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Regular paper

Enhancement of radial distribution network with distributed generation and system reconfiguration

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This paper investigates the performance enhancement of Radial Distribution Network (RDN) integrated with Distributed Generation (DG), using optimal placement and sizing of DG and applying the required network reconfiguration. Binary Particle Swarm Optimization (BPSO) has been used to decide the best changing Sectionalizing Switches' (S.S) and Tie Switches' (T.S) status between on and off. The best location and size for DG are optimized using typical Particle Swarm Optimization (PSO). The objective function of the optimization problem is minimizing the power losses. The study has been applied to a real network with 59-bus Cairo distribution system, Egypt. Different scenarios of network operation and DG placement have been obtained. The results demonstrate that the reconfiguration of RDN firstly then optimize the placement and size of the DG penetration could reduce the network losses by 53.7%.

Keywords: Distributed generation; system reconfiguration; daily loading; power losses; particle swarm optimization.

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1. Introduction

The distribution network's main concern is to ensure delivering power to customers. In order to achieve continuity in power supplying; system stability and load balancing have to be observed. The radial distribution networks (RDN) mostly suffers from voltage instability problems. Voltage reduction caused by power losses could drop under the accepted limits and block the power delivered to the network. Distributed Generation (DG) is a small generation unit directly connected to the distribution network to enhance the network performance. DG optimum placement and sizing achieve minimum power losses and improve the voltage profile of the system [1]. Network reconfiguration is considered an operational technique to achieve minimum power losses. By changing the Sectionalizing Switches' (S.S) and Tie Switches' (T.S) status between on and off, the load flow starts to change. The optimal operating conditions are obtained to minimize the power losses and balance the load of each feeder [2].

In recent years, the use of Artificial Intelligence (AI) based techniques for network reconfiguration has proved to achieve enhanced network operation, as mentioned in [3-6]. The Genetic Algorithm (GA) was used in the meshed distribution network configuration to achieve minimum losses [3]. Numerous researchers focused on Partial Swarm Optimization (PSO) as optimizing technique because it is easy to set parameters and costs less time than GA. Traditional PSO adopts continuous encoding, but reconfiguration of distribution feeders is a discrete issue, so Binary Particle Swarm Optimization (BPSO) encoding was used [4]. The hybrid algorithm of PSO with Ant Colony Optimization (ACO) has been applied for optimum system configuration in the study [5] which aims to decrease the system losses and improve the voltage profile. In [6] Harmony search Algorithm (HAS) was used to get the optimal configuration of RDN to achieve minimum losses.

Using renewable DG systems as Photovoltaic (PV) plants and wind turbines (WT) plants are considered a modern effective solution to meet the demand load. Different researches

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developed diverse optimization strategies to decide the optimal penetration of the DG [7-8]. Both the analytical approach and the PSO algorithm are proposed for the long term and short term planning for the optimal DG units' management [9]. (GA),(PSO) and biogeography-based optimization (BBO) technique has been used to determine the optimal placement and sizing of different types of DGsconsider a single or multiobjective function to minimizing the power and energy losses while improving the overall voltage stability index in [10-13]. Firefly algorithm (FA) is used to decide the optimal sizing of DG unit and placement to enhance the voltage stability by minimizing the network losses [14-15]. Ant-lion inspired algorithm (ALIA)has been utilized to optimize the RDN performance integrated with different types of DGs by minimizing the losses and mitigate the voltage stability indexconsidering the daily loading profile [16].

Modified flower pollination algorithm (MFPA) has been presented to determine the optimal location of a DG to minimize the network losses in the study [17]. In [18], Improved Versions of Genetic Algorithm (IGA), Improved Particle Swarm Optimization (IPSO) and Improved Cat Swarm Optimization (ICSO) manage the problem of the allocation of DG units and shunt capacitor. Quantum particle swarm algorithm (QPSO) has been suggested to determine (PV)and (WT) to minimize the power losses in the study [19].Multiple objective NSGA-II method along with fuzzy satisfying method (FSM) has been used to determine the optimal DG sitting and sizing considering active power loss index (APLI), line loading index (LLI) and voltage deviation index (VDI) in [20]. In [21], hybrid Particle Swarm Optimization in addition to a Gravitational Search Algorithm (PSOGSA) and Moth-Flame Optimization (MFO) are proposed to realize the location and the size of (PV) and (WT) based on minimizing the power losses and the operation cost.

Aiming to improve the voltage stability and reduce the network losses, new methodologies of reconfiguration networks integrated with DGs have been proposed in recent researches. Different techniques as (PSO), (FA), gravitational search algorithm [22] and (GA) with respect to dynamic time-varying loads [23] are suggested to solve the problem of feeder reconfiguration with distributed generations. The distribution network reconfiguration problem in the existence of different DGs using the modified PSO algorithm is presented [24-25].

Improved binary PSO (IBPSO) algorithm indicated that the optimal configuration of the distribution network with DG is capable of reducing power loss and improving the voltage profile and reliability of the network significantly [26]. Methodology for distribution system feeder reconfiguration considering a different model of DGs based on Decimal coded quantum PSO (DQPSO) was applied [27].Reconfiguration of the smart distribution network in the existence of renewable DG's using Grey Wolf Optimizer (GWO) Algorithm has been proposed in [28]. Multi-objective approach NSGA-II method along with fuzzy and bacterial foraging optimization (BFO) accompanied by fuzzy are recently involved in solving the stochastic modeling of using simultaneous reconfiguration and optimal DGs sizing and shunt capacitors in a distribution system [29-31].

This paper presents different scenarios of incorporations between system reconfiguration and DG integration to improve RDN's performance. The proposed strategy optimizes the sizing of DG and clarifies the optimal placement using PSO technique. Also, BPSO is used to submit the required network reconfiguration. Different scenarios are applied to study the case of real RDN to minimize the power losses and achieve voltage stability enhancement.

2. Notation

The notation used throughout the paper is stated below.

RDN	radial distribution networks
DG	distributed generation
PSO	particle swarm optimization
BPSO	binary particle swarm optimization
v_i^{new}	New velocity of particle i
v_i^{old}	Old velocity of particle i obtained in previous iteration
x_i^{new}	New position of particle i
x_i^{old}	Old position of particle i obtained in previous iteration
w_i	Weight function for velocity of particle i
$rand(o)$	Independent uniform random number
c_1, c_2	Learning factors
p_i^{best}	Best solution of particle i found in previous iteration
g_i^{best}	Best solution of particle i ever found the calculation

3. Problem formulation

3.1. Objective function

The reduction of total power losses and enhancement of the voltage profile of the network could be achieved by finding the best configuration of the RDN integrated by DG units with optimal location and size while the imposed operating constraints are satisfied. The objective function is minimizing the active power losses as follows:

$$Ploss = \sum_{i=1}^{nb} I\mathrm{i}^2 R\,\mathrm{I} \tag{1}$$

Where nb is the no. of branches, $\mathcal{R}i$, and Ii are the ith branch resistance and current respectively.

3.2. Constraints

- Load flow equation:

$$Psource + PDG = Ploss + Pload \tag{2}$$
$$Qsource + QDG = Qloss + Qload \tag{3}$$

- Voltage constraints: the system voltage limits, that is, ± 5% of the nominal value:

$$0.95\ pu \leq |Vi| \leq 1.05\ pu \tag{4}$$

- DG unit size:

$$PDG < 10\ \%\ \Sigma Pdemand \tag{5}$$

- Distribution system should be kept in a redial structure

4. Optimization Technique:

4.1. Particle swarm optimization

The concept of the PSO technique came from observing the behavior of a group of birds during their act of searching for food. Every member of the group could be considered as a possible solution. Every single solution represents a particle in searching space with fitness value evaluated by objective function to find the best solution for itself [32]. All particles update their position and velocity to get the best solution according to this equation:

$$v_i^{new} = w_i . v_i^{old} + c_1 . rand(o) . \left[p_i^{best} - x_i^{old}\right] + c_2 . rand(o) . \left[g_i^{best} - x_i^{old}\right] \quad (6)$$

$$x_i^{new} = x_i^{old} + v_i^{new} \quad (7)$$

4.2. Binary particle swarm optimization

BPSO was proposed in 1997 [33]. The binary edition of PSO has defined the relevant variables (velocities and positions of the particles) by changes of probabilities while the particles are represented by value either 0 or 1. The position of each particle is constrained to the interval [0, 1] and updated based on its velocity. The speed of particle could be limited by following sigmoid transfer function:

$$S(v_{id}^{new}) = \frac{1}{1 + e^{-v_{id}^{new}}} \quad (8)$$

The particle's pbest and gbestare updated in the same equation (4) of typical PSO to find the velocity of the particle. The velocity is restricted to the interval [0, 1] using sigmoid function (9). The new position of the particle is updated according to the following equation:

$$\begin{aligned} if\left(rand(o) < S(v_{id}^{new})\right)\ then\ x_{id}^{new} &= 1 \\ eslse\ x_{id}^{new} &= 0 \end{aligned} \quad (9)$$

5. Case study

In this current work, Study case of real RDN with 59-bus Cairo distribution system, Egypt is obtained. Results of medium voltage levels 22 kV for Cairo network are considered. The proposed technique of BPSO and typical PSO are applied to achieve the best reconfiguration and DG placement and sizing penetration using MATLAB programming software. The software program determines the optimum injected active and reactive power related to their power factor to minimize the power losses. Different operation scenarios are applied to Cairo RDN according to the network topology.

Scenario 1:Initial condition without DG penetration and before reconfiguration
Scenario 2:Reconfiguration of the system without DG penetration using BPSO
Scenario 3:Optimize sizing and location of 5 DG penetration in the system using PSO after reconfiguration results of Scenario 2

Scenario 4:Optimize sizing and location of 5 DG penetration in the system using PSO
Scenario 5:Reconfiguration of the system using BPSO after applying the DG penetration results of Scenario 4

5.1. Case study Cairo-59 bus radial distribution network:

Diverse scenarios of DG penetration and system reconfiguration are applied on real distribution network Cairo-59 bus RDN. The Cairo-59 bus RDN has 22 KV operation voltages, 100 MVA power base and 50.348 MW, 21.448 MVAR total power load. The real system consists of 59 buses with 65 normally closed (S.S) and 6 normally open (T.S) which are branches number [59-60-61-62-63-64]. The Five DGs are integrated into the system before and after applying the reconfiguration method to minimize the power losses of the system. BPSO and PSO techniques are used with parameters of population size 30 and maximum iteration of 200. The voltage constraints are set to be 0.95 and 1.05 p.u. Each bus changes the loading value during the 24 hours a day according to the customer loading pattern. Cairo-59 bus RDN gives three different daily loading models. The three daily loading curves M1, M2,and M3 are obtained in figures (1) respectively. Each bus loading in the network is presented by one of the loading models which are obtained in the table (1).The daily loading profile of the feeder at bus 1 is obtained according to the changes in the loading at each bus during the day. The substation daily loading profile is illustrated in figure (2). The peak load is 50.348 MW at hour 9 to hour 12 (from 8 am to 11 am).

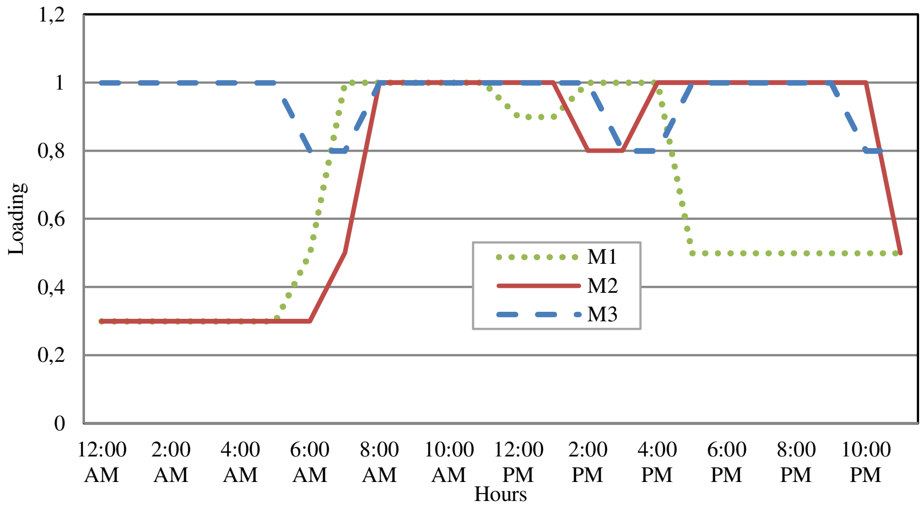

Fig.1. Daily loading curves M1, M2,and M3 for different busses in Cairo-59 bus RDN

Table 1: Loading models for each bus in Cairo-59 RDN

Loading Model	Bus Number
M1	(5,6,8,14,15,19,25,27,29,34,35,37,39,40,52,54)
M2	(2,3,7,9,12,13,16,21,22,24,26,31,32,36,41,43,48,55,56,57,58,59)
M3	(4,10,17,18,20,23,28,30,33,38,42,44,45,46,47,49,50,53)

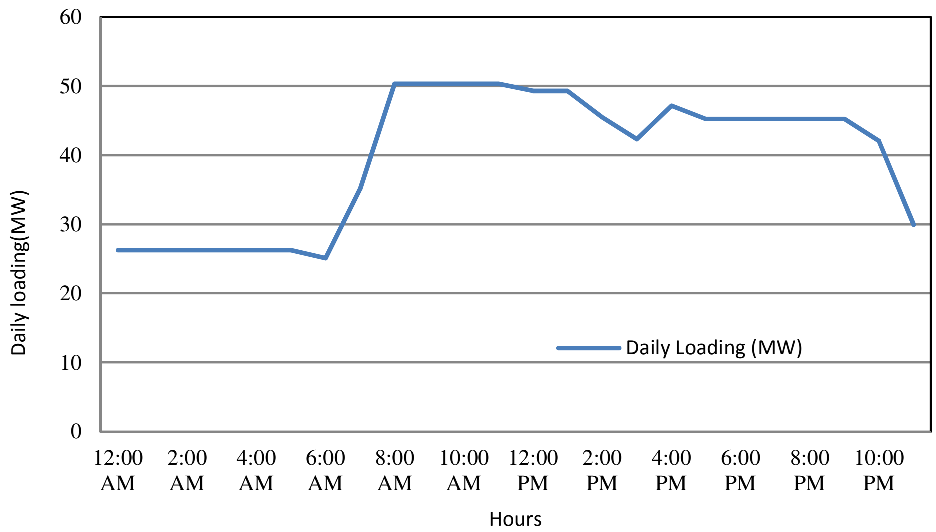

Fig.2. Daily loading profile of substation on bus 1

Considering the worst operation state at peak hour, five different scenarios are applied on Cairo-59 bus RDN. The results of system topology changes with the applied scenarios as follows. The first scenario is considered to be the initial condition. The results of the next four scenarios are compared to the initial condition's results. The system topology is obtained in figure (3) without DG penetration and before reconfiguration. Six (T.S) numbers [59-60-61-62-63-64] are open. In the second scenario, optimum reconfiguration is obtained after using BPSO technique on Cairo-59 bus RDN system at initial condition topology mentioned in the first scenario. The reconfiguration changes four branches statuses. The (S.S) of [7-38-47-55] are opened and (T.S) of [59-61-62-64] are closed. The second scenario results show improving in voltage profile and decreasing in total power losses of the system.

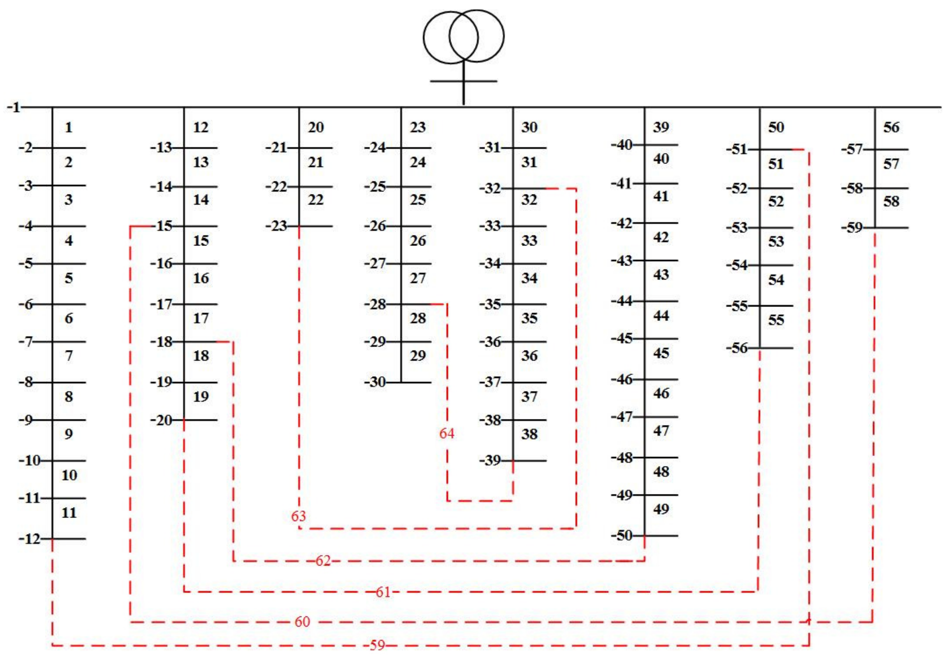

Fig.3. Cairo-59 bus system

The third scenario discusses the results of a newly modified network topology demonstrated in figure (4) after reconfiguration and DG penetration. Five DGs are implemented on a modified network topology of Cairo-59 bus RDN which are mentioned in the second scenario. PSO determines the same power rating of (1MW and 0.75 MVAR) for five DGs implemented on buses number (7,29,47,49,56) as an optimal solution for size and placement of the DGs. The results show improving in voltage level and decreasing in total power losses and after spread DGs on the network. The fourth scenario shows the five DGs penetration which are distributed on the original network topology of Cairo-59 bus RDN which are mentioned in the first scenario. The PSO determines the optimum sizing and placement of the DGs. The DGs are implemented on buses number (10,12,48,49,50) with the same power rating of (1MW and 0.75 MVAR) for five DGs. The results show decreasing in total power losses and improving in voltage level at each bus after DG penetration.

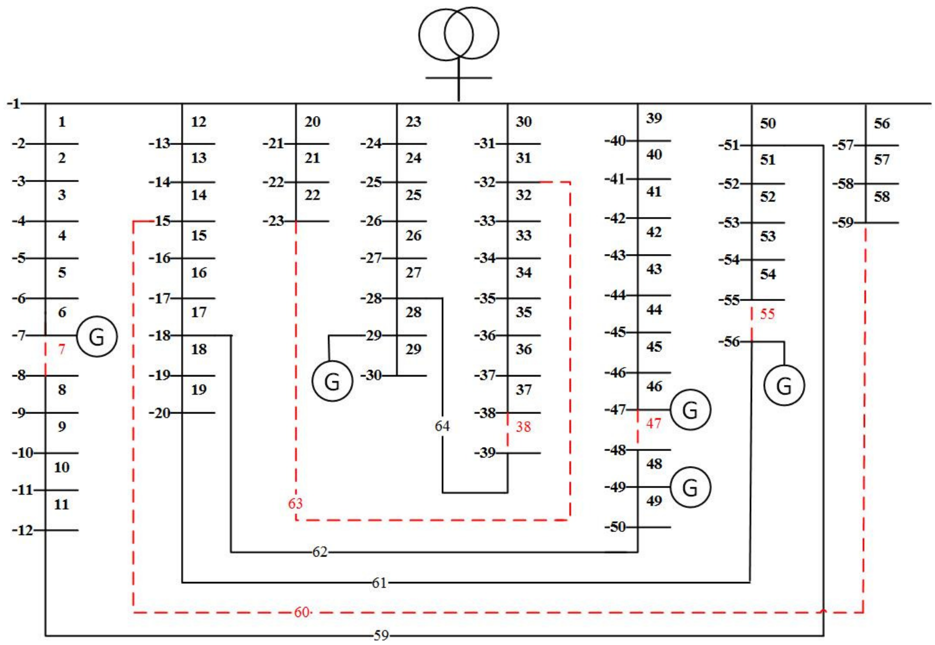

Fig.4. Cairo-59 bus system after reconfiguration and DG penetration

The fifth scenario applies BPSO technique on Cairo-59 bus RDN system with five DGs penetration which are mentioned in the fourth scenario to achieve the optimum reconfiguration. The reconfiguration changes four branches statuses as presented in figure (5). The (S.S) of [7-38-47-55] are opened and (T.S) of [59-61-62-64] are closed. Table (2) presents the results of CAIRO-59 bus network performance under different scenarios of network reconfiguration integrated with DGs units. The results demonstrate different performance indicators for each scenario. Results show the decrease in active and reactive power losses compared to the first scenario which submitted as an initial condition. Also, it shows the highest and lowest voltage level of the network and the minimum value of the voltage stability index (VSI). From a practicalperspective, the daily loading variation of each bus will affect the DG penetration and will change the network configuration. The results of system performance are discussed according to the daily behavior of the load.

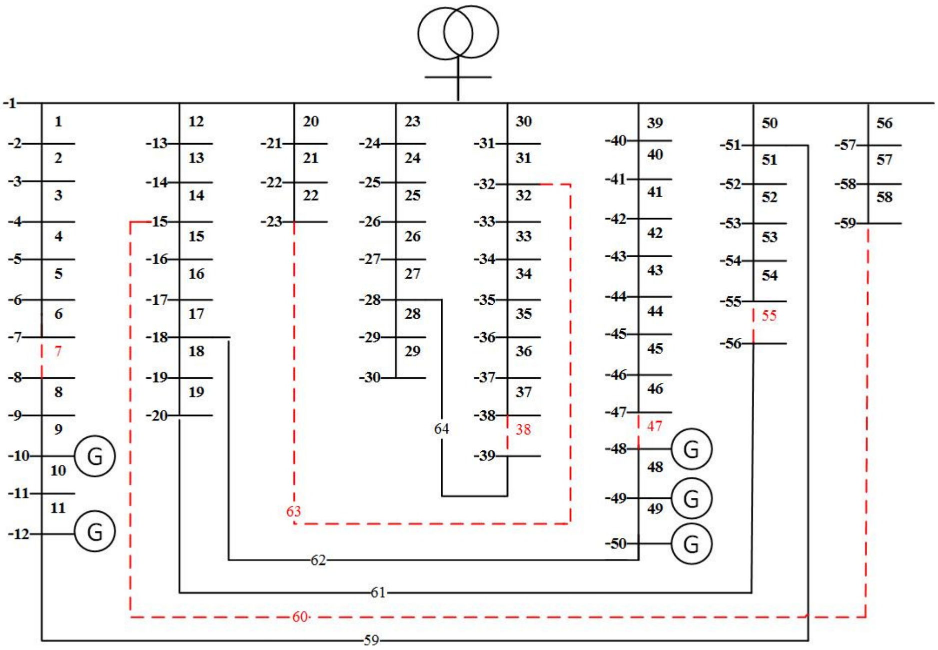

Fig.5. Cairo-59 bus system with DG penetration and after reconfiguration

Table 2: Cairo-59 bus network performance results

Scenario	1	2	3			4			5
DG Penetration	------	------	Location	DG_MW	QG_MVAr	Location	DG_MW	QG_MVAr	------
			7	1	0.75	10	1	0.75	
			29	1	0.75	12	1	0.75	
			47	1	0.75	48	1	0.75	
			49	1	0.75	49	1	0.75	
			56	1	0.75	50	1	0.75	
Tie Switch (NO)	59	7	7			59			7
	60	38	38			60			38
	61	47	47			61			47
	62	55	55			62			55
	63	60	60			63			60
	64	63	63			64			63
Ploss (kW)	218.99	151.09	101.39			126.46			122.75
Reduction in Ploss%	------	31.01	53.70			42.26			43.95
Qloss(kVAr)	130.90	90.31	60.60			75.59			73.37
Reduction in Qloss%	------	31.01	53.70			42.26			43.95
Vmin (P.U)/bus	0.9865 /50	0.9933 /56	0.9948 /20			0.9934 /50			0.9944 /8
Vmax (P.U)/bus no.	1.000 /1	1.000 /1	1.000 /1			1.000 /1			1.000 /1
VSI min	0.9469	0.9733	0.9792			0.9739			0.9776

Different scenarios' results of CAIRO-59 bus network performance due to network reconfigurations and DGs penetration are obtained in the table (2). In the first scenario which is considered as the initial condition, the total active power loss is 218.99 kW and the total reactive power losses is 151.09 kVAr. After applying the reconfiguration method on the network in scenario 2, the total active power losses is 151.09 kW and total reactive power losses is 90.31 kVAr. The reduction of both the active and reactive power losses by 31.01% each is recorded in scenario 2 compared with the initial condition. Significant reduction in power losses is recorded in scenario 3 due to five DGs implemented on the new modified system after the reconfiguration of the network. The highest value of power losses reduction is recorded in scenario 3 at 53.7% for both active and reactive power losses. The total active and reactive power losses for scenario 3 are 101.39 kW and 60.6 kVAr, respectively.

The results have been changed in other scenarios, as the five DGs are firstly implemented in the system as mentioned in scenario 4, the total active and reactive power losses of scenario 4 are 126.46 kW with 42.26% reduction and 75.59 kVAr with 42.26 % reduction respectively, compared with the initial condition. Slight improvement in power losses is recorded in scenario 5 after applying the reconfiguration method on the network with five DGs penetration. The reduction of both active and reactive power losses reached 43.95%, as the total active power losses is 122.75 kW and the total reactive power losses is 73.37 kVAr.

The daily energy losses with respect to loading change around the day are obtained in the table (3). Scenario 3 records the lowest energy losses with 1540.14 kWh /day. These results clarify the improvements in the network performance due to DGs penetration before and after network reconfiguration. Significant improvement in power losses reduction is recorded in scenario 3 as the active power losses record the maximum decrease with 101.39 kW compared with other different scenarios. Scenario 3 achieves the highest daily energy saving with 59.14 % compared with other scenarios' results. It is clearly observed that the system reconfiguration method has a significant effect on system losses reduction, while the DG penetration directly improves the voltage profile and enhances the voltage stability of the system.

Table 3: Cairo-59 bus network daily energy losses results

Scenario	**1**	**2**	**3**	**4**	**5**
Daily energy losses (kWh)	3769.55	2495.16	1540.14	1915.98	1820.44
Daily energy Saving (%)	__	33.80	59.14	49.17	51.706

The DG penetration and system reconfiguration also affect the voltage profile of the network. Improving in the voltage level for each bus is recorded due to different applied scenarios as shown in figure (6). In addition, the voltage stability index (VSI) has been improved due to enhancement in the voltage profile of the network as shown in figure (7). The initial condition has a minimum and maximum voltage level which is 0.9865 p.u. at bus 50 and 1 p.u., respectively. In scenario 2 the lowest voltage increases to 0.9933 p.u. at bus 56 after the system reconfiguration. The maximum voltage is kept 1 p.u. at bus 1 in both scenario 1 and scenario 2. The VSI of the initial condition is 0.9469 which improves to 0.9733 in scenario 2. Another increase in each voltage level is achieved in scenario 3 after implementing as many as five DGs on the new modified network. The minimum voltage magnitude increases to 0.9948 at bus 20, while other buses' voltages reach the maximum voltage magnitude of 1 p.u. as illustrated in figure (6). According to improvements in the voltage level at each bus, the minimum VSI improves to 0.9792 in scenario 3.

Direct improvements in the voltage profile level and the VSI of the system are recorded in scenario 4 after applying as many as five DGs in the system. The buses connected to DGs or near the DGs implementation record great improvements in the voltage level, as shown in figure (6). The minimum and maximum voltage magnitudes are 0.9934 p.u. at bus 50 and 1 p.u. at bus 1, respectively. The minimum VSI in scenario 4 is 0.9739. In scenario 5, the improvement in the voltage magnitude and VSI are recorded. Reconfiguration of the system recorded a minor enhancement on the system voltage profile. The voltage deviation of the system has slightly improved due to changing in (TS) after implementing DGs on different buses. The voltage deviation around all buses decreased compared to the results reached in scenario 4. The minimum voltage magnitudes improved to 0.9944 p.u. at bus 8 and the highest voltage magnitude remained 1 p.u. at bus 1. The minimum VSI also improved to 0.9776 p.u. in scenario 5. Furthermore, the voltage of all buses and VSI of the system are improved to be close to 1 p.u., as shown in figure (6) and figure (7).

The system performances according to the daily loading are discussed. The five scenarios are applied considering the load changing around the day. The DGs penetrations change according to the daily loading while the system reconfiguration considers the peak load results. The lowest voltage magnitude of all buses during the day is illustrated in figure (8). The lowest VSI of all buses during the day is demonstrated in figure (9).

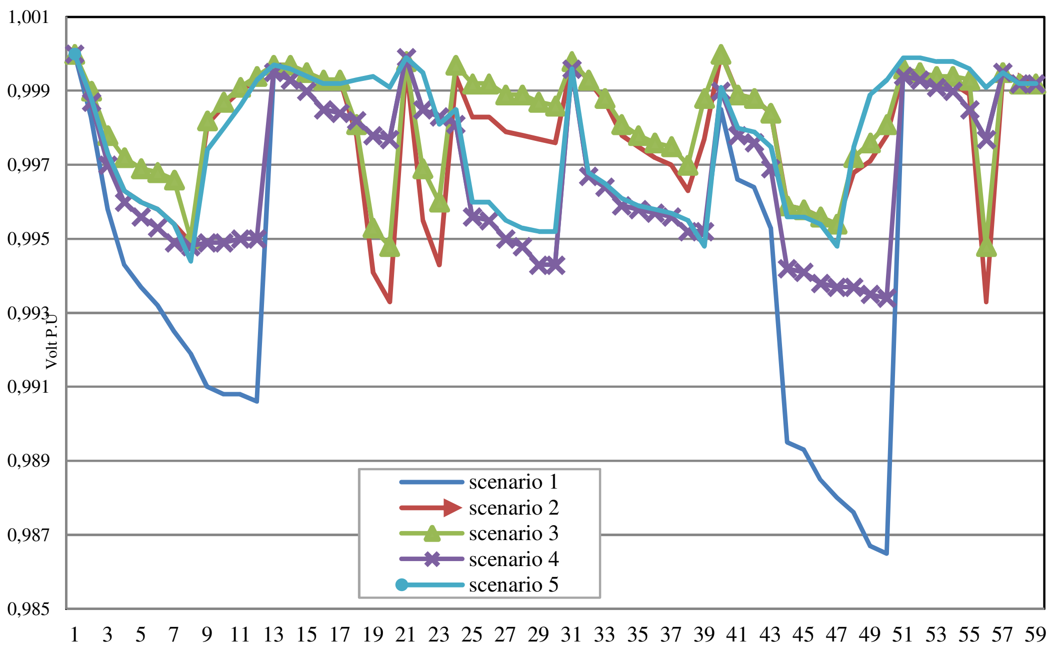

Fig.6. Voltage Profile of Cairo-59 bus Redial Distribution Network

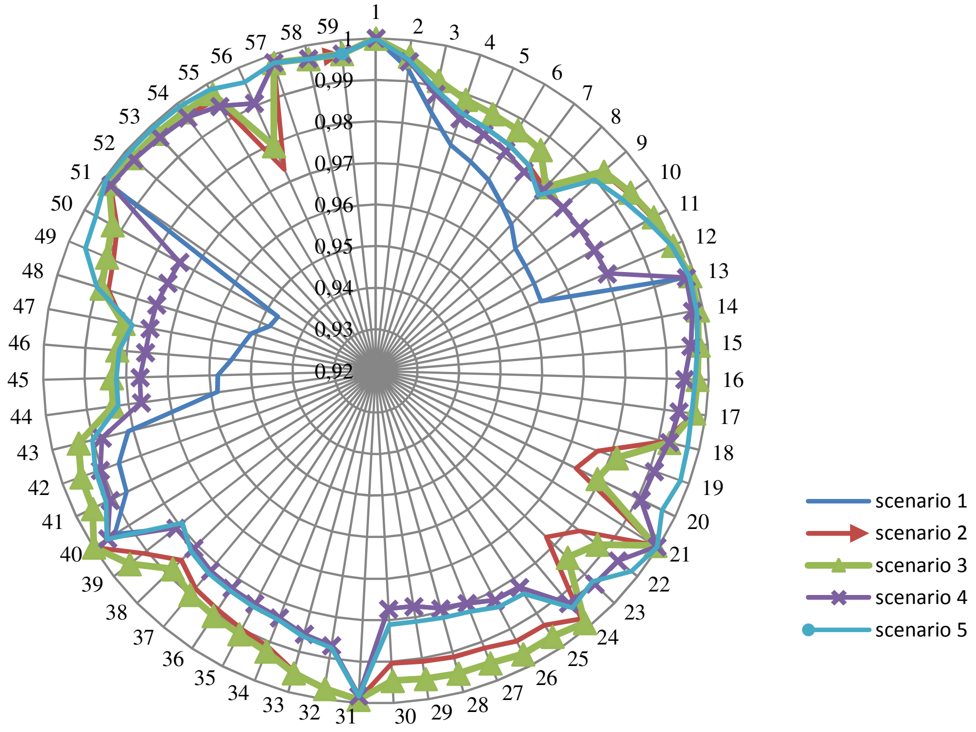

Fig.7. Voltage Stability Index of Cairo-59 bus RDN

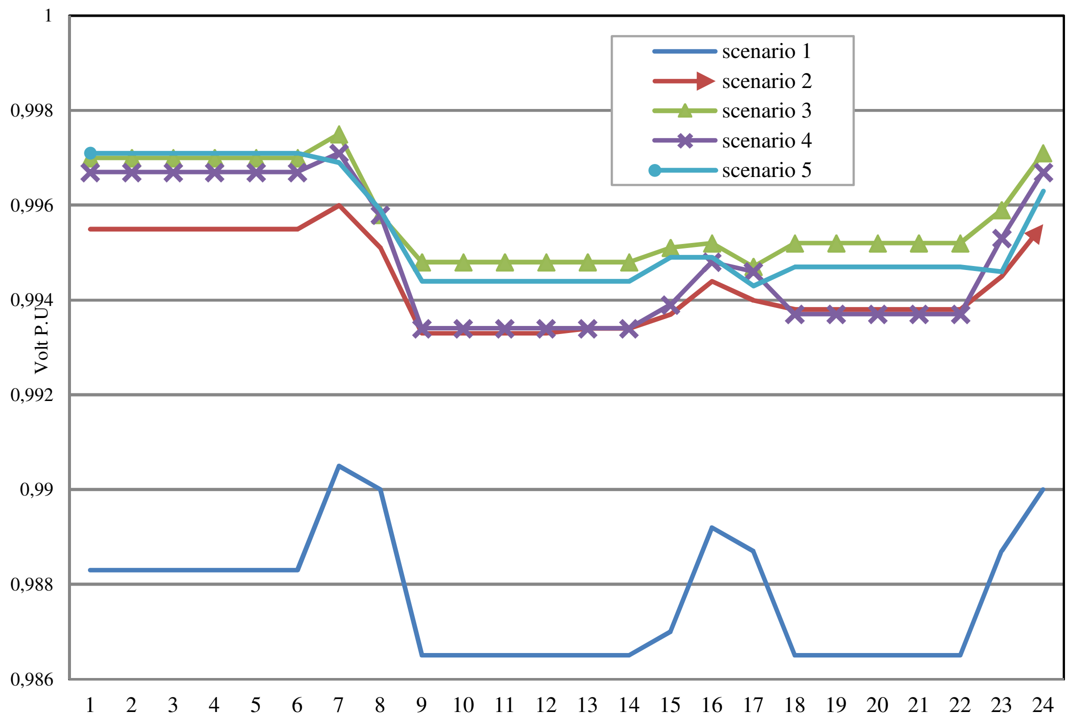

Fig.8. Lowest Voltage Magnitude of Cairo-59 bus RDN according to daily loading

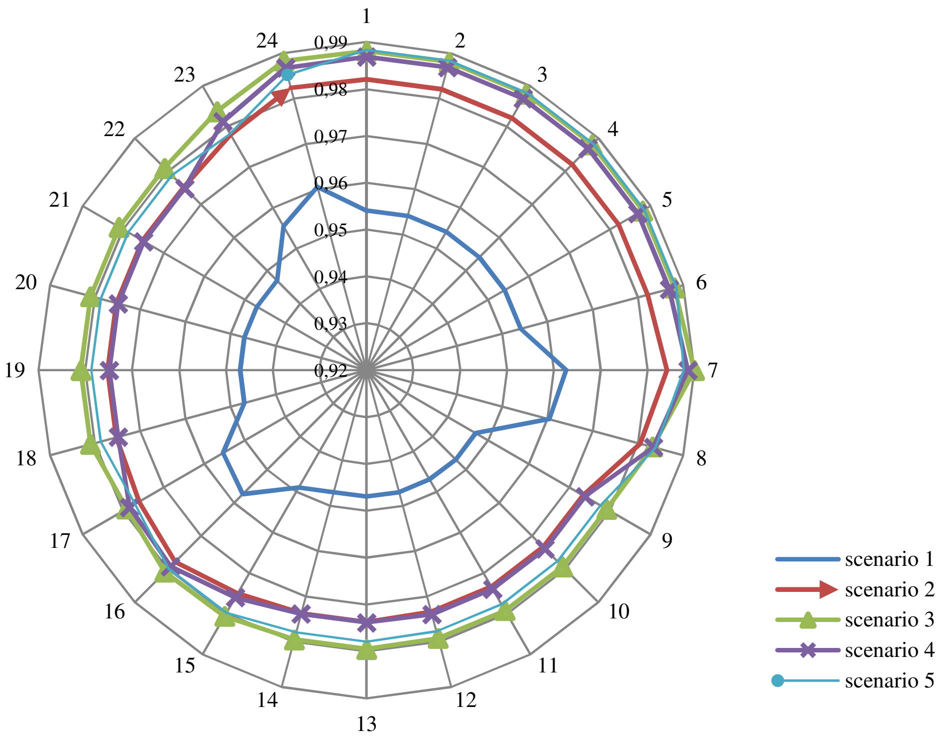

Fig.9. Lowest VSI of Cairo-59 bus RDN according to daily loading

5. Conclusion

In the current paper, BPSO is used to determine the optimum reconfiguration and PSO is applied to decide the optimum location and sizing of DG penetration units. BPSO and PSO are tested on RDN systems based on minimizing the power losses. The tested system is a real distribution network with 59-bus Cairo distribution system, Egypt with respect to its daily loading. According to the results, the optimization techniques achieve a significant improvement in the system performance. Different schemes of system reconfiguration integrated with DG are applied. Reducing the power losses, improving the voltage profile and enhancing the voltage stability of the system could be achieved using different scenarios of system reconfiguration and DGs penetration. CAIRO-59 bus RDN achieves the best result of minimizing the power losses and improving voltage profile by applying system reconfiguration before spreading as many as five DGs on the system buses as mentioned in scenario 3. This scheme leads to 101.39 kW active power losses with 53.7% reduction and 60.6kVAr reactive power losses with 53.7% reduction compared with the initial case. The voltage profile improves with a minimum voltage level of 0.9948 p.u. at bus 20 and the maximum voltage level of 1.00 p.u. at bus 1; along with a minimum VSI of 0.9792. Enhancement of RDN performance could be achieved by applying reconfiguration of the system then implementing DGs penetration on the system buses.

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APPENDIX

Cairo-59 RDN system data and parameters

Branch Number	Send Bus	End Bus	Line Impedance		Load power at End bus	
			Resistance $\mathcal{R}(\Omega)$	Reactance $X(\Omega)$	Active P(kW)	Reactive Q(kVAR)
1	1	2	0.07281	0.04352	1471	626
2	2	3	0.12297	0.07350	368	157
3	3	4	0.08090	0.04836	735	313
4	4	5	0.03236	0.01934	735	313
5	5	6	0.03236	0.01934	49	21
6	6	7	0.04854	0.02901	2945	1254
7	7	8	0.08414	0.05029	735	313
8	8	9	0.16180	0.09671	147	63
9	9	10	0.03883	0.02321	1177	501
10	10	11	0.04530	0.02708	0	0
11	11	12	0.05339	0.03191	735	313
12	1	13	0.03641	0.02176	1471	626
13	13	14	0.01133	0.00677	735	313
14	14	15	0.04045	0.02418	273	116
15	15	16	0.05339	0.03191	735	313
16	16	17	0.02751	0.01644	735	313
17	17	18	0.05178	0.03095	735	313
18	18	19	0.15371	0.09188	210	89
19	19	20	0.03560	0.02128	735	313
20	1	21	0.01294	0.00774	735	313
21	21	22	0.21196	0.12669	1838	783
22	22	23	0.07281	0.04352	735	313
23	1	24	0.10193	0.06093	1471	626
24	24	25	0.17798	0.10638	424	180

Continued Cairo-59 RDN system data and parameters

25	25	26	0.00647	0.00387	735	313
26	26	27	0.04530	0.02708	697	297
27	27	28	0.02103	0.01257	735	313
28	28	29	0.06229	0.03723	2213	943
29	29	30	0.01052	0.00629	735	313
30	1	31	0.02832	0.01692	1471	626
31	31	32	0.24270	0.14507	735	313
32	32	33	0.03398	0.02031	735	313
33	33	34	0.06148	0.03675	735	313
34	34	35	0.02427	0.01451	368	157
35	35	36	0.02103	0.01257	368	157
36	36	37	0.02427	0.01451	284	121
37	37	38	0.09223	0.05513	1103	470
38	38	39	0.00324	0.00193	168	72
39	1	40	0.05339	0.03191	406	173
40	40	41	0.06957	0.04159	735	313
41	41	42	0.00971	0.00580	735	313
42	42	43	0.04854	0.02901	2209	941
43	43	44	0.33169	0.19826	735	313
44	44	45	0.01133	0.00677	735	313
45	45	46	0.06148	0.03675	735	313
46	46	47	0.04369	0.02611	735	313
47	47	48	0.04369	0.02611	735	313
48	48	49	0.11650	0.06963	735	313
49	49	50	0.03560	0.02128	2209	941
50	1	51	0.03398	0.02031	0	0
51	51	52	0.00971	0.00580	1471	626
52	52	53	0.01294	0.00774	1103	470
53	53	54	0.01618	0.00967	735	313
54	54	55	0.06472	0.03868	1471	626
55	55	56	0.21034	0.12573	1471	626
56	1	57	0.07524	0.04497	1471	626
57	57	58	0.14562	0.08704	735	313
58	58	59	0.02427	0.01451	172	73
59	12	51	0.05339	0.03191		
60	15	59	0.12297	0.07350		
61	20	56	0.02912	0.01741		
62	18	50	0.00340	0.00203		
63	23	32	0.12944	0.07737		
64	28	39	0.03236	0.01934		