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RESEARCH ARTICLE

Calculating Optimal Cost of Using DGs in Micro Grids by Using Imperialistic Competitive Algorithm (ICA)

Navid Javidtash[1], Reza Sedaghati[2]

[1] Department of Electrical Engineering, Beyza Branch, Islamic Azad University, Beyza, Iran

[2] Department of Electrical Engineering, Beyza Branch, Islamic Azad University, Beyza, Iran

Abstract— How to use renewable sources has been a great problem for many years. Researchers have invented and developed Microgrids, flexible networks with a central control system; nevertheless, for installing renewable sources on them there is still questions. As a result, researchers started to use different algorithms in order to solve problems and find best answers for electrical functions. One of the most novel algorithms for this purpose is Imperialistic Competitive Algorithm (ICA). It is based on historical events and provides marvelous results and speed in comparison with similar algorithms such as Genetic Algorithm or PSO. In this paper we will investigate best answers for cost function in a 14-Bus Microgrid by using ICA algorithm. Finally answers will be compared with GA and PSO so that it can be shown that proposed algorithm is more efficient than its counterparts.

Keywords— Distributed Generation; Imperialistic Competitive Algorithm (ICA); Microgrid; PSO; GA

I. INTRODUCTION

In last decades due to increasing use of electricity in the world, most of countries have attempted to extend their electricity network which obliges them to change structure of their networks, as well. Thus nowadays we can see a lot of research on modern network called Microgrids. In traditional networks we can only see conventional power plants. Exploiting renewable sources are difficult in conventional networks. That is why electricity researches introduced Microgrids [1]. The modern networks includes renewable sources, loads and storage facilities as well as lots of advantages such as high reliability, controlling demand systems, producing local demands and so on. Because of new structure of these networks we need new explanations about elements of network, for example to reduce rate of cost or emission web, some calculations are necessary which are our goal in this paper [2]. For obtaining optimal answers different approaches and algorithms have been used but in this study we want to try one of the newest algorithms named as Imperialistic Competitive Algorithm (ICA) to obtain better results in less time. Researchers have presented many interesting algorithms and solutions, as some of the solutions, which referred in [3] as

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analytical approaches [4] numerical programming and heuristic [5,6]. Some researches are based on evolutionary algorithms. In [7] the DG allocation problem is solved using artificial bee colony.

In this paper we review structure of Microgrids and their abilities. Afterwards ICA algorithm flow chart is investigated, then we consider a standard 14-Bus Microgrid for optimizing cost function in it using ICA algorithm. At the end results are compared with conventional approaches to show the quality of proposed algorithm.

II. THE MICROGRID STRUCTURE

In contrary to previous networks generation with conventional power plants, Microgrids have a lot of properties such as producing base and backup power, high reliability, high efficiency, high security and so on. Microgrids have been used in some countries, for instance in USA, UK, Japan and other modern countries. Additionally, Microgrids are good option to utilize DGs because Microgrids are so much flexible comparing older networks that many countries try to distribute this modern network to improve use of renewable sources. Microgrids can work in two modes, connected to other networks and isolated from other networks, island mode. In each mode we have two controlling parts, local controller and central controller. Local controller gives data of each source to central controller and gets command from it while central controller gets data, analyzes it and gives the best command to keep network stable and secure [8]. If a Microgrid have connection with other Microgrids central controllers exchange data's between each other. In this paper we use a Microgrid in our simulation. A schematic plan of Microgrid has been shown on figure (1) [9].

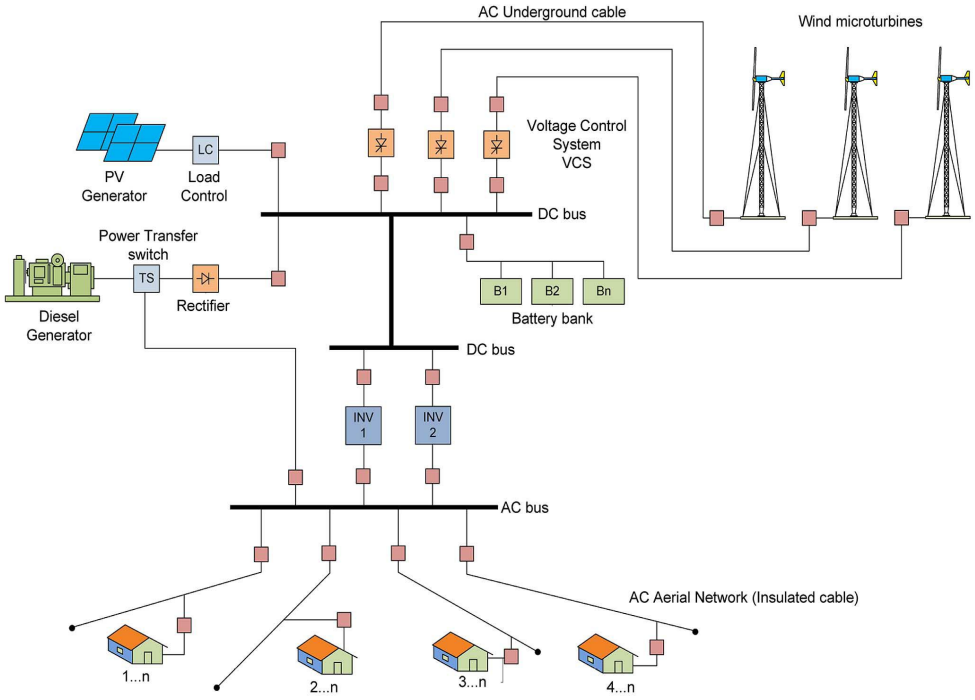

Fig. 1 A schematic plan of Microgrid

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III. **PROPOSED ALGORITHM**

As using algorithms for optimizing objective functions has recently become common, a variety of algorithms have been developed and utilized for optimizing goals. Most of algorithms have been created based on natural process of life whereas ICA algorithm, for the first time, is based on political events during history. In ICA algorithm we have some data as initial countries, and then we chose some of them as imperialists and the others as colonies hence some empires are created in this section. After that, two stage of competition occurs between countries, intra competition and inter competition. In intra competition each country tries to improve itself and dominate on imperialist, while in inter competition empires make efforts to get the weakest colony from the weakest empire. This procedure continues until all of colonies are conquered by other colonies and eventually one empire remains. When there is no colonies remained in an empire, imperialist of that colony becomes like a colony and is taken by other empires and that empire will be eliminated [10]. A schematic plan of ICA has been shown on figure(2).

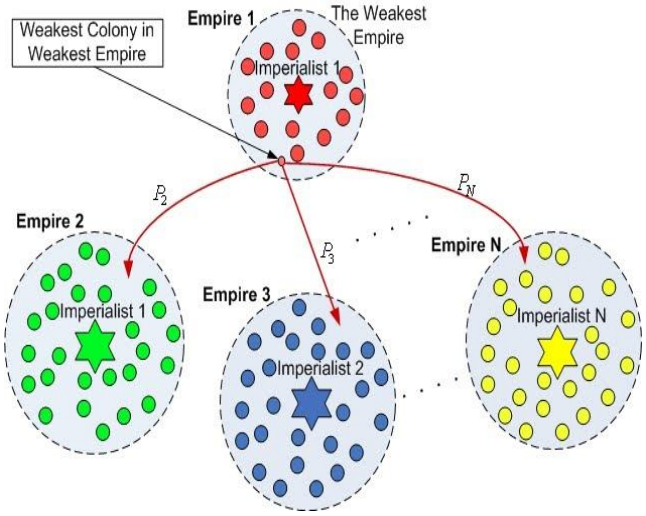

Fig. 2 Competition between empires

During this process two important events occur, assimilation and revolution. In assimilation part we have some changes inside each empire, in this action imperialist of empire try to change structure of colonies based on their needs, therefore it change some parameters of colonies. This action has historical roots in imperialistic history. In revolution that also has historical root, one colony or more inside each empire may change suddenly and these changes could improve level of colony resulting in its domination on imperialist, so it can increase cost of colony to an upper level than imperialist and become imperialist. In revolution action some parameters of colony change suddenly and other colonies or imperialists don't have any impact on this action [11].

In each part of ICA algorithm, we should evaluate cost function because value of each country is demonstrated via result of cost function. Since we aim to minimize cost function in this study, a country is better than others when its cost is the least. Utilizing ICA algorithm, it can be seen that results are more accurate and time of convergence is less than older algorithms such as Genetic algorithm or PSO algorithm. Generally cost of each empire can be calculated by following equation:

$$\text{Cost of Empire} = F(\text{Imp}) + \xi * \text{Mean}(F(\text{col})) \quad (1)$$

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Where F (Imp) stands for the cost of imperialist and impact of average cost function of colonies is modelled by a constant coefficient, ξ. A block diagram for ICA algorithm has been shown in figure (3) [12].

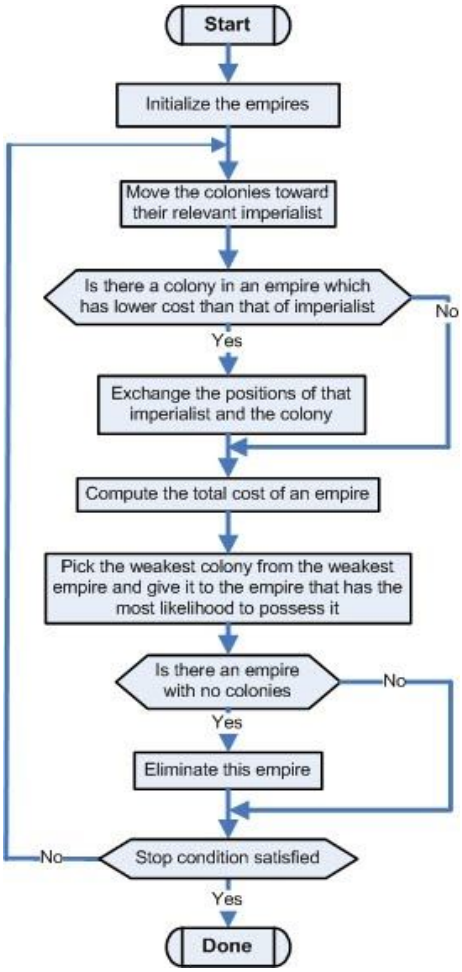

Fig. 3 Block diagram of ICA algorithm

IV. SIMULATION RESULTS

In previous sections, Microgrids and main structure of ICA algorithm were discussed, now we want to implement proposed algorithm in a Microgrid and evaluate it considering cost of determining DG's capacity. So our cost function is [13]:

$$Cost(P) = a + b * P \quad (2)$$

(3)

$$a = \frac{Capital\ Cost\left(\frac{\$}{KW}\right) * Capacity\ (KW) * Gr}{Life\ Time\ (year) * 365 * 24 * Lf}$$

$$b = Fuel\ Cost\ (\$/Kw\ h) + O\ \&\ M\ Cost\ ((\$/Kw\ h) \quad (4)$$

Lf is the load factor, Gr is the annual interest rate and the O & M cost is the operation and maintenance cost. So our equation is:

$$F(x) = (P_{DG\,i}) + Cost_{sub} \quad (5)$$

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Where Cost($P_{DG\ i}$) shows cost of i'th DG's and Cost $_{sub}$ denotes cost of installation of substations. Here we consider three kind of DG's which their data can be found in Table (1).

TABLE 1
Data of DGs

DG Type	CHP	Photovoltaic	Wind Turbine
Rated Capacity(kw)	200	100	10
Capital Cost($/kw)	3674	6675	3866
Fuel Cost($)	0.029	0	0
O & M Cost($/kwh)	0.01	0.005	0.005
Life Time(year)	10	20	20

Constraints:
The voltage of the network should always be kept within the permissible limits:

$$V_{min} \leq |V_K| \leq V_{max} \quad (6)$$

Where Vmin and Vmax are the lower and upper voltage limits, respectively. Also, |Vk| is the voltage magnitude at bus k.

DG size:
Depending on the maximum allowable investment of DG, the total DG size should be governed by:

$$\sum_{K=1}^{NDG} KW^{K}_{DG} \leq \sum Pload \quad (7)$$

Where KW^{K}_{DG} is the capacity of the Kth DG and Pload is the total load power. Moreover, NDG is number of DGs. For implementation of ICA algorithm we use a standard 14-BUS Microgrid that is depicted in figure (4) and its data are represented in Table(2) and Table(3).

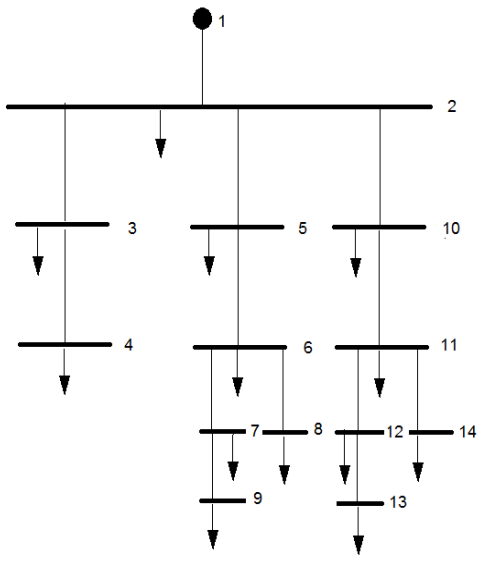

Fig. 4 14-Bus Microgrid

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TABLE 2
Bus Data of Microgrid

No.Bus	Pli	Qli
1	0	0
2	20	6
3	85	27
4	40	1
5	20	6
6	20	6
7	76	16
8	10	30
9	61	16
10	12	75
11	10	90
12	16	61
13	90	59
14	35	61

Table 3
Line Data of Microgrid

from	to	R(pu)	X (pu)	B (pu)
1	2	0/0133	0/042	0/006
2	3	0/0194	0/059	0/026
3	4	0/0312	0/16	0/028
2	5	0/023	0/12	0/0071
5	6	0/023	0/12	0/0071
6	7	0/0193	0/059	0
6	8	0/032	0/084	0
7	9	0/034	0/17	0
2	10	0/016	0/042	0/008
10	11	0/193	0/059	0/026
11	12	0/067	0/017	0/017
12	13	0/04	0/1	0
11	14	0/05	0/15	0

In given Microgrid our power demand is brought by a mixture of conventional substations and DG's so we want to find the best state of using them when our cost is near to minimum.

Because of exploiting ICA algorithm we should express some factors of this algorithm that is important in implementation of it. When we want to choose the best countries in ICA algorithm, we can use different methods. In this algorithm we use Roullette wheel selection for this goal. In theory of Roullette wheel selection we have a wheel that is rotated and

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stopped in a chancy point; however, we can simulate this action in a line. For example if we have 4 probabilities we can show 4 different parts in a line like figure (5).

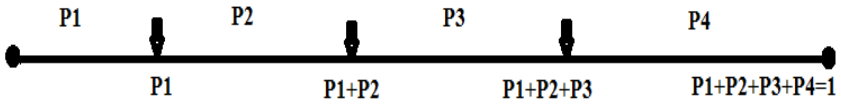

Figure. 5 Roullette Wheel Selection Method

Each probability is derived from rate of propriety, thus we can write proper codes for this action. At first we should select a random point between 0 and 1:

$P1+P2+P3+P4 = 1$ (8)

$r \sim Random\ Point(0,1)$ (9)

$0 \leq r \leq 1$ (10)

If $r \geq 0$ & $r \square P1$; *so first regional is selected* (11)

If $r \square P1$ & $r \leq P1+P2$; *so second regional is selected* (12)

If $r \square P1+P2$ & $r \leq P1+P2+P3$; *so third regional is selected* (13)

If $r \square P1+P2+P3$ & $r \leq P1+P2+P3+P4$; *so last regional is selected* (14)

For implementation of revolution in ICA algorithm we can use various methods but in this paper we use normal distribution. In this method the density of selection near X point is more than other points.

$X' \sim N(X, \sigma^2) \sim X + \sigma N(0,1)$ (15)

$\sigma = \gamma (X_{Max} - X_{Min})$ (16)

Where γ=0.1 and σ represents step size. If σ is a large number, accuracy of checking is high but time of searching is long and vice versa (, inversely, if σ is a small number, accuracy of checking is low but time of checking is short.)

Now we can use ICA algorithm in a Microgrid, for this purpose number of variables in ICA is 3, number of countries is 50, number of empires is 10 and number of iterations is 100. After using proposed algorithm, output is shown in figure (6). It illustrates that the speed of algorithm is high and rate of convergence is marvelous. Numerical answers are listed in table (4) in comparison with Genetic algorithm and PSO algorithm. Answers show the fact that output of ICA algorithm for cost function in a Microgrid is less than the other algorithms; furthermore, time of convergence in this algorithm is better than others. So structure of ICA algorithm is more beneficial than similar algorithm.

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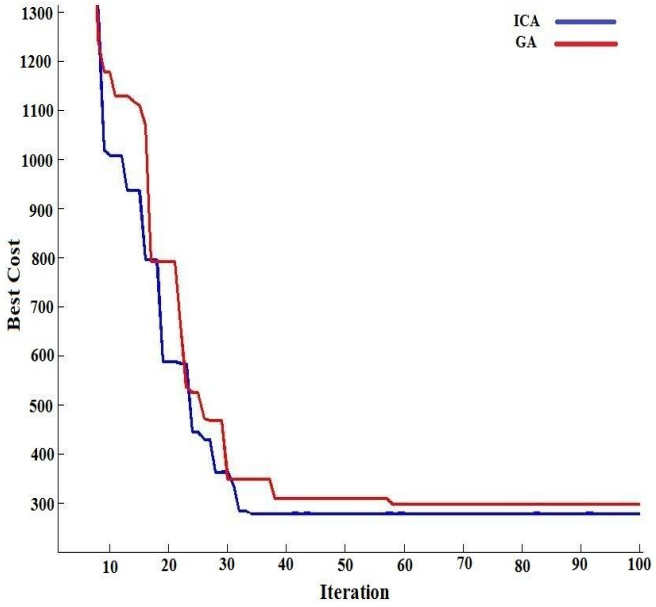

Fig. 6 Comparison of ICA and GA

Table 4
Comparison of different methods

Method	Best Cost	Time
Genetic Algorithm	301.26	1.341
PSO	287.37	1.138
Proposed Algorithm (ICA)	279.71	0.972

V. CONCLUSION

By increasing progress of using renewable sources in power systems around the word, we need modern systems to reduce the rate of cost, emission, losses and so on. These networks were named Microgrid. Microgrids can be used in two modes, connected to other networks and island mode. They provide lots of advantages comparing to old networks including high performance, high reliability, high efficiency and so on. On the other hand when we want to increase rate of efficiency in these networks, we should exploit optimization algorithms such as ICA algorithm. This algorithm is the first algorithm that is made based on historical events. In this study we considered a standard 14-Bus Microgrid and our cost function was cost function. Then results of proposed algorithm were represented which showed better answers and time of convergence in comparison with other algorithm like PSO and GA.

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REFERENCES

[1] Piagi, P., Lasseter, R.H., 2006., Autonomous Control of Microgrids, *IEEE PES Meeting*, Montreal, PP. 1.

[2] Lasseter R.H., Piagi P., 2004., "Microgrid: A Conceptual Solution", *Proc. Power Electronics Specialists Conf*, Aachen, Germany, Volume. 6, Issue.1, pp. 4285–4290.

[3] Ng HN, Salama MM, Chikhani AY., 2000., "Capacitor allocation by approximate reasoning: fuzzy capacitor placement". *IEEE Trans Power Deliv*;15(1):93–398.

[4] Augugliaro A, Dusonchet L, Mangione S. 1990., "Optimal capacitive compensation on radial distribution system using nonlinear programming". *Electric Power Syst Res*;19:129–35.

[5] Gallego RA, Monticelli AJ, Romero R. 2001., "Optimal capacitor placement in radial distribution networks". *IEEE Trans Power Syst*;16(4):630–7.

[6] Varilone P, Carpinelli G, Abur A. 2002., "Capacitor placement in unbalanced power systems". In: *Proc 14th PSCC, Sevilla*, Session 3, Paper 2 .

[7] Fahad S. Abu-Mouti and El-Hawary M. E., 2011, "Optimal Distributed Generation Allocation and Sizing in Distribution Systems via Artificial Bee Colony Algorithm," *IEEE TRANSACTIONS ON POWER DELIVERY*, VOL. 26, NO. 4.

[8] Chowdhury, S., Chowdhury, S.P., Crossley, P., 2009, Microgrids and Active Distribution Networks, London, Pub. *The Institution of Engineering and Technology*, PP. 145-157.

[9] Rebeiro, L., Saveedra, O.R., Lima, S.L., 2011, Isolated Micro-Grids With Renewable Hybrid Generation: The Case of Lençóis Island, *IEEE TRANSACTIONS ON SUSTAINABLE ENERGY*, VOL. 2, NO. 1, PP. 3-5.

[10] Atashpaz-Gargari, E., & Lucas, C., 2007. Imperialist competitive algorithm: An algorithm for optimization inspired by imperialistic competition. *IEEE Congress on Evolutionary Computation*, 4661–4667.

[11] www.ICAsite.info

[12] Nazari-Shirkouhi, S., Eivazy, Ghodsi, H.R., 2010., "Solving the integrated product mix outsourcing problem using the Imperialist Competitive Algorithm", *Expert Systems with Applications.* 7615–7626.

[13] Niknam, T., Taheri, S.I., Aghaei, J., Tabatabaei, S., Nayeripour, M., 2011, A modified honey bee mating optimization algorithm for multiobjective placement of renewable energy resources, *Elsevier, Applied Energy*, 88, PP. 4818-4821.

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