm, 8 pm, 10 am, 9 am, 12 am, 5 am) untill the voltage be within ± 5 %,then the size of generation will be selected based on that. The results are shown in Table 6.

After the analysis of the system, it was decided to add 3 DGs with a total size of 600 kW to minimize losses and improve voltages to be within ± 5 %. The optimal place and size of DGs were found by the Autoadd algorithm as in Table 7.

After the addition of DGs, the voltage has been improved for all the buses of the proposed system for the four-level of loads, as presented in Figure 8 to Figure 14. Moreover, the losses of the system have decreased significantly, as in Figure 15, and that is because the distributed generators are located near the load.

6.2.2. Isolated mode

In this section, the possibility of isolating the Microgrid during the fault time is going to be discussed. As the total load of the network equals 1 MW at peak time and 500 kW at low demand times, the total generation will be leveled up to 1.2 MW by adding two standby units for this scenario to cover the load as in Table 8.

A time-series load flow is applied for 24 hours and the cases of (100%,75%,50%) at hours(12 am, 10 am, 12 pm) were taken

Table 4. Power flow analysis on 33-bus IEEE compared with other research.

Algorithm	Losses	Minimum voltage pu	Location of bus
Proposed method	202.6 kW	0.913	18
[24]	202.7 kW	0.9131	18
[25]	202.6 kW	0.913	18
[26]	202.6 kW	0.913	18

Table 5. Losses and minimum voltages before and after adding 3DGs.

Without DG		With three DGs	
Losses in kW	Minimum voltage & bus	Losses in kW	Minimum voltage & bus
202.6 kW	0.913 (18)	12.29	0.99178 (18)

Table 6. Power flow results of the proposed system.

Percentage of load	Total load in kW	Losses in kW	Min voltage & bus
100 %	1000	74.4	0.873(39)
90 %	900	58.95	0.88796(39)
80 %	800	45.5	0.9017(39)
70 %	700	34.17	0.915(39)
60 %	600	24.59	0.92807(39)
50 %	500	16.7	0.94075(39)
40 %	400	10.52	0.95312(39)

Table 7. Results of optimum size and location selection for connected mode.

DG type	Size in MW	Location	PF
Diesel engine	0.3 MW	5	0.85
PV	0.2 MW	10	1
Fuelcell	0.1 MW	57	0.9
Total	0.6 MW		

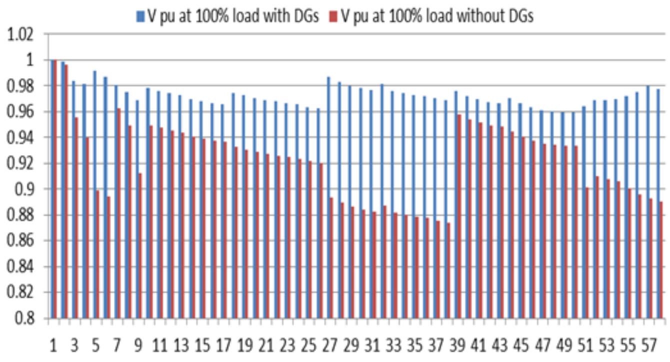

Figure 8. Voltages of all buses at 100% load before and after the addition.

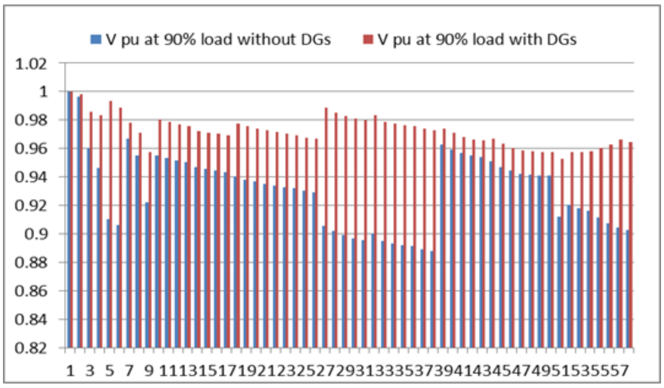

Figure 9. Voltages of all buses at 90% load before and after the addition.

Table 8. Results of optimum size and location selection for isolated model

DG type	Size in MW	Location	PF
Diesel engine a	0.3 MW	5	0.85
Diesel engine b	0.5 MW	7	0.85
PV	0.2 MW	10	1
Fuel cell	0.1 MW	57	0.9
Micro turbine	0.1 MW	25	0.9
Total	1.2 MW		

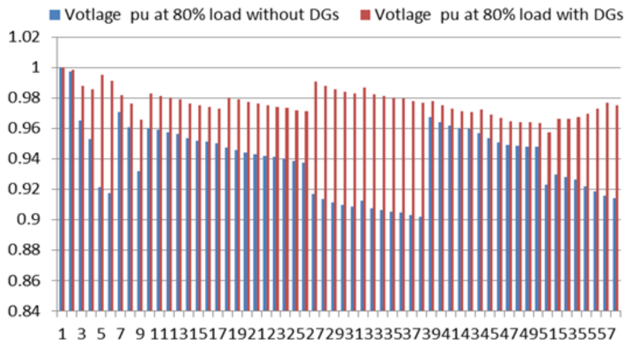

Figure 10. Voltages of all buses at 80% load before and after the addition.

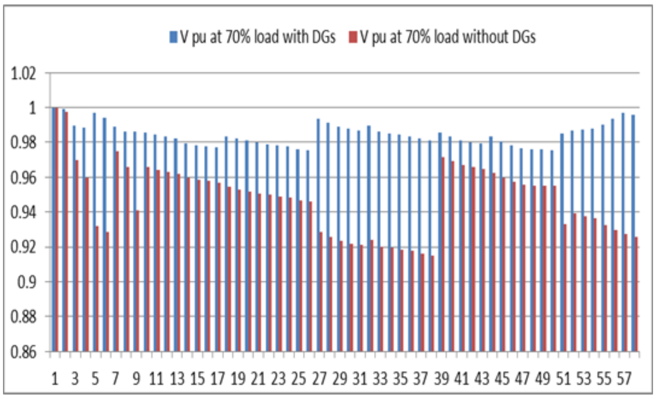

Figure 11. Voltages of all buses at 70% load before and after the addition.

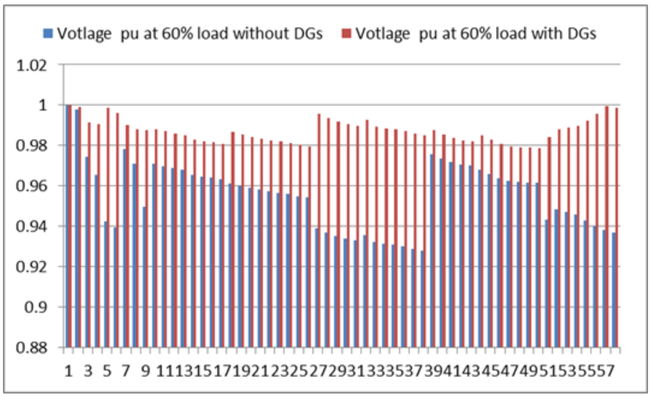

Figure 12. Voltages of all buses at 70% load before and after the addition.

to evaluate for different load and irradiance cases, the results are shown in Figure 16 and Figure 17.

The minimum voltage for all the cases is within ± 5, and the system can operate successfully in the isolated mode. The losses are less in case of 100 % than 50 % even though the load is higher due to the PV isn't working at night.

7. DISCUSSION

For increasing the performance of Microgrids by improving the voltage and reducing the losses and at the same time reducing the effect of GHG by integrating RES this paper is conducted. The results showed that DGs have a major impact on the voltage profiles.

The DGs increased the level of voltage for all the studied cases, and it is proportional to the capacity of the DG. It can be noticed from the results of simulations that the location of the

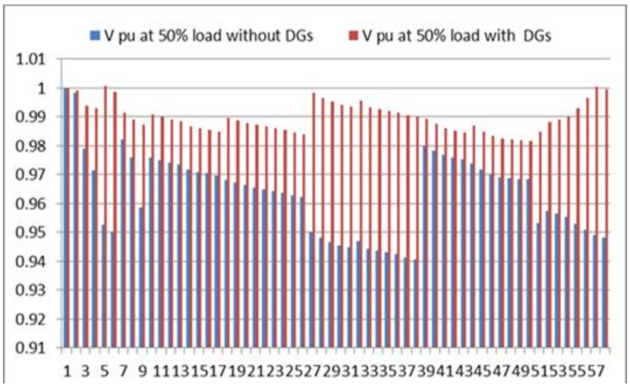

Figure 13. Voltages of all buses at 50% load before and after the addition.

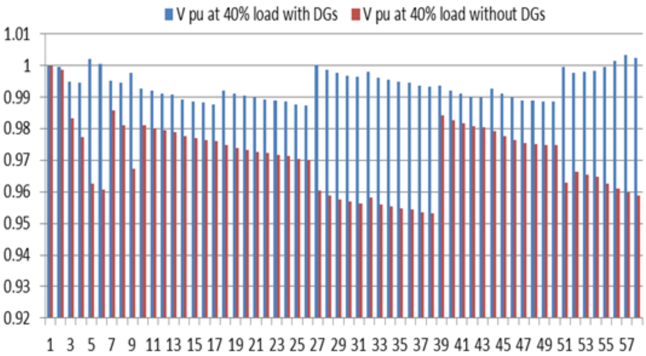

Figure 14. Voltages of all buses at 40% load before and after the addition

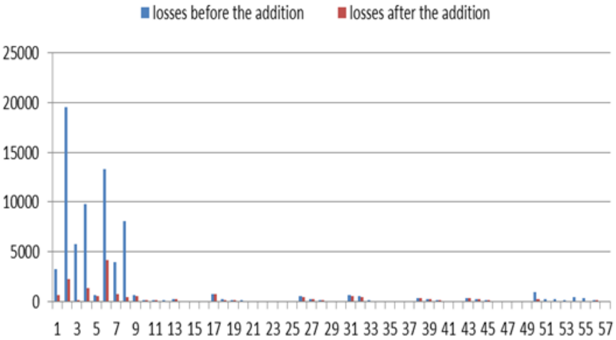

Figure 15. Losses of all buses before and after the addition for 100% case

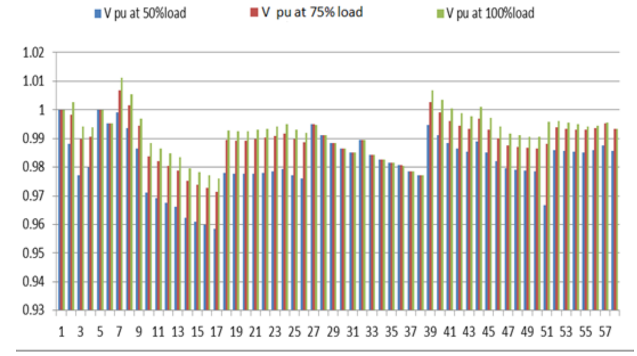

Figure 16. Voltages of all buses for (50%, 75%, and 100%) load.

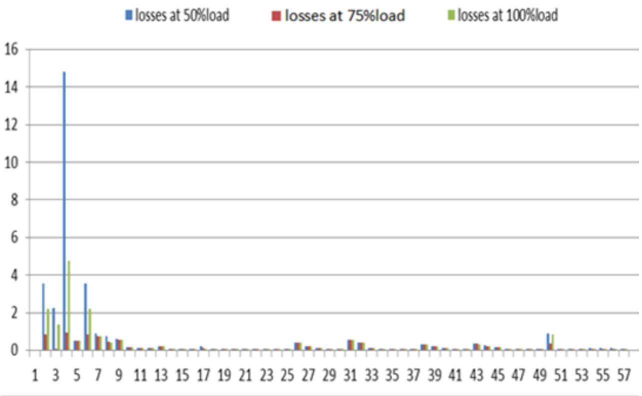

Figure 17. Losses of all buses for (50%, 75%, and 100%) load.

DG is important for the whole network, and that is shown in the results. As for the losses, it can be seen from the results that the size of DG is important, and that has been noticed that where the bigger the size gets, the more reduction in losses. The Autoadd algorithm is used to find the optimal size of DGs; this algorithm is fast, accurate, and very easy to use, so it does not need any prior experience or learning to use it. The proposed algorithm was applied to the IEEE 33-bus, and the results were compared against the results of other research in Table 4. The results showed that the suggested algorithm is effective in finding the optimal size and location of DGs and helps in achieving better results in terms of losses reduction and voltage improvement, so it was used for the real system to install many types of DGs that improved the voltage and losses as in the results. The scenario of isolating the low voltage Microgrid is applied for the first time in an Iraqi case to solve the problem of intermittency of power, and the result showed it was successful. Some parameters have not been taken in this work that should be mentioned which are the annual variation of load and the economic issues related to the installation of the DG unit. The Loads in the distribution network vary continually, and that results in the variation of the network's losses and voltages. But On the other hand, a large PV system of 200 kW and a Fuel-cell of 100 kW have been installed, which are pollution-free, so they don't affect the nature and run on low cost.

8. CONCLUSION

In this paper, the reduction of losses and improvement of voltage has been discussed, and the Autoadd algorithm has been introduced and used for finding the optimal size and location of DG. The IEEE 33-bus has been used to test the proposed algorithm, and the results of the work were compared against results from other studies, the comparison proved that the proposed algorithm is acceptable and helps in achieving more efficient DG integration. The problem of intermittency of electrical power is solved for the Iraqi case considering the maximum load condition. The Future work will be using the practical Microgrid in this work after the addition of the DGs and the improvement of voltage and losses to integrate the electric vehicles to prepare a suitable electrical environment for them to achieve zero pollution in the transportation sector and take into consideration the installation cost of DGs, charging stations and the variation of the loads.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

REFERENCES

[1] T. Addabbo, A. Fort, M. Mugnaini, L. Parri, S. Parrino, A. Pozzebon, V. Vignoli, A low-power IoT architecture for the monitoring of chemical emissions, Acta IMEKO 8(2) (2019), pp. 53-61.
DOI: 10.21014/acta_imeko.v8i2.642

[2] Y. Zahraoui, M. R. Basir Khan, I. AlHamrouni, S. Mekhilef, M. Ahmed., Current Status, Scenario, and Prospective of Renewable Energy in Algeria: A Review. Energies, 14(9) (2021)
DOI: 10.3390/en14092354

[3] IEA (2021), World Energy Outlook 2021, IEA, Paris, Online [Accessed 28 August 2022]
https://www.iea.org/reports/world-energy-outlook-2021

[4] A. S. Hassan, A. Firrincieli, C. Marmaras, L.M. Cipcigan, M.A. Pastorelli, Integration of electric vehicles in a Microgrid with distributed generation, 49th International Universities Power Engineering Conference (UPEC), 2014.

[5] N. W. A. Lidula, A. D. Rajapakse, Microgrids research: A review of experimental Microgrids and test systems. Renewable and Sustainable Energy Reviews 15(1) (2011), pp. 186-202
DOI: 10.1109/TII.2018.2819169

[6] Y. Yan; Y. Qian; H. Sharif; D. Tipper, A Survey on Smart Grid Communication Infrastructures: Motivations, Requirements and Challenges. IEEE Communications Surveys & Tutorials, 2013. 15(1), pp. 5-20.
DOI: 10.1109/SURV.2012.021312.00034

[7] S. C. Reddy, P. V. N. Prasad, A. J. Laxmi, Power quality and reliability improvement of distribution system by optimal number, location and size of DGs using Particle Swarm Optimization. in 2012 IEEE 7th International Conference on Industrial and Information Systems (ICIIS), 2012

[8] V. Vita, T. Alimardan, L. Ekonomou. The Impact of Distributed Generation in the Distribution Networks' Voltage Profile and Energy Losses. in 2015 IEEE European Modelling Symposium (EMS), 2015.

[9] M. Husain Rehmani; M. Reisslein; A. Rachedi; M. Erol-Kantarci; M. Radenkovic., Integrating Renewable Energy Resources Into the Smart Grid: Recent Developments in Information and Communication Technologies. IEEE Transactions on Industrial Informatics 14(7) (2018), pp. 2814-2825
DOI: 10.1109/tii.2018.2819169

[10] J. J. Jamian; M. W. Mustafa; H. Mokhlis; M. N. Abdullah, Comparative Study on Distributed Generator Sizing Using Three Types of Particle Swarm Optimization, Third Int. Conference on Intelligent Systems Modelling and Simulation. 2012.

[11] D. Mazzeo, G. Oliveti, E. Labonia, Estimation of wind speed probability density function using a mixture of two truncated normal distributions. Renewable Energy 115 (2018) pp. 1260-1280
DOI: 10.1016/j.renene.2017.09.043

[12] K. R. Devabalaji, K. Ravi, Optimal size and siting of multiple DG and DSTATCOM in radial distribution system using Bacterial Foraging Optimization Algorithm. Ain Shams Engineering Journal, 2016. 7(3), p. 959-971
DOI: 10.1016/j.asej.2015.07.002

[13] K. S. Alimgeer, Z. Wadud, I. Khan, M. Usman, A. B. Qazi, F. A. Khan, An Innovative Optimization Strategy for Efficient Energy Management With Day-Ahead Demand Response Signal and Energy Consumption Forecasting in Smart Grid Using Artificial Neural Network. IEEE Access, 2020, 8: p. 84415-84433
DOI: 10.1109/access.2020.2989316

[14] A. Ramamoorthy, R. Ramachandran, Optimal siting and sizing of Multiple DG units for the enhancement of voltage profile and Loss Minimization in transmission Systems using Nature Inspired Algorithms. The Scientific World Journal (2016), art. no. 1086579.
DOI: 10.1155/2016/1086579

[15] A. Hasibuan, S. Masri, W. A. F. W. B. Othman, Effect of distributed generation installation on power loss using genetic algorithm method. IOP Conference Series: Materials Science and Engineering 308 (2018) art. no. 012034
DOI: 10.1088/1757-899x/308/1/012034

[16] A. Nieto, Power Quality Improvement in Power Grids with the Integration of Energy Storage Systems. International Journal of Engineering and Technical Research 5 (2016), pp. 438-443.

[17] A. Amos Ogunsina, M. Omolayo Petinrin, O. Olayemi Petinrin, E. Nelson Offornedo, J. Olawole Petinrin, G. Olusola Asaolu, Optimal distributed generation location and sizing for loss minimization and voltage profile optimization using ant colony algorithm, SN Applied Sciences, 2021. 3(2), p. 248.
DOI: 10.1007/s42452-021-04226-y

[18] V. S. Lopes, C. L. T. Borges, Impact of the Combined Integration of Wind Generation and Small Hydropower Plants on the System Reliability. IEEE Transactions on Sustainable Energy 6(3) (2016), pp. 1169-1177.
DOI: 10.1109/TSTE.2014.2335895

[19] S. Habib, M. Kamran,U. Rashid, Impact analysis of vehicle-to-grid technology and charging strategies of electric vehicles on distribution networks – A review, Journal of Power Sources, 2015. 277, p. 205-214.
DOI: 10.1016/j.jpowsour.2014.12.020

[20] S. Singh, D. Shukla, S. P. Singh, Peak demand reduction in distribution network with smart grid-enabled CVR. in 2016 IEEE Innovative Smart Grid Technologies - Asia (ISGT-Asia). 2016.

[21] R. C. Dugan, Institute, EPR OpenDSS Manual, Train. Mater., pp. 1–184, 2019.

[22] M. Nasser, I. Ali, M. Alkhafaji, Optimal Placement and Size of Distributed Generators Based on Autoadd and PSO to Improve Voltage Profile and Minimize Power Losses. Engineering and Technology Journal 39(3A) (2021), pp. 453-464.
DOI: 10.30684/etj.v39i3A.1781

[23] O. D. Montoya, W. Gil-González, C. Orozco-Henao, Vortex search and Chu-Beasley genetic algorithms for optimal location and sizing of distributed generators in distribution networks: A novel hybrid approach, Engineering Science and Technology, an International Journal 23(6) (2020), pp. 1351-1363
DOI: 10.1016/j.jestch.2020.08.002

[24] R. Rao, S. Narasimham, M. Ramalingaraju, Optimization of Distribution Network Configuration for Loss Reduction Using Artificial Bee Colony Algorithm. 2007, 1.

[25] M. E. Soliman, A. Y. Abdelaziz, R. M. El-Hassani, Distribution power system reconfiguration using whale optimization algorithm. Int. Journal of Applied Power Engineering, 9 (2020), pp. 48-57.

[26] A. Y. Abdelaziz, R. A. Osama, S. M. Elkhodary, Distribution Systems Reconfiguration Using Ant Colony Optimization and Harmony Search Algorithms. Electric Power Components and Systems 41(5) (2013), pp. 537-554.
DOI: 10.1080/15325008.2012.755232

[27] T. T. Nguyen, A. V. Truong, T. A. Phung, A novel method based on adaptive cuckoo search for optimal network reconfiguration and distributed generation allocation in distribution network. International Journal of Electrical Power & Energy Systems 78 (2016), pp. 801-815.
DOI: 10.1016/j.ijepes.2015.12.030

[28] A. Mohamed Imran, M. Kowsalya, D. P. Kothari, A novel integration technique for optimal network reconfiguration and distributed generation placement in power distribution networks. Int. Journal of Electrical Power & Energy Systems 63 (2014), pp. 461-472.
DOI: 10.1016/j.ijepes.2014.06.011

[29] M. R. AlRashidi, M. F. AlHajri, Optimal planning of multiple distributed generation sources in distribution networks: A new approach, Energy Conversion and Management, 2011. 52(11), p. 3301-3308.
DOI: 10.1016/j.enconman.2011.06.001

[30] M. Kumar, P. Nallagownden, I. Elamvazuthi, Optimal placement and sizing of distributed generators for voltage-dependent load model in radial distribution system. Renewable Energy Focus (19-20) (2017), pp. 23-37.
DOI: 10.1016/j.ref.2017.05.003