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An Improved Particle Swarm Optimization Algorithm for Energy Management in Distribution Grid Considering Distributed Generators

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Abstract

This study proposes, a novel approach for optimal energy management's problem and capacitor switching in the distribution network at the presence of distributed generators, energy storage units and solar photovoltaic arrays. Modern distribution networks, in addition to the importance of economic issues, must operate at an acceptable level of system reliability, Failure to pay attention to the reliability importance can lead to irreparable damages in the distribution network. Toward this end, energy not supplied as a reliability index along with operation cost are considered as objective functions. Also, the effect of uncertainty resources related to solar photovoltaic arrays power generation and electricity price are considered in the optimization problem evaluations. Considering the effects of distributed generators and energy storage units causes the proposed problem more be complicated, for this reason, an improved particle swarm optimization algorithm is provided to deal the complexity of the problem. The proposed algorithm is tested in the IEEE 33-node test system, and its superiorities are shown through comparison with other evolutionary algorithms.

Keywords: *Energy Management, Capacitor Switching, Distributed Generators (DGs), Improved Particle Swarm Optimization (IPSO), Multi-Objective Optimization alic style, Keywords*

1. Introduction

The influence of renewable energy resources and energy storage (ES) units in distribution systems can greatly alter the performance of the network grid [1-3], and integration them in the distribution grid have positive effects such as improvement of bus voltage profile, reliability, and reduction of network loss. In addition to the benefits, any undesirable management in their simultaneous operation on the network can decrease their lifespan. Toward this end, an optimal management schedule is necessary for the good operation of these units [4-5]. One of the major goals of the distribution grid operator is to reduce the operation cost. Because reducing the operation cost of network lead to decrease the electricity prices [6]. Furthermore, Reliability is another important objective in distribution network studies that play a significant role in improving system performance, especially in reducing subscriber blackouts, and any operational program is not acceptable regardless of reliability indicators in modern power systems [7].

Some recent studies have emphasized the use of renewable energy resources and ES units for obtaining energy management in the micro-grids. In [8-9], an energy management's schedule was provided in the micro-grid integrated with ES units and renewable energy resources according to sensitivity of DC-nodes. In [10], a novel approach was presented in the micro-grid for optimal energy management based on mixed integer strategy considering security constraint. In [11], an energy management's schedule was provided in the micro-grid considering solar photovoltaic (PV) arrays to minimize the power outages. In [12], a new approach was provided for energy management in the micro-grid integrated with ES units and solar PV arrays according to load requirement. An efficient strategy was presented for dynamic energy management in the micro-grid considering solar PV array and electrolyzer with regards to dynamic demand [13].

In some studies, the effects of distributed generators (DGs) and ES units have considered in order to obtain the energy management strategy in the distribution grid. A dynamic energy management schedule was provided in the distribution network integrated with ES units to reduce the peak load shaving [14]. In [15], an energy management's problem was solved in the distribution grid considering renewable energy resources to minimize the operation cost. In [16], a novel strategy using statistical approach was provided for energy management's problem in the distribution grid integrated with ES units, wind turbines and solar PV arrays in distributed networks in order to decrease peak demand. In [17], a new energy management strategy based on demand response approach was performed to the balance among power generation and power consumption in distribution grids integrated with renewable energy sources. In [18], The distribution company's profit in distribution networks was maximized by optimizing energy storage units planning and distribution generators. In order to obtain the energy storage units' characteristics in terms of location and size, a new energy management strategy was presented in the distribution grid considering DGs [19]. In [20], a new approach using an evolutionary algorithm was provided for energy management's problem and capacitor placement in the distribution system. In [21], a new strategy was provided for energy management's problem in the distribution grid considering electrical vehicles to reduce the fuel emission.

The literature survey shows that few studies have considered the simultaneous effect of DGs and ES units in solving energy management [12,16,18]. Moreover, the effect of capacitors has considered only in [20] to solve the problem of energy management.

Most studies [14-19] have considered power loss and operation cost as objective functions and have paid little attention to the reliability of the distribution network. Lack of attention to the reliability of the distribution network can lead to multiple blackouts on the distribution system

Few studies have considered the effect of uncertainty resources in solving the problem of energy management optimization. Lack of attention to sources of uncertainty in solving the optimization problem causes the problem not to be solved in real space and the optimal answer is far from the optimal operating point of the system.

Most studies [10-17] have not considered the problem of energy management optimization as multi-objective and have not provided a specific strategy for solving the multi-objective energy management problem.

Solving the energy management's problem in the distribution network requires an accurate and powerful optimization algorithm. For this purpose, an improved particle swarm optimization (IPSO) algorithm is proposed to overcome the complexities of the considered problem. The PSO algorithm can be employed for solving many engineering problems based on simplicity of its implementation and flexibility, but it has some defects such as: trapped into local optima or premature converge. For this purpose, a new innovation is added to make IPSO algorithm based on categorizing the particles into several memeplexes to increase the search ability of the algorithm. Moreover, two objectives including Energy not supplied (ENS) and operation cost are considered in this study. According to the objective functions in this study including ENS and operation cost, the Pareto-based approach is presented for obtaining a set of non-dominated solutions instead of an optimal solution such as in a single objective. For this reason, a repository is employed for saving non-dominated solutions in each iteration.

The salient features of this study are presented below to cover the weaknesses of the reviewed studies:

- Presenting a new approach for solving optimal energy management's problem and capacitor switching in the distribution network.
- Considering the ENS as reliability objective function
- Considering the uncertainty sources to evaluate the objectives in solving the problem of energy management.

- Considering the effects of DGs, ES units, and solar PV arrays simultaneously on different objective functions.
- Presenting a novel algorithm (IPSO), based on dividing particles in different memeplexes.

The rest of this paper is provided as follows: problem formulation is structured in section 2, the multi-objective approach and introducing of IPSO algorithm are described in section 3. Simulation results and conclusion are presented in sections 4 and 5, respectively.

2. Problem Formulation

The problem formulation is divided to two parts; objective functions, constraints and uncertainty modeling.

2.1. Objective functions

A) Energy not supplied (ENS)

Energy not supplied (*ENS*) [22-23] is an important reliability indicator that indicates the total energy load not distributed during outage. In this regard, the formulation of ENS as one of the most important indicators in the reliability assessment of distribution grid is as follows:

$$ENS_k = P_k \sum_{k,m \in Z,\, k \neq m} (\partial_{k,m} \times t_{k,m} + \partial_{k,m} \times t'_{k,m}) \tag{1}$$

$$f_1(X) = \sum_{k=2}^{N_{BUS}} ENS_k \tag{2}$$

B) Operation Cost

The operation cost is one of the important objective functions in the distribution grid's optimization problems which its formulation as follows:

$$f_2(X) = \sum_{t=1}^{24} \left(\sum_{j=1}^{N_{dg}} Price^t{}_{dg,j} \times P^t{}_{dg,j} + \sum_{h=1}^{N_{sub}} Price^t{}_{sub,h} \times P^t{}_{sub,h} \right) \tag{3}$$

$$X = [\ \overline{P_{dg}}\ ,\overline{Q_{Cap}}\ ,\overline{P_{ES}}\ ] \tag{4}$$

$$\overline{P_{Dg}} = \left[P_{dg1}^{1}, P_{dg2}^{2}, \ldots .P_{DgN_{Dg}}^{24} \right] \tag{5}$$

$$\overline{Q_{Cap}} = \left[Q_{Cap1}^{1}, Q_{Cap2}^{2}, \ldots .Q_{CapN_{Cap}}^{24} \right] \tag{6}$$

$$\overline{P_{ES}} = \left[P_{ES1}^{1}, P_{ES2}^{2}, \ldots .P_{ESN_{ES}}^{24} \right] \tag{7}$$

2.2. Constraints

In this section, all equality and inequality constraints of the proposed problem are described. Equations (8) -(9) are related to distribution line limits and load flow equation, then (10) -(11) are related to bus voltage and capacitor limitation, respectively. Finally, equations (12) -(16) are related to DGs power generation and energy storage unit’s limitation, respectively.

A) Distribution line limits

$$\left|P_{xy}^{line}\right| \leq P_{xy,Max}^{line} \tag{8}$$

B) Distribution Power flow equations

$$S_i = \sum_{j=1}^{N_{bus}} V_i V_j Y_{ij} cos\left(\Theta_{ij} - \delta_i + \delta_j\right) \tag{9}$$

C) Bus voltage limit

$$V_{min} \leq V_j \leq V_{max} \tag{10}$$

D) Capacitor constraint:

$$Q_{cap}^{min} \leq Q_{cap,j} \leq Q_{cap}^{max} \tag{11}$$

E) DGs Power generation:

$$P_{dg}^{min} \leq P_{dg,j} \leq P_{dg}^{max} \tag{12}$$

F) Energy storage operational constraints

Some limitations intended that must be followed within a 24-hour time interval by ES units in order to increase their lifespan and performance [24-25] are as follows:

$$E_{l,t} = E_{l,t-1} + \sigma_{ch,l}\, P_{ch,l,t} \times \Delta t - \frac{1}{\sigma_{dis,l}}\, P_{dis,l,t} \times \Delta t \tag{13}$$

$\Delta t = 1$ *hour*, $l = 1, 2, \ldots N_{ES}$

$$E_l^{min} \leq E_{l,t} \leq E_l^{max} \tag{14}$$

$$P_{ch,l,t} \leq P_{ch,l}^{max} \tag{15}$$

$$P_{dis,l,t} \leq P_{dis,l}^{max} \tag{16}$$

2.3. Uncertainty modelling

In this section, the effects of uncertainty sources including the power output of solar PV units and the electricity purchase price from the market are examined:

A) Power generation of solar PV units modeling

The beta distribution function in equation (17) is used to determine the solar irradiance according to the past data, the *PV* units power generation [26] can be approximated by using equation (18):

$$f_b(s) = \begin{cases} \frac{\Gamma(\varphi+\omega)}{\Gamma(\varphi)\cdot\Gamma(\omega)} \cdot \rho^{\varphi-1} \cdot (1-\rho)^{\omega-1} & 0 \leq \rho \leq 1,\ \varphi,\omega \geq 0 \\ 0, & Otherwise \end{cases} \tag{17}$$

$$P_{pv} = \begin{cases} P_{sn} \frac{Rad^t}{Rad_{std}\,\partial_c} & 0 < Rad^t < \partial_c \\ P_{sn} \frac{Rad^t}{Rad_{std}} & Rad^t > \partial_c \end{cases} \tag{18}$$

B) Electricity market price modeling

The log-normal distribution function in equation (19) is used to describe the electricity price according to the past data related to power market price.

$$f_p(E^{pr},\mu,\sigma) = \frac{1}{E^{pr}\sigma\sqrt{2\pi}} \exp(-\frac{(lnE^{pr}-\mu)^2}{2\sigma^2}) \tag{19}$$

In order to model the uncertainty associated with the parameters considered in this study, the scenario generation approach based on roulette wheel mechanism method in [27] is used. After the scenario generation, the high number of scenarios may reduce the speed of solving optimization problem and increase computations. For these reasons the backward approach is provided in this study to remove the similar scenarios for reducing the computational process. Suppose that the probability distribution Q is defined on the scenario set Ω. The problem of optimal reduction of set Ω can be expressed as follows:

Define a subset of scenarios $\Omega s \subset \Omega$ and assign a new distribution to remaining scenarios so that the reduced probability distribution Q' defined on Ωs set is the nearest distribution to the main distribution Q in terms of probability distance. The Kantorovich distance [28] can be expressed as follows:

$$K_D(S,S'') = \Pi s \times d\,(S,S'') \tag{20}$$

$$d\,(S,S'') = (\sum_{i=1}^{H} (s_i - s_i'')^2)^{1/2} \tag{21}$$

In the above equation, S is a string scenario that has H subsets of s_i, $d\,(S,S'')$ is the distance between the two scenarios S and S'' and is expressed as follows:

3. Multi-objective optimization approach

In this section, Improved particle swarm optimization (IPSO), multi-objective strategy including Pareto-solution and fuzzy decision approach are briefly described.

3.1. Improved particle swarm optimization algorithm

PSO is one of the best swarm-based evolutionary methods which is inspired by groups of birds and fishes, each particle is known as possible solution in this algorithm, and its position is updated by using its last direction as inertia the own best previous position and best particle's position in the whole swarm [29-31]. In the search space, the position and velocity of j^{th} particle in the $t+1\ th$ iteration are updated by using (22)-(23):

$$V_j^{t+1} = W \cdot V_j^t + c_1 \cdot r_1\left(Pb_j^t - X_j^t\right) + c_2 \cdot r_2(Gb^t - X_j^t) \quad (22)$$

$$X_j^{t+1} = X_j^t + V_j^{t+1} \quad (23)$$

In addition to many benefits of PSO algorithm, such as minimum storage requirement and simple implementation, this algorithm has some defects such as trapped into local optima or premature convergence, for this purpose an IPSO algorithm is provided in this study, the main idea of the proposed algorithm, categorizing the particles into several memeplexes in order to enhance the IPSO algorithm's search ability. In IPSO algorithm, particles are divided to several memeplexes, then position and velocity i^{th} particle at j^{th} memeplex are updated based on (24)-(25), this process is done for all particles in each memeplex. Finally, information is exchanged between all memeplexes and global best solution is extracted. The flowchart of IPSO algorithm for multi-objective optimization problem is depicted in Fig. 1.

$$V_{i,j}^{t+1} = W \cdot V_{i,j}^t + c_1 \cdot r_1\left(X_{Pbesti} - X_{i,j}^t\right) + c_2 \cdot r_2\left(X_{Gbest} - X_{i,j}^t\right) \quad (24)$$

$$X_{i,j}^{t+1} = X_{i,j}^t + V_{i,j}^{t+1} \quad (25)$$

3.2. Pareto optimal solution

In solving multi-objective problem, there are non-dominated solutions instead of a single optimal solution [32-33], the vector X_1 dominates vector X_2 if:

$$\forall i \in \{1,2,\ldots,N_{obj}\},\ f_i(X_1) \le f_i(X_2) \quad (26)$$

$$\exists j \in \{1,2,\ldots,N_{obj}\},\ f_j(X_1) < f_j(X_2) \quad (27)$$

3.3. Fuzzy based clustering

According to the difference of each objective function of optimal values and range, a fuzzy set theory is used for substituting each objective value between zero and one. In this regard, the fuzzy membership function for i^{th} objective function can be modeled as follows [32-33]:

$$\mu_i(X) = \begin{cases} 1 & if \quad f_i(X) \leq f_i^{min} \\ 0 & if \quad f_i(X) \geq f_i^{max} \\ \dfrac{f_i^{max} - f_i X)}{f_i^{min} - f_i(X)} & if \quad f_i^{min} \leq f_i(X) \leq f_i^{max} \end{cases} \tag{28}$$

The normalized membership value for each individual in the repository is evaluated by using [33-34]:

$$N_{\mu,j}(X) = \frac{\sum_{i=1}^{N_{obj}} w_i \times \mu_i(X)}{\sum_{j=1}^{M} \sum_{i=1}^{N_{obj}} w_i \times \mu_i(X)} \tag{29}$$

4. Simulation Result

In this section, a 33-node test system is chosen for assessing the IPSO approach’s ability to solve the considered problem. Parameters of the IPSO are as follows: number of initial swarm is 1000, maximum number of iterations is 200 and number of memeplxes is 10. All simulations are performed in MATLAB software with core i5, 4GB RAM computer. The test system is composed of two-feeder, 33 nodes and 5 tie-switches [25]. The diagram of the test system is shown in Fig. 2. The test system includes two DGs with capacity of 500 kW at buses #7 and #24 as well as three capacitors with capacity of 200 kVar at buses #24, #25, and #30. Moreover, two 3000 kW solar PV units and their relevant 200 kWh ES systems are installed on buses #8, #25. The costs of DG units are 0.042 $/kWh. Figs. 3 and 4 show the load profile of the test system and electricity price during 24-hour, 30 scenarios are implemented to simulate the uncertainty parameters.

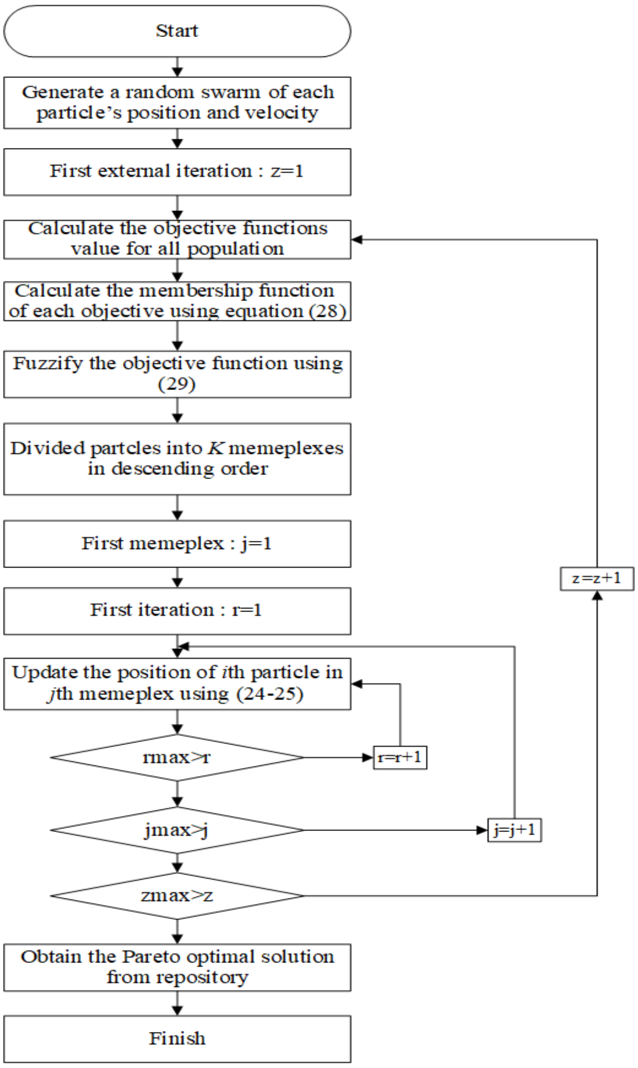

Fig .1 Flowchart of IPSO algorithm

4.1. Single-Objective Optimization

Table 1 shows the results of operation cost optimization considering DGs, ES unis and PV arrays, employing shuffled frog leaping algorithm (SFLA), PSO and IPSO algorithms. Tables 2 and 3 show the optimization results for ENS objective without and with DGs, ES units and PV arrays employing different algorithms. The best, mean, and worst solutions of three algorithms in 30 iterations are shown in Tables 1 to 3. From these tables, obviously that the obtained results by IPSO algorithm are better than SFLA and PSO algorithms, the proposed algorithm’s capability is proved for searching global answer compared to other algorithms. According to Table 1, the optimal values for operation cost optimization using IPSO and SFLA are obtained $ 3210.215 and $ 3245.526, respectively. The operation cost value for base case before the energy management and capacitor switching without DGs, ES units and solar PV arrays are equal to $ 3590.15. As it can be seen, the operation cost values obtained by proposed IPSO and SFLA algorithms are reduced by about 12% and 11% compared to its value before energy management and capacitor switching without DGs, ES units and solar PV arrays. Fig. 5 shows the convergence plot for the operation cost optimization by IPSO, SFLA and PSO algorithms. According to Fig. 5, the IPSO converges an optimal solution before the SFLA and PSO, or it can be said that the IPSO can achieve better results in shorter time than other algorithms.

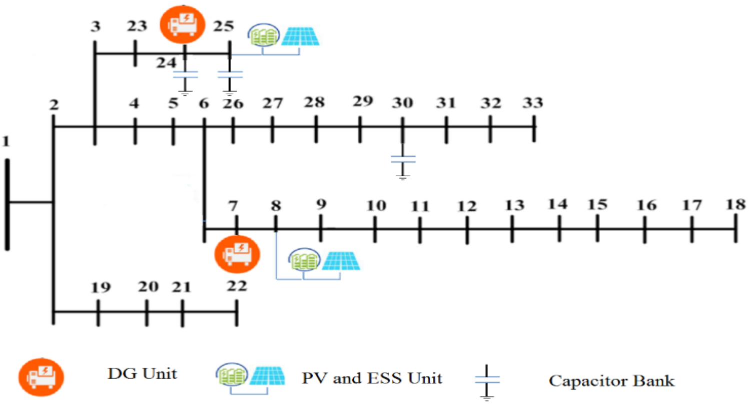

Fig .2 Single-line diagram of 33 bus test system

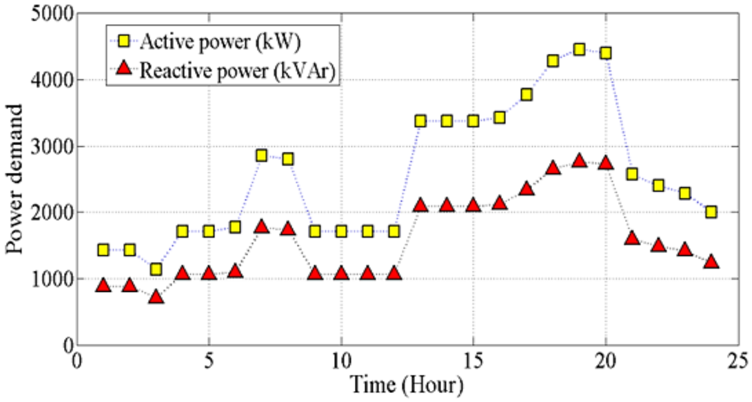

Fig .3 The load profile of test system during 24-hour

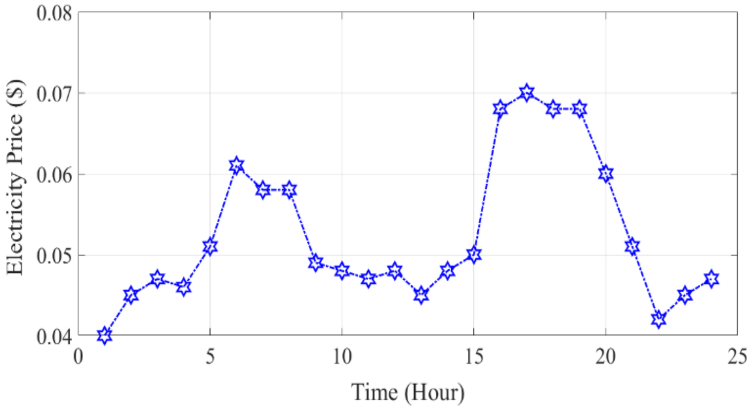

Fig .4 24-hour electricity price

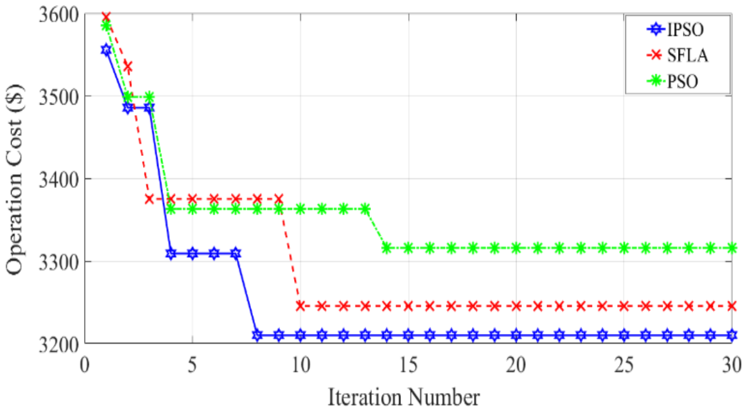

Fig .5 Convergence plot for operation cost minimization

According to tables 2 to 3, it is clear that the optimal values for ENS optimization using IPSO without and with DGs, ES units and solar PV arrays are obtained 53299.337 kWh/year and 29255.85 kWh/year, respectively. These values obtained for ENS optimization using SFLA without and with DGs, ES units and solar PV arrays are 53299.337 kWh/year and 29455.96 kWh/year, respectively. According to tables 2 to 3, it is clear that, the ENS values obtained by proposed IPSO and SFLA algorithms are reduced by about 5 % and 4 % compared to these values before considering DGs, ES units and solar PV arrays. As it can be seen, DGs, ES units and solar PV arrays can play a significant role in the reduction of ENS objective.

Table 1. Results obtained by optimizing the operation cost with DGs, ES units and solar PV arrays

Method	Best	Mean	Worst	STD
PSO	3315.853	3345.637	3368.146	33.41
SFLA	3245.526	3269.319	3285.213	20.56
IPSO	3210.215	3224.415	3235.512	14.25

Table 2. Results obtained by optimizing the ENS without DGs, ES units and solar PV arrays

Method	Best	Mean	Worst	STD
PSO	53798.199	54185.41	54692.231	309.818
SFLA	53299.337	53399.23	53798.199	209.89
IPSO	53299.337	53299.337	53299.337	0

Table 3. Results obtained by optimizing the ENS with DGs, ES units and PV arrays

Method	Best	Mean	Worst	STD
PSO	29732.09	29818.87	29915.33	56.13
SFLA	29456.96	29539.34	29635. 95	49.71
IPSO	29245.85	29314.93	29392.96	44.33

4.2. Multi-Objective optimization

One of the main goals of this study is to provide an efficient approach for solving the bi-objective problem. For this reason, Pareto-based approach is utilized to optimization two objectives simultaneously with DGs, ES units and solar PV arrays. Table 4 shows the best compromise solution for two-objective optimization problem using IPSO and other algorithms. Tables 5 represents the DGs' output and the capacitors' output during the 24-hour in the case of two-objective proposed problem using IPSO algorithm, Also, Fig .6 represents the optimal ES units' output during the 24-hour scheduling for the given case study.

Table 4. Best compromise solution for two-objective optimization problem

Method	ENS (kWh/year)	Operation Cost ($)
PSO	29848.32	3385.45
SFLA	29751.36	3290.74
IPSO	29557.52	3245.54

Fig .7 depicts a set of non-dominated solutions for solving the two-objective problem using the proposed IPSO algorithm. As an illustration, the minimum values of operation cost and ENS are $ 3212.85 and 29249.52 kWh/year, respectively. These values in the Pareto-front are close to the optimal value for each of the objective functions that have been reached in single-objective optimization. The optimal values of operation cost and ENS for the best-compromised solution (i.e., indicated with the red color) are $ 3245.54 and 29557.52 kWh/year, respectively. The difference between each objective function value in the best-compromised solution is less than 2% compared to its optimal values, which confirms the effectiveness of the proposed IPSO method for solving the multi-objective optimization problems.

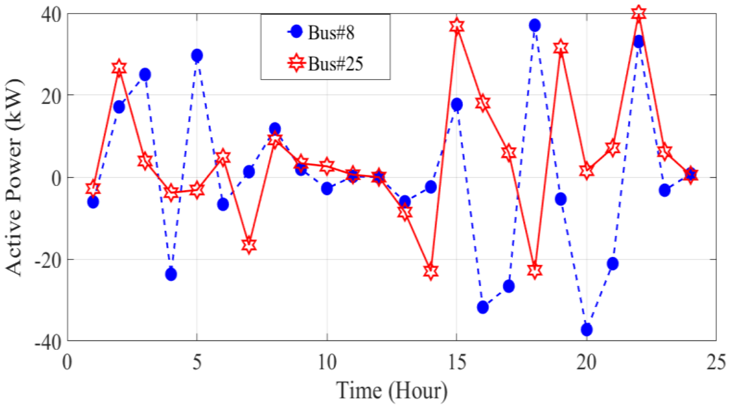

Fig .6 Active power output of ES units obtained from the IPSO algorithm for two-objective optimization problem

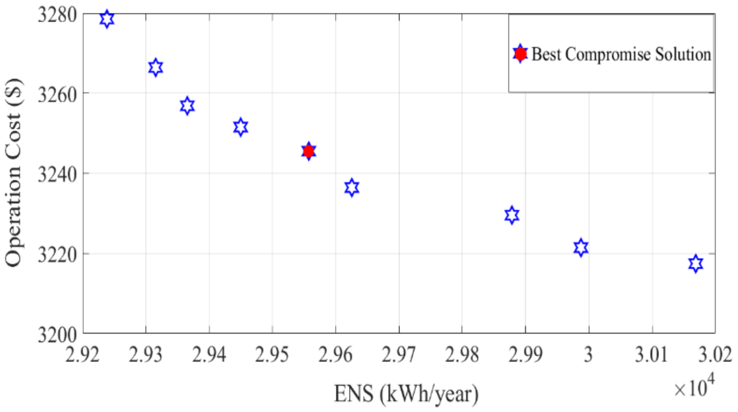

Fig .7 Pareto-front for two-objective optimization using IPSO algorithm

Table 5. DGs output and optimal capacity of capacitors obtained from the proposed IPSO algorithm for two-objective problem

Hour	DGs Output (kW)		Capacitors Output (kVAr)		
	DG1	DG2	Cap1	Cap2	Cap3
1	106.97	134.92	17.221	59.206	60.998
2	59.55	53.66	18.587	63.828	63.649
3	83.41	82.66	6.905	62.973	35.647
4	66.44	99.88	72.932	41.357	59.263
5	15.52	171.45	56.493	57.845	57.823
6	180.41	150.79	16.463	68.514	68.013
7	206.21	154.89	74.792	99.804	65.461
8	152.72	170.09	90.493	60.362	87.654
9	37.08	144.42	69.705	35.700	73.705
10	185.97	154.97	75.946	22.201	39.413
11	119.92	142.75	28.720	6.457	53.738
12	122.15	115.29	76.280	65.937	32.593
13	99.65	128.09	19.358	60.147	63.449
14	183.16	28.33	47.894	38.050	34.423

15	332.04	423.09	175.527	190.147	146.831
16	269.47	288.32	111.334	100.858	165.660
17	431.71	409.04	138.622	140.278	184.363
18	343.96	287.00	186.784	131.248	191.031
19	301.11	331.86	44.805	44.138	38.680
20	340.45	394.21	191.051	175.032	111.016
21	82.23	133.52	161.435	29.672	112.056
22	67.70	61.55	21.589	48.151	34.564
23	185.57	183.73	69.174	44.398	68.682
24	191.49	161.37	74.139	14.695	34.376

A comparison of ENS and operation cost values corresponding to the single objective optimization and the best-compromised solution obtained by IPSO is shown in Fig. 8. As shown in Fig. 8, the ENS value of the best-compromise solution is 29557.52 kWh, which is between 29245.85 kWh (for single-objective ENS minimization) and 30789.50 kWh (for single-objective operation cost minimization). According to the Figs 7 and 8, the strength of the proposed IPSO algorithm in solving the multi-objective energy management schedule problem is proven.

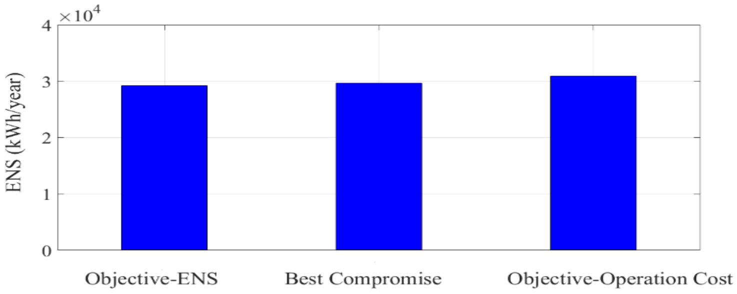

Fig. 8 Comparing values for ENS of best-compromised solution with these values of optimum single-objective solutions

5. Conclusion

A powerful evolutionary algorithm was provided in this study to solve the optimal energy management's problem and capacitor switching in distribution network. To overcome the early convergence of the conventional PSO as well as to improve the searching ability of PSO to find quality solutions, a new innovation presented in an improved particle swarm optimization (IPSO) algorithm based on categorizing of particles into several memeplexes. Objective functions in this study include minimizing the ENS and operation cost. The constraints of the proposed problem are voltage of the nodes, current of lines, capacity of transformers and ES units. A standard 33-bus distribution grid is considered as test system for implementing simulation. Based on the simulation results, the IPSO algorithm provides some reasonable solutions comparing to other evolutionary algorithms in terms of high quality solutions and more accuracy. Finally, the following conclusions can be drawn:

•The IPSO algorithm's capability is proved to solve single and multi-objective problems irrespective of intricacy and scale.

•Investigating the DGs' impact, ES units and solar PV arrays in solving the considered optimization problem has led to decline in ENS and operation cost objectives. As well as presence of capacitors in distribution grid has significant role in reduction considered objectives.

•Considering the ENS index with operation cost simultaneously as objectives provides a more reliable condition for distribution grid.

References

[1] A. Rajabi, L. Li, J. Zhang, and J. Zhu, "Aggregation of small loads for demand response programs—Implementation and challenges: A review," 2017 IEEE International Conference on Environment and Electrical Engineering and 2017 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe), pp. 1-6,2017.

[2] Fardin Far, S. and M. Alaei, "A New Method to Reduce Energy Consumption in Manet Network Routing based on OLSR Protocol and Genetic Algorithm". Journal of Advances in Computer Research, 2018. 9(3): p. 55-70.

[3] Payam, M.S. and E. Bijami, "Multi-Machine Power System Stability Improvement Using a New Fuzzy Wavelet Neural Network Damping Controller". Journal of Advances in Computer Research, 2016. 7(3): p. 105-130.

[4] M. H. Kapourchali and M. Sepehry, "Fault Detector and Switch Placement in Cyber-Enabled Power Distribution Network," IEEE Transactions on Smart Grid, Vol.9, No.2, pp-980-992, 2018.

[5] S. Ghavidel, J. Aghaei, K. M. Muttaqi, and A. Heidari, "Renewable energy management in a remote area using Modified Gravitational Search Algorithm," *Energy*, Vol. 97, pp. 391-399, 2016.

[6] M. Tabari, A. Yazdani, "An energy management strategy for a DC distribution system for power system integration of plugin electric vehicles". IEEE Transaction on Smart Grid, Vol.7, pp. 659- 668, 2016.

[7] M. Falahi, S. Lotfifard, M. Ehsani, K. Butler-Purry, “Dynamic model predictive-based energy management of DG integrated distribution systems", IEEE Transaction on Power Delivery, Vol.28, pp. 2217-2227, 2013.

[8] N. Korada and M. K. Mishra, "Grid Adaptive Power Management Strategy for an Integrated Microgrid with Hybrid Energy Storage," IEEE Transactions on Industrial Electronics, Vol. 64, No. 4, pp. 2884-2892, 2017.

[9] M. Falahi, S. Lotfifard, M. Ehsani, and K. Butler-Purry, "Dynamic model predictive-based energy management of DG integrated distribution systems," IEEE Transactions on Power Delivery, Vol. 28, No. 4, pp. 2217-2227, 2013.

[10] P. P. Vergara, J. C. López, L. C. da Silva, and M. J. Rider, "Security-constrained optimal energy management system for three-phase residential microgrids," Electric Power Systems Research, Vol. 146, pp. 371-382, 2017.

[11] D. Michaelson, H. Mahmood, and J. Jiang, "A Predictive Energy Management System Using Pre-Emptive Load Shedding for Islanded Photovoltaic Microgrids," IEEE Transactions on Industrial Electronics, Vol. 64, No. 7, pp. 5440-5448, 2017.

[12] S. Gaurav, C. Birla, A. Lamba, S. Umashankar, S. Ganesan "Energy management of PV-battery based microgrid system," Procedia Technology, Vol. 21, pp. 103-111, 2015.

[13] L. Zhang, N. Gari, L.V. Hmurick "Energy management in a microgrid with distributed energy resources," Energy Conversion and Management, Vol. 78, pp. 297-305, 2014.

[14] E. Reihani, S. Sepasi, L.R. Roose, M. Matsuura, "Energy management at the distribution grid using a Battery Energy Storage System (BESS) ", Electrical Power and Energy Systems, Vol. 77, pp. 337-344, 2016.

[15] S. Ghavidel, L. Li, J. Aghaei, T. Yu, and J. Zhu, "A review on the virtual power plant: Components and operation systems," *IEEE International Conference on* in *Power System Technology (POWERCON)*, pp. 1-6,2016.

[16] A. Abbassi, M. A. Dami, and M. Jemli, "A statistical approach for hybrid energy storage system sizing based on capacity distributions in an autonomous PV/Wind power generation system," Renewable Energy, Vol. 103, pp. 81-93, 2017.

[17] D. Kotur and Ž. Đurišić, "Optimal spatial and temporal demand side management in a power system comprising renewable energy sources," Renewable Energy, Vol. 108, pp. 533-547, 2017.

[18] H. Saboori and R. Hemmati, "Maximizing DISCO profit in active distribution networks by optimal planning of energy storage systems and distributed generators," Renewable and Sustainable Energy Reviews, Vol.71, pp.365-372,2017.

[19] Z. Lei, D. Qin, Y. Liu, Z. Peng, and L. Lu, "Dynamic energy management for a novel hybrid electric system based on driving pattern recognition," Applied Mathematical Modelling, Vol. 45, pp. 940-954, 2017.

[20] R. Koubaa and L. Krichen, "Ant colony optimization based optimal energy management for an FC/UC electric vehicle,"17th International Conference on Sciences and Techniques of Automatic Control and Computer Engineering (STA), pp. 363-367, 2016.

[21] C. M. Martinez, X. Hu, D. Cao, E. Velenis, B. Gao, and M. Wellers, "Energy management in plug-in hybrid electric vehicles: recent progress and a connected vehicles perspective," IEEE Transactions on Vehicular Technology, Vol.66, No.6, 2017.

[22] Azizivahed, A., Narimani, H., Fathi, M., Naderi. E, Safapour, H. "Multi-objective dynamic distribution feeder reconfiguration in automated distribution systems," Energy, Vol. 147, pp.896–914,2018.

[23] Hosseini Shirvani, M. and M. Khanramaki, "Reliability Evaluation in Tree-structured Grid Services with Colored Petri Net". Journal of Advances in Computer Research, 2016. 7(2): p. 1-21

[24] Azizi Vahed A, Naderi E, Narimani H, Fathi, M, Narimani, M.R. "A New Bi-Objective Approach to Energy Management in Distribution Networks with Energy Storage Systems," IEEE Transactions on Sustainable Energy 2017, Vol.9,No.1,pp.56-64,2017.

[25] Azizi Vahed A,Ghavidel S,Jabbari M, Li and Zhang. "New Energy Management Approach in Distribution Systems Considering Energy Storages," 20th International Conference on Electrical Machines and Systems, 11-14 Aug, 2017.

[26] Lotfi, H., et al., "An Enhanced Evolutionary Algorithm for Providing Energy Management Schedule in the Smart Distribution Network". Majlesi Journal of Electrical Engineering, 2020. 14(2): p. 17-23.

[27] Niknam T, Narimani M. R, Aghaei J, Azizipanah-Abarghooee R. "Improved particle swarm optimization for multi-objective optimal

power flow considering the cost, loss, emission, and voltage stability index," IET Gener. Transm. Distrib, Vol.6, No.6, pp. 515–527,2012.

[28] Lotfi, H., R. Ghazi, and M.B.N. Sistani. "Providing an Optimal Energy Management strategy in Distribution Network Considering Distributed Generators and Energy Storage Units". in 2019 International Power System Conference (PSC).

[29] Kennedy, J., Eberhart, R. "Particle swarm optimization," In: IEEE international conference on neural networks Piscataway, NJ, 4, pp. 1942–48,1995.

[30] Lotfi, H., M. Samadi, and A. Dadpour. "Optimal capacitor placement and sizing in radial distribution system using an improved Particle Swarm Optimization algorithm". in 2016 21st Conference on Electrical Power Distribution Networks Conference (EPDC). 2016. IEEE.

[31] Lotfi, H., A. Dadpour, and M. Samadi. "Solving economic dispatch in competitive power market using improved particle swarm optimization algorithm". in 2017 Conference on Electrical Power Distribution Networks Conference (EPDC). 2017. IEEE

[32] Lotfi, H., R. Ghazi, and M. bagher Naghibi-Sistani, "Multi-objective dynamic distribution feeder reconfiguration along with capacitor allocation using a new hybrid evolutionary algorithm". Energy Systems, 2019: p. 1-31.

[33] Azizivahed, A., et al. "Dynamic Feeder Reconfiguration in Automated Distribution Network Integrated with Renewable Energy Sources with Respect to the Economic Aspect". in 2019 IEEE Innovative Smart Grid Technologies-Asia (ISGT Asia). 2019. IEEE.

[34] Lotfi, H. and R. Ghazi. "An Optimal Co-operation of Distributed Generators and Capacitor Banks in Dynamic Distribution Feeder Reconfiguration," in 2019 24th Electrical Power Distribution Conference (EPDC). 2019. IEEE.