Modified Invasive Optimization Algorithm to DG Allocation Problem Considering Demand Response Programs

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ABSTRACT:
In this paper, a comprehensive algorithm using modified invasive weed optimization is introduced for allocating distribution generation (DG) sources along with considering demand response (DR). Three aspects such as technical, economic and environmental are taken to account to define the optimized size and location for DG or DR. In addition, a new voltage fitness function is proposed for better improvisation of voltage profile. The study is done on 30-bus IEEE transmission system and to examine the proposed algorithm, three other optimization algorithms such as GA, PSO and DE are used. The simulation is carried out in MATLAB which shows excellent performance of the proposed algorithm.

KEYWORDS: Modified invasive optimization algorithm, Demand response, Distribution generation, DG allocation.

1. INTRODUCTION

In recent years, the power grid had grown significantly in both developed and developing countries. The primary reasons are change in lifestyle and improvement of social welfare which lead to more electricity demand. To respond the growing demand, the governments are planning to build new power plants such as gas turbines, wind farms or solar power plants which many of them, contrary to traditional power plants are not concentrated. The connection of these new sources to power grid has made a new concept which is known with different names, distribution generation (DG) or embedded generation in different countries [1].

Many definitions are proposed to specify DG sources, but generally DG refers to power suppliers with low capacity (compared to centralized power plants) which are connected to low voltage or medium voltage side of the power grid [2, 3, 1]. DGs are playing an important role in today's power system and the objectives of installing DG include, but not limited to, improving the voltage profile of the grid, reducing the power transmission losses, increasing system reliability and in case of using renewable sources, it has environmental and economic benefits. All of these benefits are depended on the optimum size and location of the DG in power system. It is impossible to gain all of the mentioned objectives in a DG allocation problem, thus a trade-off is necessary among them.

In recent years, numerous research papers are published which aim to solve DG allocation problem. Some of them investigate performance of new optimization algorithms in DG allocation and compare the results with pervious works. For instance, in [4], the modified honey bee mating algorithm is used which shows some improvements in both accuracy and speed of the algorithm for DG allocation purposes. The cuckoo search algorithm is used in [5] which shows a better performance in comparison with the particle swarm optimization (PSO) algorithm and the genetic algorithm (GA). The hybrid algorithms are also popular in DG allocation. In [6], the improved PSO (IPSO) and Monte Carlo Simultaneous are used, and the author claims that the proposed algorithm has a better performance in comparison with the PSO and bee colony algorithm (ABC). The fitness function is also subjected for study in many papers. Ant colony algorithm is used in [7] to solve DG allocation problem in a radial distribution system. The effect of simultaneous optimal network reconfiguration along with DG and fixed/switched capacitor banks placement on a distribution is studied in [8] where GA is used for optimization purposes. In [9] mixed integer non-linear programming (MINLP) is proposed for fitness function which increases the accuracy, but in expense of more computation processing. In [10], three different fitness functions are used for solar panels, wind turbines and fuel cells. The society welfare is included in fitness function as a factor for DG allocation in [11]. Although these papers try to solve the DG allocation problem, they ignore new trends of power system as a possible solution.

Demand response (DR) is one of newfound topics in field of power system. DR is defined as "Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized" [12]. Based on definition, there are two types of DSM: 1)price-based DSM which means that customer will change their consumption pattern according to electricity price and 2) incentive-based DSM which rewards the costumers due to reduction in their electricity usage [13]. Consequently, the DR can be seen as a negative load or even a virtual DG and so, it can be considered as a new solution to DG allocation problem.

This paper aims to introduce a novel algorithm for DG allocation problem with considering DR. To find the optimized size and place of DG and DR, the predefined properties for transmission system (availability of DG sources and DR) are taken to account and the algorithm has proposed DG or DR base on it. For this study, the 30-bus IEEE standard transmission system is used. Then the fitness function is formed using weighted-sum method. For optimization purpose, the modified invasive weed optimization (mIWO) algorithm is used and its results are compared with GA, PSO and differential evolution (DE) algorithms which demonstrate superiority of mIWO. The result of this study proves that considering DR has economic and environmental benefits and moreover it improves the power system characteristics. The contents of the paper are presented as follows: in sections two, the algorithm for DR and DG allocation is presented. In addition, a new fitness function regarding voltage improvement is proposed in this section. Then, in section three, the simulation results are carried out for the under study power grids. And finally, the last section contains the conclusion of this paper.

2. DG ALLOCATION WITH CONSIDERING DR

In this paper, for DG allocation problems, four different types of DG sources such as fuel cells, wind turbines, solar panels and gas turbines are considered in this study. Table 1 contains the characteristics of these DG sources and also DR.

In the following subsections, the modified invasive weed optimization (mIWO) algorithm is introduced and the proposed allocation algorithm is presented.

2.1. The modified invasive weed optimization algorithm

The classical invasive weed algorithm is categorized in metaheuristic algorithm group and it was introduced by Mehrabian and Lucas in 2006 [14]. The algorithm steps are divided into four sections:

I. Initialization

Finite numbers of weeds are generated randomly, placed in the search space and their fitness values are evaluated.

Table 1. The characteristics of DG sources and DR

Source type		Cost(s)	Advantage(s)	Disadvantage (s)
DG sources	Wind turbine and solar panel	-Initial costs	-Environmentally friendly -Elimination of fuel cost	-Decrease of system reliability -Not available on all places
	Fuel cell	-Initial costs -Fuel cost	-Producing water	Environmental pollution
	Gas turbine	-Initial costs -Fuel cost	-Using CHP	Environmental pollution
DR		Discount on electricity bill	-Elimination of fuel & initial costs -Decrease in storage power	Limited usage

II. Reproduction

Each member of weed population is able to produce seeds which number of its seeds is related to its value of fitness function in a way that the worst fitness will produce the lowest number of seeds and the best fitness produces the highest number of seeds.

III. Spatial distribution

In this algorithm, the standard deviation is used to guarantee the error reduction in each iteration. The standard deviation for each iteration is defined as in (1).

$$sd_{iter} = \left(\frac{iter_{max} - iter}{iter_{max}}\right)^{pow} \times (sd_{max} - sd_{min}) + sd_{min} \tag{1}$$

Where the sd_{max}, sd_{min} and $iter_{max}$ are the maximum standard deviation, minimum standard deviation and maximum iteration, respectively which will be defined by the operator. The *pow* is a real number and makes the standard deviation a nonlinear function which increases the accuracy of algorithm [14].

IV. Competitive Exclusion

To find the optimum solution in this algorithm, the number of members should not exceed the population limit or pop_{max}, so it is necessary to eliminate those members with the worst fitness values. At first iterations, the members are allowed to reproduce quickly and distribute freely throughout the search space until the population reaches the maximum population. After it reaches the pop_{max}, only the fittest members are allowed to reproduce and the steps 2 to 4 will be repeated. The flowchart of the algorithm is shown in Fig. 1.

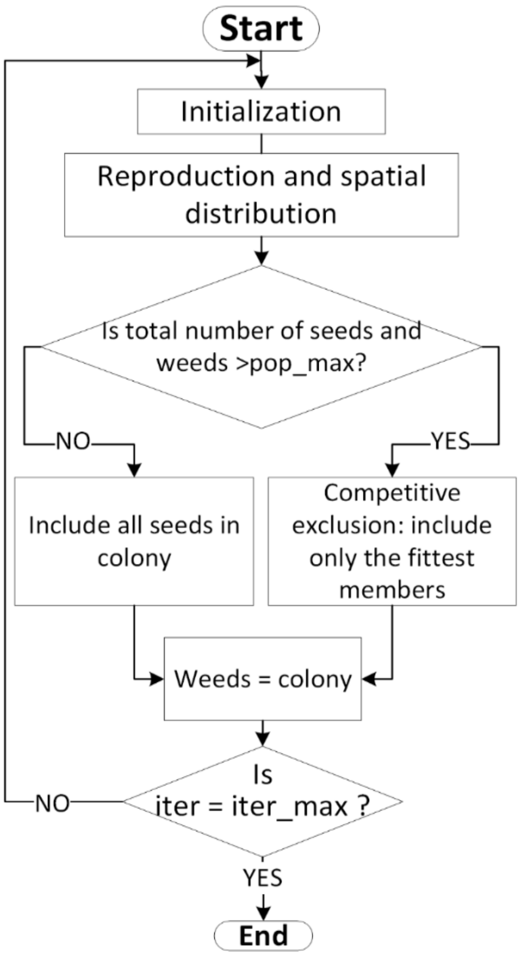


Fig. 1. The flowchart of classic IWO algorithm

Reviewing the literature reveals that, many modifications are proposed in research papers [15, 16, 17, 18] regarding improvement in the standard deviation equation, but the modification in [19] has the best performance, according to the presented results. In [19], the author proposes to use an additional term which is a function of iteration number (*iter*). As a result, the accuracy of the algorithm will be improved especially when it gets near to the optimum solution.

$$sd_{iter} = \left(\frac{iter_{max} - iter}{iter_{max}}\right)^{pow} |\cos(iter)| \times (sd_{max} - sd_{min}) + sd_{min} \quad (2)$$

The results show a better performance comparing to PSO, DE and even classic IWO [19].

2.2. Allocation algorithm

In this study, three major factors form the fitness function
which are technical, economic and environmental where the importance of each factor is defined by a weight value. Three factors are presented in below subsections.

3. TECHNICAL FITNESS FUNCTION

Transmission Losses and Voltage Profile
The primary commitment of algorithm is to improve technical performance of power system which are defined as power transmission losses and the voltage profile. The transmission losses for a N-bus power system is calculated by Eq. (3). [20].

$$F_{T1} = P_{Loss} = \sum_{i=1}^{N}\sum_{j=1}^{N}[\alpha_{ij}(P_iP_j + Q_iQ_j) + \beta_{ij}(Q_iP_j - P_iQ_j)] \quad (3)$$

Where the P_i and Q_i are the active and reactive power injection at bus i and P_j and Q_j are the active and reactive power injection at bus j. the α_{ij} and β_{ij} are defined in Eq (4).

$$\alpha_{ij} = \frac{r_{ij}}{V_iV_j}\cos(\delta_i - \delta_j)$$
$$\beta_{ij} = \frac{r_{ij}}{V_iV_j}\sin(\delta_i - \delta_j) \quad (4)$$

The r_{ij}, V_i, V_j represent line resistance between bus i and j, voltage magnitude at bus i and voltage magnitude at bus j respectively. The δ_i and δ_j are voltage angel at bus i and voltage angle at bus j respectively. Unlike transmission losses function which has a unique Eq. (3), different fitness functions are proposed regarding voltage profile. It is expected that a proper voltage fitness function (VFF) makes two improvements in voltage profile (1) converges the extreme values to nominal value (2) improves the overall voltage magnitude of buses. We proposed a new VFF to satisfy these conditions and to compare the proposed with other VFFs from literature, 5 cases with different voltage profile are defined (Fig. 2). The voltage of all cases vary in a range between 1.05 and 0.95 (p.u.). The cases are designed in a way that the voltage profile gets worse from case 1 to case 5. It is expected that the VFFs reflect this trend in their outputs. However, as it is shown in Fig. 3, the VFFs do not satisfy this requirement.

Table 2. the most common used VFF and the proposed

No.	The VFF	Reference(s)
1	$\lvert 1-\min(U_i.\forall i \in n)\rvert$	[21]
2	$max\left\lvert\frac{U_i - U_0}{U_0}\right\rvert$	[22, 23, 4]
3	$\frac{1}{n}\frac{\sum_{i=1}^{n}\lvert U_i - U_0\rvert}{\sum_{i=1}^{n}U_0}$	[5]
4	$\left\lvert 1-\frac{\sum_{i=1}^{n}U_i}{n}\right\rvert$	[24]
5	$\sum_{i=1}^{n}(U_i - U_0)^2$	[25]
6	$\sqrt{\frac{1}{n}\sum_{i=1}^{n}(U_i-\bar{U})^2} + \lvert 1-\min(U_i.\forall i \in n)\rvert$	Proposed VFF

Where $\bar{U}$, U_0, U_i and n are the average of voltage values, the nominal voltage, voltage of i^{th} bus, the nominal voltage and number of buses respectively.

In Fig. 3, It is obvious that the proposed VFF has the desirable trend in its output because its fitness value is increased from the first case to the fifth one. The proposed VFF is defined as follow.

$$F_{T2} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(U_i-\bar{U})^2} + \lvert 1 - \min(U_i.\forall i \in n)\rvert \quad (5)$$

- System Reliability

The most significant drawback of renewable sources is uncertainty and consequently reliability reduction of power system. Using renewable sources (i.e. wind turbine and solar panel) as electricity sources are always along with uncertainty. Therefore, although these kind of DGs have many environmental and economic benefits, it has undesirable effects on power system. Many studies, such as [26], propose a limitation for integration of these sources into main power grid. The (6) is used to involve reliability concerns of RES sources in technical fitness function.

$$F_{T3} = \begin{cases} 0 & for\ P_{rDG} < 30\%\ (P_{load.i} + P_{in.i}) \\ \frac{P_{rDG.i}}{P_{load.i} + P_{in.i}} & for\ P_{rDG} > 30\%\ (P_{load.i} + P_{in.i}) \end{cases} \quad (6)$$

Which P_{rDG}, P_{load} and Pin are active power capacity of renewable source, load demand and injected power into the bus. The subscript i shows the location of the bus which renewable source will be connected.

Finally, the technical fitness function is defined using weighted-sum of (3), (5) and (6).

$$F_T = F_{T1} \times W_{T1} + F_{T2} \times W_{T2} + F_{T3} \times W_{T3} \quad (7)$$

Where W_{T1}, W_{T2} and W_{T3} are the weights of the fitness functions of loss, voltage profile and reliability.

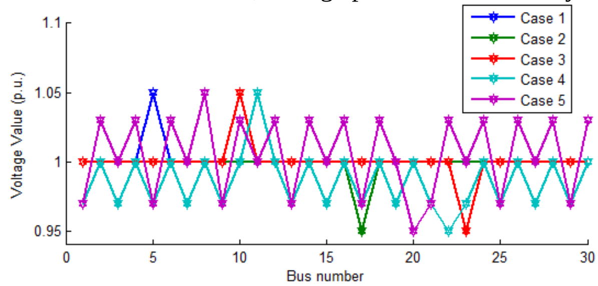


Fig. 2. The defined voltage profiles

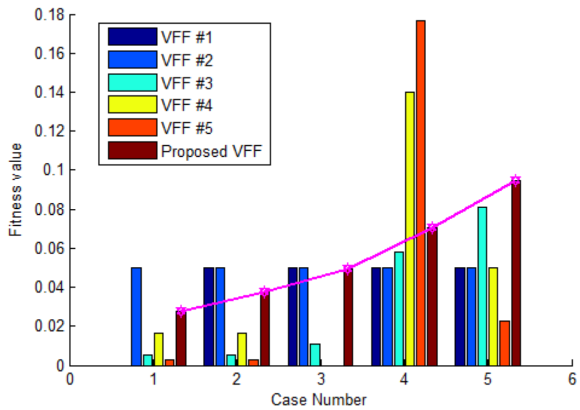


Fig. 3. The trend of each VFF in 5 defined voltage profiles Economic fitness function

For an optimized allocation of DR and DG in power grid, the costs of each method should be considered. These costs include initial cost and also maintenance cost (if applicable). Moreover, the fuel cost should be considered in fuel-based power plants and fuel cell. The DR does not have any initial costs, but some discounts and incentives should be given to consumers in order to get the permission to manage consumer's loads. In this study, the technical fitness function is defined in (8).

$$F_E = F_{int} \times W_{E1} + F_{maint} \times W_{E2} + F_{fuel} \times W_{E3} + F_{disc} \times W_{E4} - F_B \times W_{E5} \quad (8)$$

Where F_{int}, F_{maint}, F_{fuel}, F_{disc} and F_B are the initial cost, maintenance cost, fuel cost, discount cost and economic cost, respectively. The W_{Ex} (x=1...5) is the respected weight for each cost.

4. ENVIRONMENTAL FITNESS FUNCTION

The environmental fitness function deals pollutions and is given in (9) which is only applicable for fuel cells and gas turbine power plants.

$$F_{En} = Pol_{GT} + Pol_{FC}$$
$$Pol_{GT} = (NOX_{GT} + CO2_{GT}) \times P_{GT} \times T \quad (9)$$
$$Pol_{FC} = (NOX_{FC} + CO2_{FC}) \times P_{FC} \times T$$

Which Pol_{GT} and Pol_{FC} are gas turbine and fuel cell emission. NOX, CO2, P_{GT}, P_{FC} and T represent NO_x emission, CO_2 emission, generated power of GT, generated power of FC and under study interval.

5. SIMULATION RESULTS

The 30-bus IEEE transmission system is used to examine the proposed algorithm for DR and DG allocation. The simulation is carried out in MATLAB™ computer program and on a personal computer of 2.1 GHz CPU and 4 GB RAM.

5.1. Costs and pollutions

The initial cost of wind turbine is considered between 1100 pound/Kw in this study [27] and the initial cost of solar panel is assumed 1 $/w [28]. According to [29], the maintenance cost is negligible for renewable sources.

The initial cost of gas turbine is defined 1100 $/Kw in Iran [30]. Also, other costs such as fuel cost and environmental cost are defined 0.00129 $/Kwh and 0.00284 $/Kwh, respectively. The maintenance cost for gas turbine is considered 0.0019 $/Kw. The cost of electricity in gas turbine is about 0.079 $/Kw.

In [31], the initial cost of fuel cell is about 5000 to 5600 $/Kw. Also, the useful lifetime of these sources is defined 5 years and the cells should be changed after this period. The cost of this process is about 0.7 $/Kwh. Also, cost of electricity of fuel cell is about 0.14 $/Kwh which is not comparable with gas turbine. However, contrary to gas turbine, it has less harmful effect on environment. The gas emission for each DG source is given in Table 3.

Table 3. Amount of gas emission for each DG source

DG type	CO2 emissions (g/Kwh)	NOx emissions (g/Kwh)
Gas turbine	580-680	0.3-0.5
Fuel cell	200-250	0.005-0.01
Solar panel	Indirect emission	Indirect emission
Wind turbine	Indirect emission	Indirect emission

In this paper, the time period of study is considered one year. Although the costs regarding expansion of substation are out of scope of this paper, it worth to mention that in order to install a DG, the substation should be upgraded to meet new added capacity.

5.2. IEEE 30-bus transmission system

In this study, the 30-bus IEEE transmission system is used along with some properties which are presented in Table 7. Also, the data of transmission lines are given in Table 8 [32]. A schematic of under study transmission system is shown in Fig. 4.

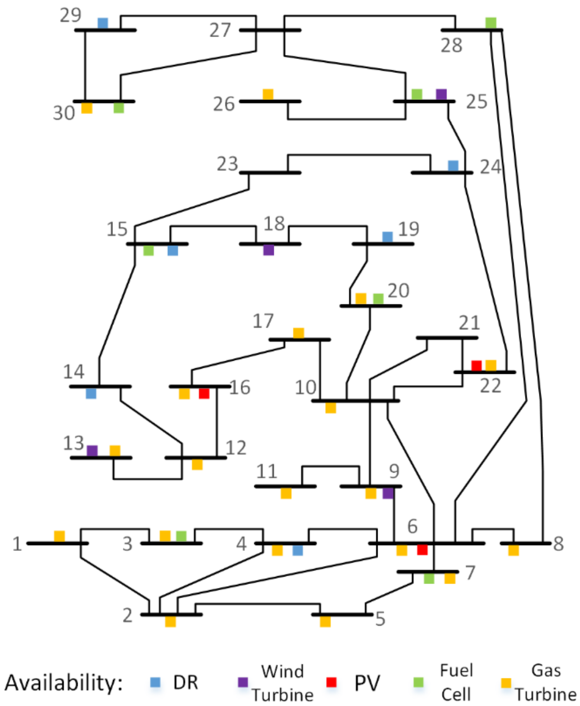


Fig. 4. The availability of DG and DR on 30-bus IEEE transmission system

Table 4. The results of each optimization method

The optimization method	Size: DR (MW)	Size: Total DG capacity (MW)	Power loss (Kw)	Voltages (p.u.): Average	Voltages (p.u.): Variance
Without DG and DR	-	-	6.624916	1.018003	0.000779
Modified IWO	0	23.26336	**6.007174**	**1.017949**	**0.000758**
GA	0	23.53899	6.023014	1.01836	0.000761
PSO	1.541473	34.79117	6.153368	1.017978	0.000778
DE	1.234771	29.86921	6.148848	1.017965	0.000778

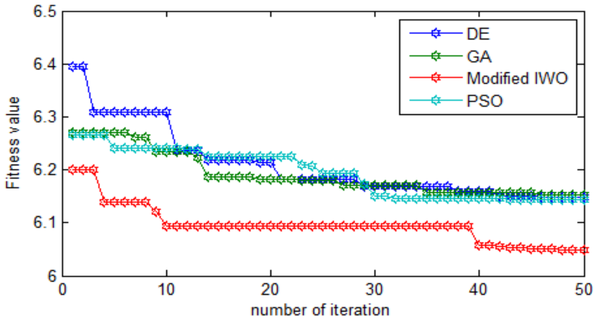
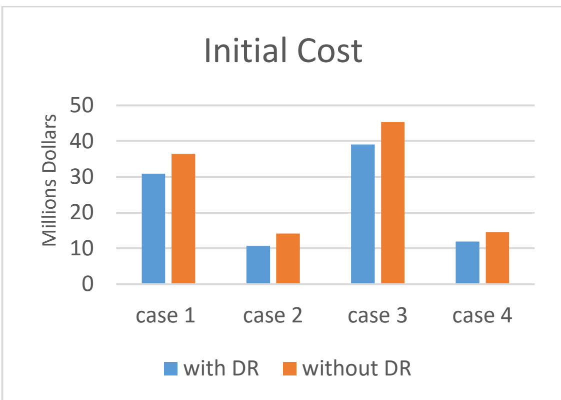
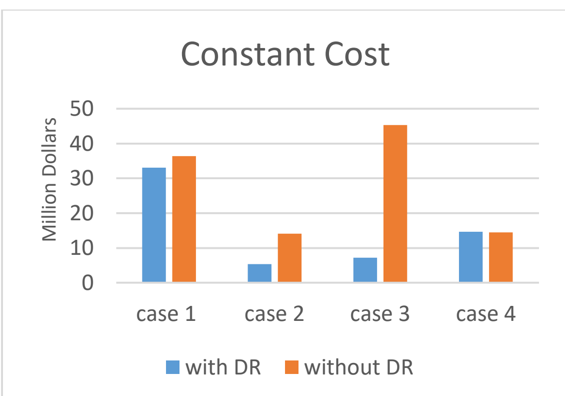


Fig. 5. The fitness values of DE, GA, PSO and modified IWO used for comparisonThe fitness values versus iteration of these optimization methods are shown in Fig. 5 and also the numeric results are given in Table 4 which demonstrate superiority of modified IWO.

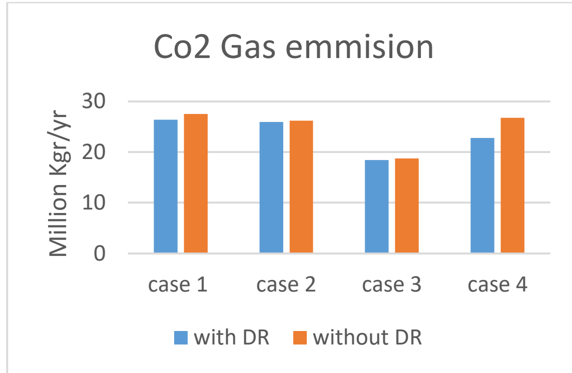
As it is shown in Table 4, the modified IWO has the best performance in both reducing transmission losses and voltage improvement.



(a)



(b)



(c)

Fig. 6. The effect of considering DR on a) initial costs b) constant costs c) CO2 emission

To study the allocation algorithm, four case studies are considered which focus on technical, economic and environmental aspects. In addition, in this paper, the environmental and economic effects of DR consideration is obvious by comparing Table 5 and Table 6. The Fig. 6 depicts the effects regarding environmental and economic aspects.

6. CONCLUSION

In this paper, a comprehensive algorithm has been proposed for DG allocation along with considering DR. The DR allocation is a novel concept which is introduced in this paper and it lets the system operator to meet energy demand without installing new DG source. The considered DG sources in this study include gas turbines, solar panels, wind turbines and fuel cells. Taking to account the characteristics of DG sources and DR, the proposed algorithm proposed the best size and place in order to improve the technical, economic and environmental factors. In addition, a new voltage fitness function is defined which leads to better voltage profile. The 30-bus IEEE transmission system is used to examine the algorithm. The simulation is carried out in MATLAB which the results demonstrate excellent performance of proposed algorithm.

Table 5. The results of DG allocation without considering DR

The case number	Factors			Type of DG source								DR		Technical parameters		Costs		Total emissions (Kg/year)
	Economic	Environmental	Technical	Gas turbine		Fuel cell		Wind turbine		Solar panel				Average of voltage (p.u.)	Power loss (Kw)	Initial costs ($)	Constant costs ($/year)	
				Size (MW)	place	Size (MW)	place	Size (MW)	place	Size (MW)	place	Size (MW)	place					
Case 1			*[1]	8.8469	30	4	7	0	4	0	10	-	-	1.0184	6.0424	30931615	36419394	27497197
Case 2	*		*	9.9993	30	5.2223	28	0	12	0	26	-	-	1.0184	6.0543	10742961	14130439	26158133
Case 3		*	*	9.7663	30	0	21	0.1922	16	0.1618	18	-	-	1.0184	6.1402	39067064	45304343	18745482
Case 4	*	*	* *	9.9893	30	0	12	0	3	0.8049	18	-	-	1.0184	6.1053	11873636	14453048	26755343

[1] The star shows the emphasize on the factor

Table 6. The results of DG allocation with considering DR

The case number	Factors			Type of DG source								DR		Technical parameters		Costs		Total emissions (Kg/year)
	Economic	Environmental	Technical	Gas turbine		Fuel cell		Wind turbine		Solar panel				Average of voltage (p.u.)	Power loss (Kw)	Initial costs ($)	Constant costs ($/year)	
				Size (MW)	place	Size (MW)	place	Size (MW)	place	Size (MW)	place	Size (MW)	place					
Case 1			*[1]	9.4815	30	3.1473	7	-	-	0.6022	18	1.7180	15	1.0178	6.0038	27772695	33029781	26386409
Case 2	*		*	28.7764	11	1.9779	20	-	-	-	-	-	-	1.0180	6.1332	4299674	5378687	25954454
Case 3		*	*	5.0000	20	-	-	-	-	0.7765	18	1.1165	24	1.0180	6.4059	6354158	7234264	18392000
Case 4	*	*	* *	10.0000	30	-	-	-	-	0.7817	18	0.4166	19	1.0180	6.1169	11000000	14644903	22784000

7. APPENDIX

Table 7. Bus data of 30-bus transmission system along with availability of DGs or DR in each bus

Bus number	System data			DG sources				DR (% of demand)
	Load (Mw)	Generator limit		Wind turbine (Mw)	Solar panel (Mw)	Fuel cell (Mw)	Gas turbine (Mw)	
		P_{min}	P_{max}					
1	0.0	50	200				5	
2	21.7	20	80				12	
3	2.4					2	5	
4	67.6						5	40
5	34.2	15	50				1	
6	0.0				1		30	
7	22.8					4	2	
8	30.0	10	35				4	
9	0.0			2			3	
10	5.8						3	
11	8.2	10	30				30	
12	11.2	12	40				5	
13	0.0						10	
14	6.2							40
15	8.2					1		30
16	3.5				0.4		2	
17	9.0						10	
18	3.2			1				
19	9.5							10
20	2.2					2	5	
21	17.5							
22	7.3				0.8		8	
23	3.2							
24	8.7							20
25	0.0			0.8				
26	3.5						16	
27	0.0							
28	0.0					8		
29	2.4				1			40
30	10.6					0.5	10	

Table 8. The lines data of 30-bus transmission system

line	From bus	To Bus	R (p.u.)	X (p.u.)
1	1	2	0.0192	0.0575
2	1	3	0.0452	0.1852
3	2	4	0.0570	0.1737
4	3	4	0.0132	0.0379
5	2	5	0.0472	0.1983
6	2	6	0.0581	0.1763
7	4	6	0.0119	0.0414
8	5	7	0.0460	0.1160
9	6	7	0.0267	0.0820
10	6	8	0.0120	0.0420
11	6	9	0.0000	0.2080
12	6	10	0.0000	0.5560
13	9	11	0.0000	0.2080
14	9	10	0.0000	0.1100
15	4	12	0.0000	0.2560
16	12	13	0.0000	0.1400
17	12	14	0.1231	0.2559
18	12	15	0.0662	0.1304
19	12	16	0.0945	0.1987
20	14	15	0.2210	0.1997
21	16	17	0.0824	0.1932
22	15	18	0.1070	0.2185
23	18	19	0.0639	0.1292
24	19	20	0.0340	0.0680
25	10	20	0.0936	0.2090
26	10	17	0.0324	0.0845
27	10	21	0.0348	0.0749
28	10	22	0.0727	0.1499
29	21	22	0.0116	0.0236
30	15	23	0.1000	0.2020
31	22	24	0.1150	0.1790
32	23	24	0.1320	0.2700
33	24	25	0.1885	0.3292
34	25	26	0.2544	0.3800
35	25	27	0.1093	0.2087
36	28	27	0.0000	0.3960
37	27	29	0.2198	0.4153
38	27	30	0.3202	0.6027
39	29	30	0.2399	0.4533
40	8	28	0.0636	0.2000
41	6	28	0.0169	0.0599

REFERENCES

1. G. Pepermans, J. Driesen, D. Haeseldonckx, R. Belmans and W. D'haeseleer, **"Distributed generation: definition, benefits and issues,"** *Energy Policy*, Vol. 33, No. 6, p. 787–798, 2005.
2. T. Ackermann, G. Andersson and L. Söder, **"Distributed generation: a definition,"** *Electric Power Systems Research*, Vol. 57, No. 3, p. 195–204, 2001.
3. W. El-Khattam and M. Salama, **"Distributed generation technologies, definitions and benefits,"** *Electric Power Systems Research*, Vol. 71, No. 2, p. 119–128, 2004.
4. T. Niknama, S. I. Taheria, J. Aghaeia, S. Tabatabaeib and M. Nayeripoura, **"A modified honey bee mating optimization algorithm for multiobjective placement of renewable energy resources,"** *Applied Energy*, Vol. 88, No. 12, pp. 4817-4830, 2011.
5. Z. Moravej and A. Akhlaghi, **"A novel approach based on cuckoo search for DG allocation in distribution network,"** *International Journal of*

Electrical Power & Energy Systems, Vol. 44, No. 1, pp. 672-679, 2013.

6. S. Abdi and K. Afshar, **"Application of IPSO-Monte Carlo for optimal distributed generation allocation and sizing,"** *International Journal of Electrical Power & Energy Systems*, Vol. 44, No. 1, pp. 786-797, 2013.
7. M. J. Kasaei and J. Nikoukar, **"DG Allocation with Consideration of Costs and Losses in Distribution Networks Using Ant Colony Algorithm,"** *Majlesi Journal of Electerical Engineering*, Vol. 10, No. 1, pp. 51-55, 2016.
8. D. Esmaeili, K. Zare, B. Mohammadi-Ivatloo And S. Nojavan, **"Simultaneous Optimal Network Reconfiguration, Dg And Fixed/Switched Capacitor Banks Placement In Distribution Systems Using Dedicated Genetic Algorithm,"** *Majlesi Journal Of Electrical Engineering*, Vol. 9, No. 4, Pp. 31-41, 2015.
9. A. Kumar and W. Gao, **"Optimal distributed generation location using mixed integer non-linear programming in hybrid electricity markets,"** *IET Generation, Transmission & Distribution*, Vol. 4, No. 2, pp. 281-298, 2010.
10. A. Singha and S. Paridab, **"A novel hybrid approach to allocate renewable energy sources in distribution system,"** *Sustainable Energy Technologies and Assessments*, Vol. 10, pp. 1-11, 2015.
11. D. Gautam and N. Mithulananthan, **"Optimal DG placement in deregulated electricity market,"** *Electric Power Systems Research*, Vol. 77, No. 12, pp. 1627-1636, 2007.
12. **"Benefits of demand response in electricity markets,"** U.S. *Department of Energy*, 2006.
13. Y. Gong, Y. Cai, Y. Guo and Y. Fang, **"A Privacy-Preserving Scheme for Incentive-Based Demand Response in the Smart Grid,"** *IEEE Transactions on Smart Grid*, Vol. 7, No. 3, pp. 1304-1313, 2016.
14. A. Mehrabian and C. Lucas, **"A novel numerical optimization algorithm inspired from weed colonization,"** *Ecological Informatics*, Vol. 1, No. 4, p. 355–366, 2006.
15. A. Basak, S. Pal, S. Das, A. Abraham and V. Snasel, **"A modified Invasive Weed Optimization algorithm for time-modulated linear antenna array synthesis,"** in *2010 IEEE Congress on Evolutionary Computation (CEC)*, 2010.
16. R. Giri, A. Chowdhury, A. Ghosh, S. Das, A. Abraham and V. Snasel, **"A Modified Invasive Weed Optimization Algorithm for training of feed- forward Neural Networks,"** in *IEEE International Conference on Systems Man and Cybernetics (SMC)*, 2010.
17. P. Pahlavani, M. R. Delavar and A. U. Frank, **"Using a modified invasive weed optimization algorithm for a personalized urban multi-criteria path optimization problem,"** *International Journal of Applied Earth Observation and Geoinformation*, Vol. 18, p. 313–328, 2012.
18. Z. D. Zaharis, C. Skeberis, T. D. Xenos, P. I. Lazaridis and J. Cosmas, **"Design of a Novel Antenna Array Beamformer Using Neural Networks Trained by Modified Adaptive Dispersion Invasive Weed Optimization Based Data,"** *IEEE Transactions on Broadcasting*, Vol. 59, No. 3, pp. 455-460, 2013.
19. G. G. Roy, S. Das, P. Chakraborty and P. N. Suganthan, **"Design of Non-Uniform Circular Antenna Arrays Using a Modified Invasive Weed Optimization Algorithm,"** *IEEE Transactions on Antennas and Propagation*, Vol. 59, No. 1, pp. 110-118, 2010.
20. E. IO**, "Electric energy system theory–an introduction**", *McGraw-Hill*, 1971.
21. N. Jain, S. Singh and S. Srivastava, **"PSO based placement of multiple wind DGs and capacitors utilizing probabilistic load flow model,"** *Swarm and Evolutionary Computation*, Vol. 19, p. 15–24, 2014.
22. X. Fu, H. Chen, R. Cai and P. Yang, **"Optimal allocation and adaptive VAR control of PV-DG in distribution networks,"** *Applied Energy*, Vol. 137, pp. 173–182, 2015.
23. A. El-Zonkoly, **"Optimal placement of multi-distributed generation units including different load models using particle swarm optimization,"** *Swarm and Evolutionary Computation*, Vol. 1, No. 1, p. 50–59, 2011.
24. A. Elmitwally, **"A new algorithm for allocating multiple distributed generation units based on load centroid concept,"** *Alexandria Engineering Journal*, Vol. 52, No. 4, p. 655–663, 2013.
25. M. Moradi and M. Abedini, **"A combination of genetic algorithm and particle swarm optimization for optimal DG location and sizing in distribution systems,"** *International Journal of Electrical Power & Energy Systems*, Vol. 34, No. 1, pp. 66-74, 2012.
26. K.-y. Liua, W. Shenga, Y. Liub, X. Menga and Y. Liu, "**Optimal sitting and sizing of DGs in distribution system considering time sequence characteristics of loads and DGs,"** *International Journal of Electrical Power & Energy Systems*, Vol. 69, pp. 430-440, 2015.
27. M. I. Blanco, **"The economics of wind energy,"** *Renewable and Sustainable Energy Reviews*, Vols. 6-7, No. 13, pp. 1372-1382, 2009.
28. S. Reichelstein and M. Yorston, **"The prospects for cost competitive solar PV power,"** *Energy Policy*, Vol. 55, pp. 117-127, 2013.
29. D.B.Nelson, M.H.Nehrir and C.Wang, **"Unit sizing and cost analysis of stand-alone hybrid wind/PV/fuel cell power generation systems,"** *Renewable Energy*, Vol. 31, No. 10, pp. 1641-1656, 2006.
30. M. Ehyaei and A. Mozafari, **"Energy, economic and environmental (3E) analysis of a micro gas turbine employed for on-site combined heat and power production,"** *Energy and Buildings*, Vol. 42, No. 2, pp. 259-564, 2010.
31. M. Ellis, M. von Spakovsky and D. Nelson, **"Fuel cell systems: efficient, flexible energy conversion**

for the 21st century," *Proceedings of the IEEE* , Vol. 89, No. 12, pp. 1808 - 1818, 2001.

32. M. Shahidehpour and Y. Wang, **"Communication and Control in Electric Payer Systems: Application of Parallel and Distributed Processing"**, *John Wiley & Sons*, 2003.