Modified Genetic Algorithm Framework for Optimal Scheduling of Single Microgrid Combination with Distribution System Operator

Jamaledini, Ashkan and Khazaei, Ehsan and Toran, Mehdi

Azad University of Shiraz, Shiraz, Iran

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Ashkan Jamaledini, Ehsan Khazaei, Mehdi Toran

Azad University of Shiraz, Shiraz, Iran

Abstract: In this paper, new reformed genetic algorithm (GA) according to the multicellular organism mechanism is developed for power management of single microgrid incorporation with the distribution system operator (DSO). Integration of single microgrid into the conventional grids cann enhance the complexity of the problem due to ability of disconnecting from the main grid as a standalone small electricity network. Hence, in this paper, a new evolutionary algorithm is developed to address the complexity of the problem. The main objective of the proposed model is to minimize the total operation cost of the microgrid in both utility connected and off utility connected modes; that means the objective is based on the economic consideration. To demonstrates the high performance and ability of the proposed method, a modified IEEE 33 distribution bus test network is selected and examined. Finally, the results are compared with the famous evolutionary algorithms such as particle swarm optimization (PSO). In it worth noting that the results are only based on the economic consideration.

Keywords: Optimal energy management; Microgrid; Economic consideration

I. Introduction

Cooperating the renewable energy sources (RESs) into the conventional grids due to their importance benefits like friendly environment, clean, and security, the microgrid has been attracted a lots of attentions [1], [2]. However, the unpredictability and addiction of these energies with the ambient conditions, many challenges take into account in power system operation.

Cooperation of distributed energy resources by the loads in a small network can be considered as the microgrid (MG). MGs have a lots of importance welfares like clossnes to the consumers, ability of disconnecting from the main grid in the emergency conditions, and standalone capability [3], [4], [5], [6]. These characteristics can contribute to less cost of operation, greater reliability and resiliency, and less power loss. But, the economic power management of the microgrid is very challenging.

Cooperation of single MG and DSO is investigated in many researches so far. To illustrate, from the market presepective, the incoperation of MG and DSO is address in [7]. The authors utilized MILP mathematical method [8] to handle the problem. The efficient power mangment of MG is studied in [9] where the authors used the energy harvesting technique of [10] and [11]. The time solution is plays as the significant roles in microgrid operation, particularly in the islanding time in order to have a stable operation. Therefore, this paper suggested a new optimization algorithm known as the adapted genetic algorithm according to the multicellular organism mechanism (GAMOM) to address the problem. Evolutionary methods that has been used in microgrid operation in many researches. For example, particle swarm optimization (PSO) and teaching learining based optimization (TLBO) used in [14-25]. However, modified GA algorithm has a superiority to others due to its high speed and resolution [25-28].

II. Mathematical Formulation Modeling

The main objective of the mentioned problem is to minimize the operation cost as

$$Min \sum_{t} \sum_{i} (F_i(P_{it}) I_{it} + SU_{it} + SD_{it}) + \sum_{t} \rho_t P_{M,t} \tag{1}$$

*t:*period

F: coefficient of cost

*P:*output power

i: generators numbers

SU,*SD:* startup/shutdown costs

ρ: coefficient cost of power purchased by the utility

M: utility.

The proposed problem contains some constraints as follows:

1. Overall power generation must be equivalent to the power request as

$$\sum_{i} P_{it} + P_{Mt} = \sum_{d} D_{dt} \qquad \forall t \tag{2}$$

D: load demand at hour t

2. Purchase power from the utility should be bounded as

$$-P_M^{max} \le P_{M,t} \le P_M^{max} \qquad \forall t \tag{3}$$

3. Power generation capacity should be bounded as

$$P_i^{min} I_{it} \le P_{it} \le P_i^{max} I_{it} \qquad \forall i \in G, \forall t \tag{4}$$

I: status of unit (binary variable).

4. Each unit should be bounded as a ramp up and down rates as

$$P_{it} - P_{i(t-1)} \le UR_i \qquad \forall i \in G, \forall t \tag{5}$$

$$P_{i(t-1)} - P_{it} \le DR_i \qquad \forall i \in G, \forall t \tag{6}$$

UR,DR: ramp up/down

5. Generation units are limited to a minimum up/down time as

$$UT_i(I_{it} - I_{i(t-1)}) \leq T_{it}^{on} \quad \forall i \in G, \forall t \tag{7}$$

$$DT_i(I_{i(t-1)} - I_{it}) \leq T_{it}^{off} \quad \forall i \in G, \forall t \tag{8}$$

T^{on} , T^{off} : numbers of sequential on/off periods

III. GAMOM Optimization method

This paper employed a modification in GA algorithm based on meiosis in the human cell. In it worth noting that the common GAs imitated the meiosis developments on sexual chromosomes. However, by applying this new modification on GA, the perception of mitosis for the asexual chromosomes will be additional to GA. This modification initiates by creating genes for the populations (known as P1 and P2) that can be considered as N1 and N2 While the size of them are n_1 and n_2. Gens generation is selected randomly, and also the gens for each population are shaped self-sufficiently.

Table I
Parameters of GAMOM [29]

Parameter	Definition	Number
m_1	Rate of mitosis	[0,1]
m_2	Rate of meiosis	[0,1]
$\alpha_1.m_1$	Chromosomes ratio in N_1 that should insert in N_1'	[0,1]
$\alpha_2.m_2$	Chromosomes ratio in N_2 that should insert in N_2'	[0,1]
$\beta_1.m_1$	Chromosomes ratio in N_2 that should insert in N_1'	[0,1]
$\beta_2.m_2$	Chromosomes ratio in N_1 that should insert in N_2'	[0,1]

It is worth noting that the parameters are established after making populations. Therefore, the sizes of divided populations can be taken into account as

$$n'_1 = \alpha_1.m_1.n_1 + \beta_1.m_1.n_2 \tag{9}$$

$$n'_2 = \alpha_2.m_2.n_1 + \beta_2.m_2.n_2 \tag{10}$$

These settings intention to control the algorithm for both population [29].

IV. Case Study & Results

Figure 1 presents the adapted IEEE 33 bus exam system including four DG, two wind power, and one breaker to disconnect the grid in the emergency condition to islanding the network.

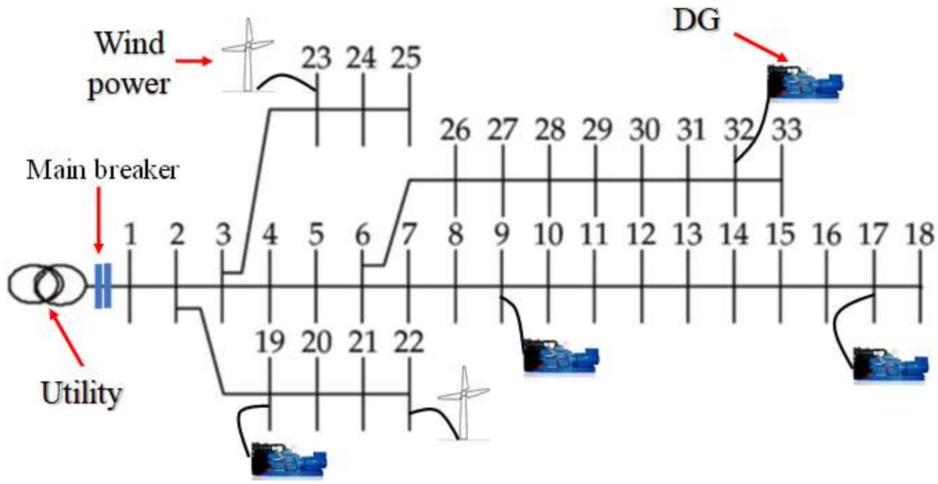

Fig. 1. Illustration of the adapted system [30]

Table I shows the production powers of the wind turbines for 24 hours along with the DG features in Table II. Also, the demand presents in Fig. 2.

Table I. Wind powers production [30]

Time	1	2	3	4	5	6	7	8	9	10	11	12
WT 1 (KW)	220	220	220	220	220	170	220	190	300	400	620	760
WT 2 (KW)	180	180	180	180	180	140	180	170	250	300	590	595
Time	13	14	15	16	17	18	19	20	21	22	23	24
WT 1 (KW)	790	600	240	225	170	220	200	220	180	180	160	120
WT 2 (KW)	540	480	180	165	190	160	165	180	150	150	140	100

Table II
DG features

#	Size (MW)	Price (Dollar per kWh)
DG1	30000-45000	0.17
DG2	22000-33000	0.21
DG3	20000-31000	0.32
DG4	8000-35000	0.43

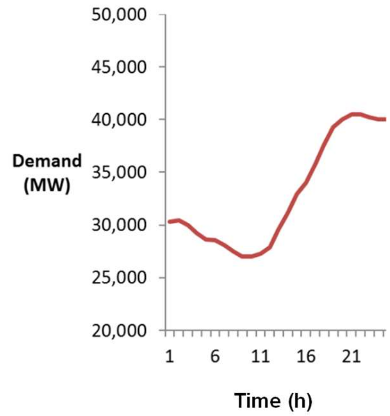

Fig. 2. Day-ahead demand [30]

By employing GAMOM, the grade of units is gained according to the following table:

Table III
Units status

Time	1	2	3	4	5	6	7	8	9	10	11	12
DG1	1	1	1	1	1	1	1	1	1	0	0	1
DG2	1	1	1	1	1	1	1	0	1	1	1	1
DG3	0	0	0	0	0	0	0	0	0	0	0	1
DG4	0	0	0	0	0	0	0	0	0	0	0	0
Time	13	14	15	16	17	18	19	20	21	22	23	24
DG1	1	1	1	1	1	1	1	1	1	1	1	1
DG2	1	1	1	1	1	1	1	1	1	1	1	1
DG3	1	1	1	0	0	0	0	0	0	0	0	0
DG4	0	0	0	0	0	0	0	0	0	0	0	0

According to the results, inexpensive units 1 and 2 are dedicated more than others. Additionally, the most exclusive unit is off in the all of the time

The performance of the proposed method is compared with TLBO, GA and PSO as follows:

Technique	Price (Million dollar)	Time to solve (s)
TLBO	23,287	22.1
PSO	28,343	35.2
GA	26,450	37.4
GAMOM	21,930	19.3

V. Conclusion

Novel evolutionary algorithm is developed based on the modified genetic algorithm known as the adapted genetic algorithm based on the multicellular organism mechanism (GAMOM). To validate the performance of the proposed method, it is applied for microgrid operation. Based on the results, the performance of the proposed method is more efficient than other techniques such as PSO, GA, and TLBO. Indeed, not only the operation cost, even the solution time is less than others which container verify the great efficiency and merit of the method.

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